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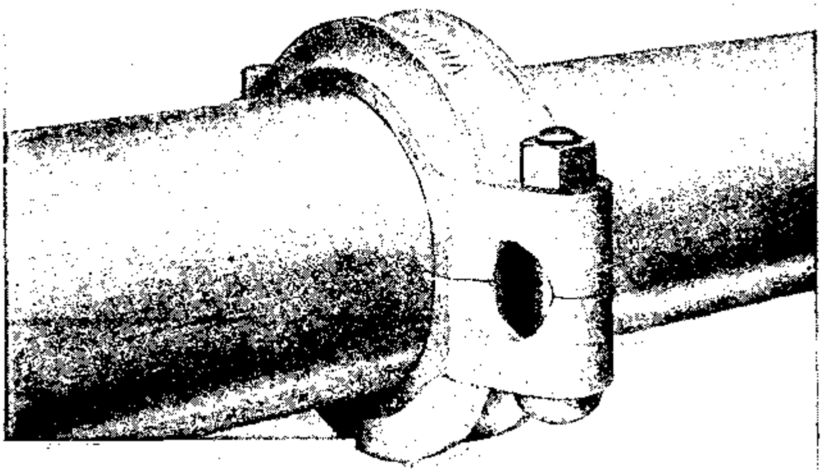

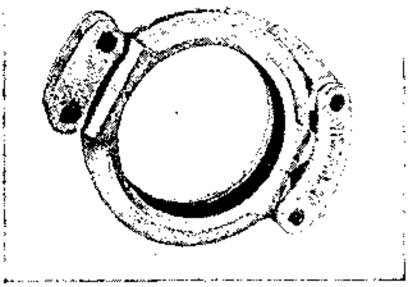

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THE ROYAL ENGINEERS JOURNAL

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H.M. The Queen inspecting R.E. Guard of Honour in Castle Gardens, Rochester. 30 March 1961.

The Queen inspecting RE

Corps Notes

THE Queen has approved the appointment of General Sir Frank Simpson, GBE, KCB, DSO, as Chief Royal Engineer in place of General Sir Kenneth Crawford, KCB, MC, who died suddenly on 5 March 1961, whose memoir is published in this edition of the *Journal*.

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Major-General Harkirat Singh has succeeded Major-General R. E. Aserappa as Engineer-in-Chief at Army Headquarters, New Delhi, India.

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Lieut-Colonel P. H. G. Hamilton, RNZE, has succeeded Lieut-Colonel A. R. Currie, DSO, OBE, as Chief Engineer, New Zealand Military Forces.

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To mark the 500th Anniversary of the grant of a Charter to the City, Her Majesty the Queen and His Royal Highness the Duke of Edinburgh visited Rochester on 30 March 1961. At a civil reception, Major-General T. H. F. Foulkes, OBE, the Engineer-in-Chief, representing the Corps as Freeman of the City, was presented to Her Majesty; the Corps of Royal Engineers received the Freedom of the City of Rochester on 22 May 1954.

In the morning the Queen attended a Service in Rochester Cathedral and distributed the Royal Maundy after which she was entertained to luncheon by the City. In the afternoon Her Majesty, accompanied by the Duke of Edinburgh, drove to the Castle Gardens where she inspected a Royal Engineer Guard of Honour commanded by Captain R. I. Foley, RE. The Corps Band was in attendance. After the inspection the Queen received the Loyal Address to which she graciously replied.

The School of Military Engineering was responsible for co-ordinating all the military requirements of the visit which included the lining of the route taken by the Queen through Rochester by units of the Territorial Army. Amongst these units was the 590 (Kent) Bomb Disposal Squadron RE (TA) who have long and close connexions with the City.

Following the Royal Visit the Commandant, The School of Military Engineering received a letter from the Lord Lieutenant of Kent which read:

"*I am commanded to convey the congratulations of Her Majesty The Queen to the Royal Engineers on the very smart Guard of Honour which they provided in the Castle Gardens on the occasion of Her Majesty's visit to Rochester on 30 March. Her Majesty wishes you to convey her appreciation to all ranks concerned.*"

* * * * *

A long and close connexion between the Corps and the Royal Navy at Chatham came to an end with the disbandment of the Nore Command on 24 March 1961. The last Commander-in-Chief, The Nore was Admiral Sir Robin Durnford Slater, KCB, a descendant of the famous Durnford family of which four members served in the Corps since 1779, the most famous perhaps being Colonel A. W. Durnford who in command of the ill fated column was killed at the disaster at Isandhlwana in 1879 and to whom there is a memorial window in Rochester Cathedral presented by officers of the Corps and unveiled by Field-Marshal Lord Napier of Magdala. Many relics of the Durnford family, including some presented by Admiral Sir Robin Durnford Slater, are held in the RE Museum, Chatham.

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In early May, Exercise Makefast IX, sponsored by Chief Engineer Northern Army Group, was held at the SME, Chatham. This was an indoor exercise and included engineer officers of the United Kingdom, Holland, Belgium and Germany, who were intermingled within syndicates. This is thought to be the first exercise run by any Arm of the Service to be organized in a truly integrated manner.

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In March the Engineer-in-Chief toured Hong Kong, Malaya, Singapore and North Borneo and inspected Royal Engineer units and establishments.

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In April and May a reinforced troop of 20 Field Squadron, 36 Corps Engineer Regiment relieved 59 Field Squadron in the Cameroons. The troop forms part of the Grenadier Guards Battalion Group relieving force. As part of the rundown of the Army, 59 Field Squadron will disband on returning home.

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The first three months of 1961 have seen a slight improvement in regular recruiting into the Corps. There is, however, no cause to relax the strenuous efforts at present directed to obtain more recruits.

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Dress Regulations for officers of the Corps were approved by the Corps Committee in March and are in the course of being printed and distributed. By 1 January 1963 all Royal Engineer officers will be required to comply with these regulations.

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37 Field Squadron and 38 (Berlin) Field Squadron recently celebrated their hundredth anniversary. Both units were first raised at Chatham on 1 April 1861.

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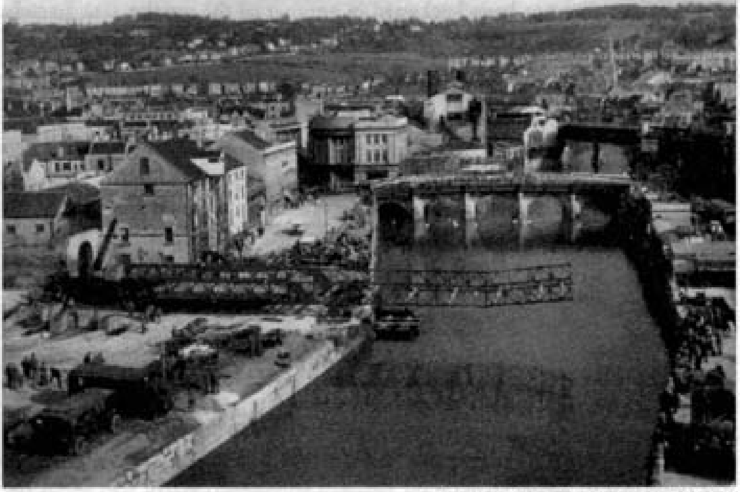
During the week-end 11/12 March last, 43 (Wessex) Divisional Engineer (TA) built a heavy girder bridge across the River Avon at Bath. The bridge which will carry a load of 80 tons has a span of 112-ft, a double carriageway 19-ft wide and a pathway each side for pedestrians. It was built close to an existing bridge and will relieve traffic congestion which has been aggravated by flood damage to the old bridge last December. The new bridge has been appropriately named The Wessex Bridge, and it is expected to be in use for at least eighteen months.

504 and 915 Companies RASC (TA) brought the bridging equipment to the site from the Engineer Stores Depot at Swindon.



(By kind permission of P. A. Reuter (Photos) Ltd.)

Launching the Wessex Bridge

The Corps will present to Coventry Cathedral a wrought iron grille, made to the design of Sir Basil Spence, which will divide the Chapel of Christ in Gethsemane from the rest of the Cathedral. The grille will be made by tradesmen at the School of Military Engineering, Chatham.

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The Corps has presented to the Canadian Army Headquarters Officers' Mess a copy of a portrait of Colonel Sir Percy Girouard, KCMG, DSO. Girouard was a graduate of the Royal Military College, Kingston, Canada and he was commissioned into the Royal Engineers in 1888. He served with distinction under Kitchener in the Sudan Campaign as Director of Railways. He later became President of the Egyptian State Railways and Alexandria Harbour while still a Subaltern aged 31. He was recalled to serve as Director of Railways during the South African War and remained in South Africa after the war as Commissioner of Railways. He later became Governor and C-in-C Nigeria, to be followed by the appointment of Governor and C-in-C East Africa Protectorate. In 1912 he joined the Board of Armstrongs as Managing Director and during the 1914/18 War he was recalled to serve as Director of the War Office Munitions Department with the local rank of Major-General.

The presentation has been acknowledged with the greatest pleasure by the Mess and letters of appreciation have been received from the Chief Engineer and officers of the Corps of Royal Canadian Engineers and from the Military Engineer Association of Canada.

Launching the Wessex Bridge

Major B. H. Brown, MBE, ARCM, our Director of Music since 1958, is to be congratulated on promotion to Lieut-Colonel as Chief Instructor at the Royal Military School of Music, Kneller Hall, the most coveted post amongst Directors of Music.

The Corps has not been backward in another of the gentler arts, namely acting; the RE Theatre Club, Aldershot produced the winning play at the Army Drama Festival of 1961. The play, a comedy called *Haul for the Shore*, was presented before the Secretary of State for War at The Scala Theatre, London on 1 May 1961.

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Lance Corporal C. A. Dennis, Royal Australian Engineers, won the 1960 Queen's Medal and clasp as Champion Shot of the Australian Military Forces.

Reopening of the R.E. Museum, Chatham

THE Royal Engineers' Museum, Chatham, which has been closed for almost two years due to the modernization of the North Block in Brompton Barracks was reopened by Lieut-General Sir Richard Goodbody, KBE, CB, DSO, the Adjutant-General to the Forces on Thursday, 20 April 1961.

He was met at the Memorial Arch entrance to Brompton Barracks by Major-General Sir Douglas Campbell, KBE, CB, DSO, MC, President of the Institution of Royal Engineers, and inspected a Guard of Honour mounted by 12 SME Regiment, commanded by Lieutenant J. L. M. Modley, RE. After a short reopening ceremony the Adjutant-General signed the new visitors' book and walked round the museum. He took tea in the Headquarters Mess afterwards. The Royal Engineers Band was on parade with the Guard of Honour and later played a selection of light music on the barrack square.

Many officers and their wives and families were present and amongst the official guests were the President and Secretary of the Royal Artillery Institution and representatives from other Regimental and Corps Institutions, the Director of the National Army Museum and the Curators of other service and civilian museums, Brigadier R. G. Thurburn, CB, CBE representing the Ogilby Trust, representatives from the Royal Navy at Chatham the Mayor of Gillingham and Canadian and French Liaison Officers and the President of the London Post of the Society of American Engineers. Major-General C. H. Foulkes, CB, CMG, DSO, the father of the present Engineer-in-Chief, also attended. He commanded the Special (Gas) Brigade RE during the 1914-18 War and surviving members of this Brigade have recently presented to the RE Museum, Chatham a most interesting collection of items, photographs and documents dealing with this special branch of Sapper activity during the First World War.

It was perhaps appropriate that General Goodbody, a Gunner, should reopen the museum since one of its top roots springs from the small museum, started in 1839, at Woolwich which was then the depot of the Royal Sappers and Miners. When the Royal Sappers and Miners were incorporated into the

The Adjutant-General to the Forces, Lieut-General Sir Richard Goodbody, KBE, CB, DSO, delivering his reopening speech.

Reopening of the RE Museum, Chatham

Corps of Royal Engineers in 1856 the museum at Woolwich was transferred to Chatham and amalgamated with a "Model Room" of engineer equipment that had been started in 1812 by Major Pasley, the originator of the present SME. In 1875 the Institute (later renamed Institution) of Royal Engineers assumed responsibility for managing the museum which now houses so many cherished Sapper personal relics and trophies of war.

In its spotless, redecorated and modernized premises our museum is indeed one of which we may be justly proud.

Joint Professional Meeting with the Institution of Civil Engineers

THE first Joint Professional Meeting of the Institutions of Royal Engineers and Civil Engineers was held at the London Headquarters of the Institution of Civil Engineers on the evening of Thursday, 2 February 1961 at which a paper entitled "Engineer Support to the Christmas Island Nuclear Tests of 1958" by Brigadier R. B. Muir, CBE, BSc, MICE, AMI Mech E, AMIEE, AMI Struct E, MBIM, was presented and discussed. Brigadier Muir's paper was published in the December 1960 edition of the *Royal Engineers Journal*.

Sir George McNaughton, who occupied the Chair at the commencement of the Meeting, said that he was taking the place of the President, Sir Herbert Manzoni, who had asked him to say how sorry he was that he was unable to be present on such an important occasion as this the first Joint Meeting of the Institution of Civil Engineers and the Institution of Royal Engineers; Sir Herbert hoped that there would be many similar meetings in the future; he had only missed this Inaugural Meeting because of a previous engagement. Major-General Sir Douglas Campbell, the President in the Institution of Royal Engineers, was present, and he had much pleasure in asking him to take the chair for the rest of the evening.

Major-General Sir Douglas Campbell, on taking the chair, said that it was his privilege to thank Sir George for allowing the members of the Institution of Royal Engineers to take part in this Joint Meeting of the two Institutions, and he called upon Brigadier Muir to present his paper.

Brigadier Muir, with the aid of a series of lantern slides, described the main problems that faced him as Chief Engineer during the series of nuclear tests carried out at Christmas Island in the mid-Pacific Ocean in 1958.

At the conclusion of his presentation the Chairman thanked him for the great trouble he had taken to prepare his paper and for the interesting manner in which he had introduced it.

Colonel R. O. H. Carver, OBE, in opening the discussion, said that when he took over from Brigadier Muir as Chief Engineer at Christmas Island towards the end of 1958 a further programme of tests existed. As a result of international discussions at Geneva, however, the tests were postponed and eventually abandoned. This uncertainty had its effects on the "Sapper tasks" on the island. There were conflicting requirements between the three Services and the scientists, and the sum total of these greatly exceeded the Royal Engineer potential on the island. A compromise programme was, however, produced. Nevertheless, the programme had to be kept flexible to meet unforeseen changes. The tasks carried out during his time on the island were similar to those described by Brigadier Muir and included, in addition, the resurfacing of the main airfields, the construction of a fully instrumented reinforced concrete control tower for the airfield and the construction of a 125-ton slipway for the Navy. However, for the Sapper it was a year of pretty continuous hard work, with very few diversions beyond sport and games such as the island could provide. One welcome change was provided by a visit of His Royal Highness the Duke of Edinburgh in the spring of 1959 on his way across the Pacific in the Royal yacht. He went all round the island and spent two days there, taking a great interest in all that was going on.

Colonel Carver went on to say that there are very few military projects that do not suffer some kind of change due to alteration in military policy or political policy, or in this case scientific policy, and it is always essential to keep a balanced programme. This uncertainty of the future, however, inevitably militates against complete efficiency. For instance, in the construction of a hutted camp it was not always possible to lay down all the drains and ancillary services before some roads and huts had to be taken into use. Another factor, particularly applicable to Christmas Island, was the long time it took to obtain stores and the need to make the maximum use of the stores which had been sent out to the island at great expense. When changes took place, as they did very often, the Sappers had to improvise. However, that was an art in which the Sapper due to long practice excells.

He also drew attention to some of the advantages of projects of certain types being given to the Army to control, either using military labour, local labour or a mixture of the two. The first major advantage was that military control was more flexible than major contract work and, as he had already mentioned, in most military projects flexibility was essential. Military labour was essentially flexible because the Sapper is a "jack of all trades" and at a few hours' notice he can be switched from road making to putting up huts or digging drains; military labour, being under discipline, it was not subject to local political trouble, or should not be, and, contrary to some perhaps popular belief, soldiers will work long hours when properly led without the payment of large sums in overtime. Lastly, security is made easier. Against these advantages have to be set the expense of troop movement to some foreign theatre and the provision of accommodation and amenities. When all these factors are taken into account, it often turns out to be more expensive to carry out a project with military labour but he wondered whether, in fact, that was often a true appraisal when political uncertainties are given their full assessment.

However, whatever the financial outcome might be, or the financial considerations, he was quite sure that unless the Corps receive more projects like the very fine one on Christmas Island, they would be unprepared when the time came, to take charge of some of the enormous engineering projects they will have to face in a future war.

Mr G. L. Hargreaves, Deputy Director Naval Works, the Admiralty, explained that his interest in Christmas Island was primarily due to his having changed jobs with a colleague who was the engineer who visited Christmas

Island on occasions to consult with Brigadier Muir on port works. He, therefore, wished to present one or two pieces of information about the port works and to ask some questions. The "port" was on flagoon containing quite deep-water but with a very shallow entrance channel. The beginning of the exercise was shrouded in very deep security, and although they were responsible in the Admiralty for carrying out the dredging and advising on the port works, they sent out a dredger under the impression that they were going to dredge silt out of the channel that used to exist. Unfortunately, when the plant arrived it was very soon found that they could not get anywhere near the depth required without going well into coral, and by a very ingenious RN/RE combined operation a rock breaker was improvized to deal with the coral too. Photographs had been sent home—in case no one believed them—of the enormous pieces of coral that were dug up by the grab also, inadvertently, a picture of one of the large sharks. During the course of the operations the entrance channel suddenly began to silt up very rapidly, to a much greater extent than could be handled by the dredger, and his colleague on going out there, discovered that the sea had started to eat away a cliff a little further round the coast and was very rapidly depositing all the risings in the entrance channel. He did not find this out at once but carried out a number of investigations to ascertain where the silt was coming from, in the course of which he painted lumps of coral different colours and kept them under observation. One peculiar thing happened: the red coral and the blue coral could be traced and followed but the silver or aluminium coral vanished completely. This had given him a lot of food for thought until it was discovered that the silver lumps were being picked up by ratings and sent home to their families and girl friends as unique specimens. However, the groynes were quite successful, as Brigadier Muir had indicated on his slides.

It might be of interest to know how Security worked in the early stages of the operation and again he would be interested to hear whether the same thing applied at Brigadier Muir's end. He was at the Nore and received very highly classified instructions, saying that they were to prepare at once a dredger suitable for working in silt which was to be despatched by heavy lift ship, complete with hoppers, to work in the tropics, together with spares and equipment to keep it going for a year. They were also to get volunteers to man this dredger. They were not told where the dredger was to go to, and the officer who was giving him his instructions said "We do not know ourselves". Fortunately for his curiosity, he had seen a paper which gave a very clear indication in detail of what the exercise was for and where it was to be carried out.

Coming back to the business in hand, it was very evident that tremendous quantities of material would be taken through the port, and he was surprised that the port did not appear to have received the planning attention which went into the very extensive works that were carried out all over the island. He would be interested to know whether the requirement for port facilities was investigated by the reconnaissance party and what their findings were.

It did seem to him that they might have provided better facilities had the need been appreciated. He thought that Brigadier Muir in his paper had already stated that the proper question to ask was, "What do you want to do?" and not "What do you want?"

There was a second point that might interest members. The Americans when they occupied the island had used a deep water quay and presumably quite a deep channel. It would be of interest, he felt, to know the grounds on which it was decided to go only for a shallow water port when a deeper port had obviously been available only a few years back.

As a personal matter he would very much like to meet any of the Sapper officers, if any were present, who were among the last to leave the island in order to obtain information from them as to what might happen should any further works be needed in relation to port facilities, as he would be concerned with that.

He had been very interested in the fresh water table as he had several times had to deal with water supplies where the fresh water floated on the salt. Would it be possible to give further information about the works that were carried out to obtain fresh water, and the length and depth of the trenches and the amount of draw-down that was permitted and the yield and salinity?

Lieut-Colonel R. L. Clutterbuck, OBE, RE who had commanded 38 Corps Engineer Regiment under Brigadier Muir in 1958, said that they had a working strength of 1,200 men, with 40 officers and 270 pieces of plant. A very wide variety of tasks had been carried out. A road had been built at the rate of a mile a day, and a large airfield, and a lot of masts and shelters and laboratories, and also a sewerage system and two or three fair-sized power stations. He had recently given a talk on this subject to the York Engineering Society and was asked how on earth they were ever trained to carry out such a variety of tasks. It might be interesting if he were to answer that very question. First of all, the great majority of the RE officers were given a University education. They took an engineering degree at Cambridge or elsewhere. The second pillar in the system was that every Sapper had a trade, and those who were trained as field engineers were also now trained in a second trade—carpenter, plumber, electrician, or whatever it might be. That meant that in a troop of twenty to thirty men they would get a great variety of men all trained in some trade, and when that troop was working on something in which that trade was paramount that tradesman would be the *prima ballerina* and the others would all be the *corps de ballet*. For example, in building a power station, he recalled that a single troop had done this from start to finish, with the assistant only in the closing stages of a Clerk of Works when it came to installing the switchgear. At the start of the job, when they were building the dwarf walls, the bricklayers were paramount and all the others assisted them. Then when the steel erectors were at work the carpenters and everybody else carried their materials for them. Then the carpenters in turn humped the pipes around for the plumbers, and the plumbers and carpenters joined hands fixing the cables and manoeuvring the generators while the electricians installed them. Luckily for them they had no Trade Unions to worry them, and this was a great advantage. That was their basic training for taking on jobs like this. They had to take it very seriously now because in the cold war—the war of today and of recent years—the job of suddenly going to a desert island and maintaining 4,000 men, and doing all sorts of mysterious and complicated things with unusual equipment, was just a very typical cold war task. Christmas Island had, therefore, been a very fine training indeed for his Regiment. They required, however, more practice at similar tasks. Since the Regiment had returned from Christmas Island they had been very lucky in being given a road to build in Northumberland and a pre-stressed reinforced concrete bridge. They had also built a large bridge for the Forestry

Commission in Northumberland. Such tasks were well worth while from their point of view, and also from the taxpayers' point of view, if they were for some public authority. The Forestry Commission job probably saved the taxpayer £17,000.

The Regiment cost about £10,000 a week to exist, therefore it was worth using it if useful work could possibly be found for it. If the Regiment were given regular work of this sort the experience would be invaluable, and he wished to end by requesting that anyone present in a position to place work in the United Kingdom with the Royal Engineers unit of Strategic Reserve should do so.

Major E. J. Sharpe, RE said that he had been invited to describe the construction of the slipway but before doing so he wished to explain the need for its construction. The entrance to the port was through a gap in the fringing reef. The channel was narrow and shallow and could only be used by small craft. The supply ships moored outside the reef and their cargoes were ferried to the wharf. A great deal of maintenance had to be done on these small craft because of the climatic conditions. Before the slipway was constructed the smaller craft were hoisted on to the decks of visiting freighters and the larger craft were towed 1,200 miles to Honolulu. To ease this situation it was decided that a slipway should be constructed at the port.

To describe the slipway briefly, its length was 380 ft, with 240-ft of underwater work. It had a slope of 1 in 16. The piers were of mass concrete 3 by 3-ft in section, and positioned in pairs at 10-ft centres. Rails bolted to RSJs were clamped to inverted channels and these in turn secured to the concrete piers. A winch with a 10-ton pull was mounted on a concrete block at the top of the slipway, and there was a downhaul anchorage at the bottom. The slipway was designed to take 125-ton lighters as a maximum load. It was a simple, straightforward job which appealed to the Sappers, most of whom liked to think they have webbed feet. The Troop who carried out the task were never able to deploy more than about fifteen men on the job as they had three other tasks to carry out at the same time. He, therefore, made the Troop Commander officer-in-charge of the working party, and his Squadron Second-in-Command was made officer-in-charge of the work. This was not really analogous with civil practice but it had many advantages in this case.

The officer-in-charge of the work was responsible for progressing the work, forward provision of stores, plant, materials, and in particular the concrete which came from the Squadron central batching plant. At a later stage he also planned the work of the divers.

The officer-in-charge of the working party arranged for the right tradesmen to be present, and supervised the positioning of the formwork for the concrete. This was then checked by the officer-in-charge of the work before concrete pouring commenced.

Generally speaking in the Corps they did not, in his opinion, have men who were comparable in experience with the joiner charge hands, blackgang bosses, etc., who were found on civil works undertaken outside the Service. There was no one who could bring a fund of practical experience to a job to assist the site engineer, and this meant that officers were concerned a great deal with details of placing formwork, strutting, fixing steel, etc., although this was to a large extent offset by the initiative of the NCOs, who learned very quickly.

The construction work was largely routine, but he wished to mention a few points of minor interest. The winch block was constructed in mass concrete 3-ft 6-in long, holding-down bolts for the winch, etc, and had to be started in three successive lifts. They had to protrude unequal heights from the top of the concrete to allow for the varying thickness and positioning of base plates, snatch-block anchorages, etc. The bolts were welded to a heavy framework in their relative positions, the whole was then surveyed and grouted into position, and the concrete lifts were then poured without any disturbance taking place. Forming the winch block was especially interesting for those Sappers who had previously been unfamiliar with concrete work.

In the underwater excavation for pier footings setting-out frames were used together with aluminium poles for surveying-in the underwater framework. Airlifts, operated by a Pescara compressor, were used to excavate the spoil and these were a great help. It was reported that at times stones of up to $2\frac{1}{2}$-in. in diameter were removed.

For placing concrete underwater it was suggested that colloidal concrete be used, but he had asked to be allowed to use a tremie and was given permission to do so by the Chief Engineer. He was familiar with the latter technique but not so familiar with placing high-grade concrete using a colloidal mixer. No troubles were experienced in this respect. There were two pontoon rafts secured alongside each other, and these were warped into the required position by the Royal Navy. One raft had the diver's equipment and the second had a batcher/mixer, a crane, a compressor, and the aggregate stockpiles.

When they came to the end block they found themselves literally in a hole, and bearing in mind the capacity of their equipment, pouring this block was a marathon task: it took the diving and concrete teams 17 hours.

In conclusion, he wished to state that from the Sapper point of view the slipway was extremely well designed by the Admiralty's Engineer-in-Chief's department. All the steelwork clipped together with great ease. He wished also to mention the divers, who, together with their experienced supervisor, worked exceptionally hard and contributed very greatly to the task of constructing the slipway.

Mr Morris T. Shaw, Chief Engineer (Civil and Structural) of the War Department Works Organization, explained that he was present in three capacities. First of all as a very good friend of Brigadier Muir, secondly as a Member of the Institution of Royal Engineers, and thirdly as a Member of the Institution of Civil Engineers. He had very much appreciated and enjoyed listening to the discussion, particularly to the introduction, and he was quite sure that the work on Christmas Island was a "natural" for Sappers.

He wished to refer to two points only in the paper, the first being where the author stated: "The recent introduction into the Army of the Civilian Works Organization has accentuated the problem of giving adequate experience in peace time to RE officers and NCOs on the type of civil engineering work the Sappers are required to execute in war."

As the Chief Engineer (Civil and Structural) of the new organization he appreciated this very much, and wished to state that they welcomed the Sapper personnel into their organization and tried to give them that sort of experience which would fit them for their tasks in war.

Again, Brigadier Muir had mentioned "backing in planning potential" as being necessary for the Engineer units. He regretted that the author had not enlarged on that remark. He well remembered, as he was in the DFW organization in a civilian capacity, that Operation Crapple had caused quite a flutter in the dovecote, and he thought that the Brigadier might have gone on to say that the civilian professional branches gave some very good help in the planning. The execution was purely a Sapper job, but in the planning effort the architects, the construction engineers and particularly the mechanical engineers, gave a very great deal of help. The latter were concerned with refrigeration, pipe-lines and water and electric light. They also produced the stores lists, which contained over 92,000 items, and they had tried to take short cuts and cut red tape by going to the Director of Army Contracts with their scissors, cutting the tape and getting things on time to meet the target dates.

In conclusion he wished to ask whether, on the coral mound, the laboratory had taken any CBR tests and, if so, what they were.

Lieut-Colonel J. D. Edgar, RE, Chief Instructor, Civil Engineering School, the School of Military Engineering, Chatham, said his remarks were addressed primarily to those present who were outside the Corps of Royal Engineers.

In the first place he wished to emphasize the point made by Brigadier Muir, for the need for co-operation between the Corps and the Civil Engineering profession, of which this meeting was a new and most encouraging sign.

He was extremely fortunate in holding the appointment of Chief Instructor of the Civil Engineering School at the School of Military Engineering, Chatham, and as such the undoubted plum of his responsibilities was the technical control of the RE officers who went every year on attachment to Civil Engineering Contractors and Consultants as part of their long civil engineering course. Part of the stated object of this course was "to give Regular RE officers advanced training in large scale engineering works in order to broaden their outlook and enable them to gain the knowledge and experience necessary for the initiation and control of major engineering projects in peace and war."

One very valuable by-product of the course was the link it provided between the Corps and the Civil Engineering Industry. During their attachments officers had to submit monthly reports on the work they had been doing with particular emphasis on problems encountered, new techniques, materials or pieces of plant met with on the site, and, generally speaking, anything of engineering interest or significance, all absolutely priceless in enabling them at the SME to keep abreast of modern practice.

Another by-product was that it enabled RE officers to qualify for their Associate Membership of the Institution of Civil Engineers thanks largely to the co-operation of the consulting firms who ensured that, during the all too short period of seven months that officers spent with them, they were given design work suitable for the professional interview. Needless to say, without a large nucleus of professionally qualified officers in the Corps they had no right to call themselves a Corps of "Engineers". As a small return for all this it was their great pleasure to entertain every year to a dinner at their Headquarter Mess at Chatham some fifty or so senior representatives of Consulting and Contracting firms, which further fostered this valuable association.

They intended during the coming summer to ask for still further co-operation from their civilian friends in the profession. In June for the first time the Civil Engineering School was running a new three week course, to be held annually in the spring or early summer, called an Engineer Planning Course, for the benefit of senior Sapper majors and above of both the Regular and Territorial Army and the Army Emergency Reserve. The course would be split into two halves, the first dealing with the detailed engineer planning required in connexion with a small "bush-fire" type of war upon which they might well be engaged at any time. The second half would deal with the broad planning of much larger scale works which any senior Sapper officer might be faced with at some time in his career—such things as large refugee camps accommodating perhaps 50,000 people, an emergency 9,000-ft runway for heavy transport aircraft, the development of a small port to increase its capacity five-fold in a hurry, and such like projects. Throughout the course they intended to invite various eminent engineers both on the contracting and consulting sides and from other spheres to come and talk to the Course on different aspects of planning the design and execution of large-scale civil works. Perhaps half a day would be spent visiting a large project in the neighbourhood, such as the new Medway bridge, at which the agent would explain how the construction had been planned. All this would be something new and, they hoped, would help to broaden the outlook of the military Sapper officer and help him, to quote Brigadier Muir, "to maintain his professional engineering standards at a level comparable with civilian life."

The Engineer Planning Course would also be a logical follow-up to the long Civil Engineering Course which, as he had said before, was partly intended to enable Sapper officers to gain the knowledge and experience necessary for the initiation and control of major engineering projects in peace and war. It was, of course, not possible for the long Civil Engineering Course by itself to achieve this somewhat ambitious aim. The Course was a very necessary preliminary to its attainment but could not be considered sufficient. Officer students generally only saw their particular project from the site engineer's point of view and could not learn much about the initial planning and over-all control of the project, particularly if it was a large one. They hoped that the new Engineer Planning Course would go some small way towards remedying this deficiency with, as he said, the help and co-operation of the heads of the civil engineering profession.

Brigadier H. A. T. Jarrett-Kerr, OBE, BA, Deputy Director, Military Engineering Experimental Establishment, Christchurch, in congratulating Brigadier Muir on his most interesting paper and for the way in which he had presented it, said that it was not often that the Corps had tasks such as this in time of peace, and it was, therefore, all the more valuable that the lessons learned from such an operation should be fully publicised and absorbed by Sapper officers.

In view of the importance of equipment in relation to Engineer effort, and as equipment was his particular interest, he wished to ask Brigadier Muir one or two questions. The first was: if he had had wheeled tractors available would he have used a higher proportion of them than tracked tractors? This was quite a relevant question in the Corps today, and perhaps in his particular case on Christmas Island, since most of the earth-moving operations were not on widespread tasks, it might have been that there was not so great a need for wheeled tractors to travel great distances, and so the advantages of the wheeled tractors might not have been so important.

His next question was: since one of the important lessons learned by the Americans in that part of the world during the war in the Pacific was that the prime importance of adequate packaging of equipment could not be over-emphasised, had Brigadier Muir anything to add to his paper to underline this subject from his own experience? No doubt, due to the urgency of the operation and the haste with which equipment had to be ordered and shipped, it was not possible to undertake all the packaging and anti-corrosion measures which might have been done had there been more time, but those would clearly have reduced the maintenance commitment to which the author had referred.

In view of the difficulties of training mentioned by Brigadier Muir and the need to train the majority of operators on the job in specific tasks, had he anything to add regarding the need for simplicity of equipment, and in particular the value of automatic control of plant as compared with manual control? The automatic control might well be more difficult under corrosive conditions.

Reference was made to concrete mixing and he wondered whether plant of the Howard type was used or whether it would have been found better in the particular circumstances to use normal concrete mixers rather than mix-in-place methods, so as to reduce the training commitment with specialized plant.

With regard to the problem of the prevalence of dust, which was mentioned in one place, this was something of which they were conscious at the Establishment, and they had been encouraging the development of the dry filter and the King filter, of which they had great hopes for the future.

With regard to the need for new types of plant to have adequate performance tests before shipping, it was very necessary for time to be made available for this to be done, even if it cost money. It was something that should be insisted upon, and was well worth-while in order to save maintenance troubles on the site.

Mr Hoare, Superintending Engineer, War Department Works Organization, congratulated the author on his interesting paper, which showed how adaptable the Sapper continued to be and he, was sure, would continue to be in the future. He wished, however, to ask one or two technical questions relating to the V-bomber air strip. Could the author say whether any precautions were necessary to keep the lagoon mud sub-base at optimum moisture content before the blacktop was laid? Also, as the runway construction was extremely light for V-bomber use, could he have the grading used for the 1-in wearing course?

The author mentioned that in this project he was in fact engineer and contractor combined. A little later on he also admitted having substantial financial latitude. He was sure, therefore, that he must have had the best job in the world, if in fact he was Engineer, Contractor and Command Secretary rolled into one.

Major T. W. Tinsley, RE said that the word "money" had been mentioned. This commodity was very seldom mentioned in the paper, probably for very good reasons, but in a civil paper it would, of course, be of fairly paramount importance. In fact, it seemed that in this case it was not money that was involved but statistics of manpower.

Brigadier Muir had mentioned that the Americans used the civil contract system at Einweitok, and he wondered if Brigadier Muir knew how his efforts compared with the troubles and difficulties—if they had them—at the other place. That brought him to the business of statistics, works study to analyse work and the effort involved and the production of "yardsticks" for planning. All planning, without good statistics, was very much guess-work. Most statistics only went half-way and did not tell the whole story. Three men went to mow a meadow but nobody knew how big it was or whether it was mechanically mowed.

Major D. H. McLellan, RE, lately commanding the RE Transportation Troop, Christmas Island, stated that he felt rather a stranger since he was the one Sapper on the island who was not directly involved in the civil engineering work. He was the envy of the Royal Navy; they said that, as the one soldier present amongst them, he spent more time at sea than they did. He was involved at the end of 12,000 miles of sea lines of communication and had under his command some fifty stevedores.

Questions had been asked about the equipment used on Christmas Island, and he wished to stress one particular point which came to his mind as a stevedore. The 270 pieces of plant and engineering equipment, some of it of considerable size and weight, all arrived by sea. Most civil engineers expect to find their equipment arriving in a horizontal direction. As a stevedore, however, he had had to move equipment in a vertical direction out of the hold of a ship and although some makers very conveniently placed their plant on wheels, in no case at all had they indicated anywhere where the centre of gravity was. He considered that it would be well worth-while for contractors who provided plant on an occasion such as this, where the stevedores available were unused to handling large pieces of equipment, to take a little extra care, or spend a little extra money, in providing something clearly indicating where and how the item of plant be lifted, in order to save the very considerable amount of money spent through damage arising in lifting equipment the wrong way.

As a case in point he would mention the automatic control gear which was provided on the Parker plant. Due to an error of calculation on his part—and he took the full blame—it did not come up level; a piece of the steel wire rope with which he was lifting it came between the control gear and the main piece of the equipment and took it off. That had had to be replaced at a freight cost of £1 per lb from the United Kingdom. In that case he had cost the Government a very considerable amount of money, and although he took the blame he felt that the responsibility might be placed elsewhere. The same was true of many other pieces of equipment sent out to the island. There was a requirement for moving bulldozers to Malden Island which they had heard mentioned in Brigadier Muir's paper. Normally to lift a bulldozer something was put underneath it. The Royal Marines doing this job said they could not manage it because the swell at Malden Island did not allow them to work down alongside the plant inside an LCM. All the lifting points had to be on top. He could not find anybody on the island who could tell him whether or not this particular piece of plant was safe to lift in the way he did lift it, and again there was no indication of how it should be done.

In winding up the discussion General Sir Kenneth Crawford, KBE, MC, the Chief Royal Engineer, said how very glad he was to be present on such an historic occasion, the first on which the Institution of Royal Engineers had combined with the Institution of Civil Engineers in a Joint Professional Meeting. It was a great thing for the Corps to have been associated so closely with the Institution of Civil Engineers whom he thanked for so kindly making available all the necessary arrangements for the meeting which he hoped would be the forerunner of other similar activities.

Brigadier Muir, in reply, expressed his appreciation of the generous response to his paper. He wished to thank Colonel Carver, Colonel Clutterbuck, and Major Sharpe for developing the story, and endorsed the remarks made on the basic need for the Sapper officer to be prepared always to improvise.

He was grateful, too, to Mr Morris Shaw for drawing his attention to an omission. He was sorry he had not elaborated more in his paper on the assistance received by the RE Planning Team. This team would be the first to acknowledge the co-operation and invaluable help they received from Mr Shaw and his civil and structural engineering staff. In this connexion he would also like to mention the engineering staff of AWRE at Aldermaston whose assistance he had much pleasure in acknowledging.

Mr Shaw had asked about CBR tests. When he was considering whether the runway of the main airfield would stand up to operations a number of test holes were dug and examined. This established the CBR value of the sub-grade to be of the order of 30, and the base of the runway varied from 31 to 47. In the new airfield which was built for V-bombers the CBR tests on completion of the formation averaged about 70, and figures as high as 140 were recorded. In the compaction of coral mud, the CBR value rises very steeply indeed as the optimum moisture content is approached. Values at 90 per cent optimum moisture content can be as low as one-third of the maximum CBR value attainable.

Mr Hargreaves had made some interesting remarks on the development of the port, for which he was grateful. He agreed with him that there were certain security restrictions and requirements which could have been rather a nuisance, but he was sure that Mr Hargreaves appreciated the reason. They had looked very longingly at various schemes, in conjunction with the Admiralty civil engineers, on the possibility of developing the deep water port, but in terms of the effort involved it just was not possible, bearing in mind the price they were paying for the comparatively small force to be maintained on the island. Apart from the fact that there was not an unlimited number of men to call upon it was important not to bring one single unessential additional man on to the island because of the expensive administrative backing that he required. It was, therefore, a question of priority and economy that they did not proceed with port development, though at the same time they looked at it very longingly.

The trenches scooped were about 200 ft in length, often running criss-cross, and were 12 ft wide at the top, with the depth of water averaging 4–5ft with 8 ft maximum. The trenches were covered over with hessian to reduce the growth of algai and evaporation losses. The depth of the fresh water layer averaged from 3–4 ft down to as little as a few inches. The rate of extraction had to be controlled strictly to avoid lowering the local water table to the extent that intruding saline water would disturb the fresh water layer. The salinity averaged fifty parts in a million and was never more than 250.

Brigadier Jarrett-Kerr had asked a sixty-four-dollar question on wheeled versus tracked tractors. From a purely Christmas Island aspect he would not have looked kindly on wheeled tractors as the requirement called for maximum power. As was brought out in his paper, a great deal of attention had been paid to packaging, particularly from the point of view of limiting the weight and size of individual bundles and ensuring that these were protected adequately for handling and against climatic effects. Corrosion of steelwork, protected to UK standards, could be quite frightening and the experience emphasised the desirability of having steelwork hot dipped galvanized before its despatch to the island. He agreed with Brigadier Jarrett-Kerr's remarks on the desirability of simplicity of equipment and plant and, for the same reason, did not go entirely with him on the question of automatic control which he considered sacrified simplicity. Because the amount of mix-in-place work involved on target and bomb line indicators was relatively small, the importation of the Howard plant would not have been justified. For concrete work weigh batching was used extensively.

Mr Hoare had asked the question whether any difficulty had been experienced in lagoon mud drying out before they had finished working on it. The reverse was, in fact, the case. This lagoon mud which, for good quality construction, was won entirely from below the water table, was compacted first with wobbly-wheel rollers. Subsequently, it had usually to be left for 24 hours to allow it to dry out to a moisture content of about 15 per cent before the final rolling with smooth wheel rollers could take place.

He had to take him up on his very reasonable point which suggested that he acted also as a Command Secretary. This was not, in fact, so. To some extent Major Tinsley had given an answer in saying that it was not always entirely a question of hard cash except in Honolulu where there was a definite limitation—he was, of course, referring to the local purchase of engineer stores. It was a matter of making the best use of the stores that were available on the island at the time. If a category of store in short supply was used today when a substitute available store might have been equally suitable, then tomorrow a job could be held up for which no store substitution was feasible. It was, therefore, very much a question of balancing out and whatever he did and whatever financial powers he assumed, he had to explain fully all expenditure to the auditors at home.

Mr Hoare had asked also about the 1-in bearing surface for the new V-bomber strip. This was laid to a minimum of 1-in thickness (on 2-in of binder course), and the grading of the mix was as follows:—

BSS Sieve	*per cent passing*	*BSS Sieve*	*per cent passing*
$\frac{1}{2}$-in	85–100	No 25	25–40
$\frac{3}{8}$-in	75–92	No 52	16–30
$\frac{3}{16}$-in	60–75	No 100	12–22
No 7	50–65	No 200	7–14
No 14	35–50		

The bitumen content was 7.5–8 per cent by weight and a cement filler of 7.5 per cent was added because of the scarcity of quarry fines passing the 200 sieve.

Major MacLellan had made a sound suggestion on the question of suitable markings on engineering plant for transport by ship.

In closing he wished to take the opportunity of paying a very well deserved compliment to all the officers and other ranks of the Royal Engineers for the magnificent work they did on Christmas Island. As far as the officers were concerned, he could not have been better served; in fact, their high calibre was in complete contrast to that young officer whose Commanding Officer cast grave doubts, in his confidential report, on his powers of leadership when he wrote: "I cannot conceive any circumstances in which men would follow this officer—except out of a sense of curiosity."

In conclusion, he wished to thank General Campbell for so kindly taking the chair.

The Chairman, General Sir Douglas Campbell, in closing the meeting, paid a very warm tribute to the Institution of Civil Engineers for inviting the Institution of Royal Engineers to join them, and said how sorry they were that the President (Sir Herbert Manzoni) had been unable to be present. He wished to thank Sir George McNaughton for taking the chair at the opening of the meeting and for the very kind remarks he had made about them.

Our First Line Reserves

By Major B. C. Prout-Richardson, RE

Most sapper officers know something about the Territorial Army either through having served with it at some time in their careers, or through meeting TA officers. Officers who have been lucky enough to have experienced the former will know what a valuable experience it is to serve with those sometimes known as "Amateur Soldiers". They will also know how the machine ticks, what type of men these territorials are, what their role and capabilities are and how they are organized. By contrast, how many officers know anything about the Army Emergency Reserve: the "First Line Reserve". It is suggested that many officers know very little and there may even be some who hardly know of its existence. In any future limited war campaign, regular sapper officers are liable to find themselves serving with, or alongside, AER RE units and it is, therefore, incumbent upon them to know about this First Line Reserve. This article has been written to help in this respect.

Background

On 6 February 1961 Mr Profumo, the War Minister, announced to the House of Commons a reorganization plan for the Army Emergency Reserve. The scheme was planned in conjunction with, and logically followed, the reorganization of the Regular and Territorial Armies which is now in progress.

The Army Emergency Reserve was formed in 1951 from the old Supplementary Reserve to support the Regular Army order of battle. Units were kept up to strength by large number of ex-national service soldiers who had completed their full time service. From 1957 national service reservists were no longer called upon to carry out peace time training and AER units were thus left with only a small hard core of volunteers to carry on. In fact, units became unbalanced and interesting training became very difficult. The role of the Reserve Armies was also changing in the same way as the role of the Regular Army. It was, therefore, decided that reorganization was necessary to bring them in line with current requirements.

Role and Liabilities

The Army Emergency Reserve is part of the first class of the Army Reserve. When members of the reserve are called out for service they will be treated in all respects as members of the Regular Forces. Its main object is to provide the specialist knowledge which is necessary to support the Regular Army in various types of warfare. Because of this requirement AER units are of a technical nature and include:—

RE (Field and Works), RE (Transportation and Movement Control), RE (Bomb Disposal), RE (Postal), RE (Survey), R Sigs, RASC, RAMC, RAOC, REME, RMP, RAPC, Intelligence Corps, RPC and some others.

Category I is an ancillary force to the Regular Army. To be able to support the Regular Army in any limited war operation its members accept the liability for permanent service overseas without the issue of a Proclamation by the Government. It has a training obligation in peace of fifteen days annual camp plus sixteen out of camp training periods of one hour each.

Category II is now reduced to those units and pools required at home and overseas on general mobilization and which cannot for various reasons be raised in the Territorial Army. Section A of this category has a training obligation of fifteen days annual camp only. Section B does no training in peace.

Category III consists of special classes of entrant who provide a pool of highly skilled technicians required by units of the Regular and Reserve Armies on General Mobilization.

AER units are mainly administrative and tend as a result to recruit specialists and tradesmen who are able to devote only limited time to training. This limitation is acceptable because the military and civilian technical employment of such reservists is similar. In this respect the type of individual in AER units tends to differ from that in the TA.

A sapper volunteering for Category I can earn approximately £100 a year. This may sound a considerable amount of money for such a limited amount of training. It must, however, be realized that the liability for immediate call up without proclamation is a very serious commitment and may well interfere with businesses, careers and domestic arrangements.

Regionalization

Unlike the TA, an AER unit has no base or barracks from which it operates and no permanent staff. The personnel are scattered over the whole country and only meet as a complete unit when at annual camp. It may be imagined in some circles that the AER is in competition with the TA but this is far from being the case. An AER member to begin with is a specialist and secondly, because of private commitments or his type of employment, cannot carry out more than a limited amount of training each year, so even if he did not join the AER he would probably not be in a position to devote enough time to fulfil the training and other requirements of the TA. Under the new organization a certain degree of regionalization has been attempted so that Category I units are able to undergo their out-of-camp training together. It is proposed to arrange this training in conjunction with the TA where possible, in order to encourage a regional feeling and use the training facilities and amenities associated with the TA. It is hoped that affiliations between units will provide a measure of corporate existence throughout the year for members of the AER. Recruiting will in the long term be concentrated into smaller recruiting areas. This will enable members of the AER to assembly more easily for Category I out-of-camp training and for social activities. As well as obtaining the benefits of military and social life from such associations it is hoped that AER units will be able to share some of the local interest which has in the past been bestowed upon Regular and TA units. To effect this, close liaison with the TA is necessary and it is hoped that from 1961 onwards the affiliation between the two reserve armies will go from strength to strength.

Quality

One important factor about the AER is that all the accepted volunteers are experts in their own line. For example, if a WOII is filling a Clerk of Works vacancy you can be certain that because of his civilian occupation his technical ability is of a high order. This factor is perhaps more easily brought out by the officers, most of whom are very highly qualified and experienced civilian engineers. During the Port Said operations in 1956 an E & M Squadron was called up to assist in the rehabilitation of the town's services and finished the campaign with a very greatly enhanced reputation. The store of technical knowledge in the AER is very large and right up to date. Although their military training is naturally not of such a high order (how could it be otherwise with only a fortnight's training a year) their military capabilities should never be underrated and could be compared very favourably with the best TA units.

Conclusion

Each branch of the AER is commanded, controlled and administered by its own Headquarters, the Commander in most cases being a Brigadier. Combined with each HQ is a Record Office. Each branch is directly responsible to the appropriate War Office Branch. The recent reorganization was a serious endeavour to put new life into the AER and to bring its roles and formation into line with current thought. A serious effort was also made to put over the idea to the public with considerable success. There is no doubt that there is now a general feeling of expectancy and zest in AER units which augers well for the future. Regular sapper officers in particular have a lot to learn from their AER brother officers and no opportunity should be missed of meeting or serving with them. In particular we should know what to expect of our "First Line Reserve".

As part of the Regular Army, the AER is served by the Regular Army Recruiting Organization. Enlistments are carried out by HQs, AER and by Army Information Offices. Most AER units are short of volunteers and the right type of reservists are urgently required. Since the reorganization was announced recruiting has been very encouraging and if the present trend continues units will be up to strength in the foreseeable future.

Integration of the Armed Forces

By "Monty Mount-Harris"

The year is 1975. The Royal Defence Force was formed five years ago. Basically it was an integration of the existing armed forces with terms of engagement transferred from the old service to the new force. The overriding reason given for its formation was economy, in the light of modern tactics. Now, five years after its birth, a post-mortem is being held to consider whether or not the aim of this new force has been achieved. All the interminable arguments for and against this revolutionary idea are to be revived and re-examined in the light of the past five years' experience. Of course there has been no world nuclear war to provide the ultimate test of the system. Only a few conventional skirmishes of a "police" nature form the experience of today. But this is as was expected when the force was formed. Thus the scene is set, and a distinguished committee of War Chiefs, financial experts, and political paragons sits in Whitehall to consider the verdict. Written in large letters on a plaque before them is the aim of The Royal Defence Force:—

"To provide economically an adequate armed force capable of national defence, and the fulfilment of such tasks as it may be called upon to perform in defence of world peace by the United Nations Organization."

After World War II two main factors dominated the military scene. One was science and the other was politics, both the age old masters of the art of war. This time, however, their effect on the three services was more rapid than ever before. Politics drastically cut the United Kingdom's overseas commitments overnight. Science caused a complete renewal of strategical and tactical thought. The age of the atomic nucleus and electronics had arrived. People talked of "push-button warfare", and the role of the foot soldier, the able seaman, or even the pilot in the future was hard to visualize. More important still, the cost of the production, maintenance, and development of the new weapons and equipments was out of all proportion to anything known in the past. Economy became essential and was first met in the way servicemen had come to expect as inevitable after any war. The "axe" fell, gently but firmly. This, together with the end of conscription, and the amalgamation of various regiments of the army, effected a substantial economy. As long ago as 1958, when these cuts were first mooted, it was freely suggested that the only realistic step would be the integration of the armed forces. World War II had taught that few battles were fought by one service alone. If all campaigns were to be combined operations, then let there be one force to carry them out. And so The Royal Defence Force was eventually born.

Financial economy and efficiency have been the keywords in the formation of this new force. These have been effected by economies in manpower and logistical overheads. Under the old system, with three independent services, there was inevitable duplication. Each service had its own records and pay systems and offices. The training of recruits in the basic essentials of any fighting force was carried out in a number of different depots, involving large staffs all teaching the same thing. Craftsmen and tradesmen, such as carpenters and sheet-metal workers, learnt their crafts in schools pertinent to the arm of their service, in spite of the fact that the knowledge they gained was basically the same for all the services. Such other essentials as the training of clerks and cooks were also carried out in a diversity of centres, as was that truly common trade of "driver". All such duplication is now a thing of the past. The force wears a common uniform, plain and durable, requiring the minimum of upkeep, and, because of the numbers involved, cheap to produce. All the old embellishments have been reduced to the bare essentials. The saving in metal alone has been quoted by the financial experts as a vast figure. A legion of numbered service forms has been reduced to a few hundreds. The accounting system has been overhauled and streamlined. In short, the committee must agree that the force is economical, and logistically efficient.

However happy the financial experts might be with the new system, the war chiefs are still dubious. Theirs is the task of physically ensuring that the force fulfils the aim. They are concerned with the phrase, " . . . adequate armed force capable . . ." Recruiting, morale, and training for war are their watchwords, and they are not happy. In the beginning they organized the force along completely new lines. It was felt that if the old must go the new must bear as little resemblance to the past as possible, or else there would be little point in reorganizing. No longer is a serviceman allied to land, sea, or air. Nowadays his trade determines the branch of the force with which he works. Signallers may be on board a submarine, in an aircraft, or bumping along in a tank. The Electrical and Electronic Engineers Branch is by far the largest arm of the force, and can be found literally everywhere. A member of the Manual Weapons Branch may be one of a routine guard on an aircraft carrier, or he may be on a policing patrol along the Central African border. The Guided Missiles Branch launch their weapons from any convenient platform in any medium. Old titles and ranks have been replaced by new. A man joins the force as a constable, chosen for its meaning of "Officer of the Peace". Through three grades of this rank he progresses to Artificer III and ends as a Grand Artificer. Officers' ranks too have been altered. An officer is first commissioned as a Section Leader and can end as a Branch Commander, a Force Commander, or even a Director of a Branch or the Force as a whole. Only the ranks of Lieutenant and Captain, common to all three of the old services, have been retained for historical reasons. So, the organization is adequate and efficient; but the chiefs know that wars are not won by economy and efficiency alone.

Recruiting figures have dropped considerably. Moreover, the type of recruit is tending to be the man who has been a "rolling stone", or he has no ambition, and seeks only a comparatively easy security. Few look on the force as a vocation. Allied with this, morale as a whole is not to be compared with that of units in the old system, and morale is a battle-winning factor. The reason for this is obvious to the chiefs, but its cure can only be with time. For generations sons in one family have gone to sea with the Royal Navy, whilst in another family they joined the County Regiment, or served the Army as a whole. All that is now a thing of the past. No longer does a regiment parade its colours, nor glory in its past battle honours. Tradition is dead; or rather, it is in the course of being reborn. Things of the soul have been replaced by technology, and the result is not the same. Battles have been won for no more and no less than the glory of the regiment. It had been considered that in this modern age such things had passed, but the war chiefs have always known that wars are won by men, and a man requires self-pride in order to beat his enemy. Service and regimental pride and team spirit had been the keystones of discipline and morale. These have now been removed and only time can rebuild them. The war chiefs must report that morale is low and recruiting is not up to par in numbers or quality, but both these factors should improve as the force gets older.

One other factor deeply concerns the War Chiefs. With the accent now on scientific efficiency a new breed of leaders is being born, technically sound, but, it seems, not tactically so. Even today the old fashioned "Principles of War" are as applicable as they ever were, and a commander in the field must have a flair for their application. This necessitates much time spent in studying the art of war, and young officers cannot devote enough time to this and keep abreast of developments in their own technical fields. Although a commander may have a superiority in weapons, equipment, and men, unless he has the knowledge of how best to apply them, he is unlikely to win the battle. This is a real problem. The War Chiefs report that they could overcome it by the introduction of a separate Staff Branch, similar to the Staff Corps of the German Army in the last World War, but concentrating not only on administration but also on the art of command in battle.

In fact, the War Chiefs have felt all along that the aim of the new force could have been fulfilled by the old system, at very little extra cost, and without losing the "cap-badge" effect on morale and recruiting. To economize, many facets of service life could have been centralized, but the three services should have remained distinct, and maintained their traditions. After all, men from one particular service in the past had often commanded forces made up of all three. The garrison in Aden in 1959 provided an excellent example, working most efficiently. During World War II the three services had worked together efficiently and harmoniously with many common logistical "overheads" pooled. If an adequate force is to be maintained, the War Chiefs feel bound to advocate a return to the old system so that regimental and service traditions can aid morale and recruiting, but that the old system should be renovated. Basic and trade training, common to all three services should be integrated. Furthermore, this would greatly ease the problem of fitting the United Kingdom's troops into the structure of NATO, whose other member nations are not contemplating such an integration of their fighting services.

The financiers are for the new system, the War Chiefs are against it. As is usual, the final decision rests with the politicians. In the present world, politics governs economy and the wars that are fought because of it. Politicians in a democracy must be the ultimate strategists. Economists and military men must first advise and then obey the country's governors. And so it must be in this Committee. The politicians decide in favour of the new system. They appreciate the arguments of the War Chiefs, but they consider that their problems can be cured in a matter of a few more years, and they do not anticipate a major war within at least the next ten years, because of the rate of the internal expansion of Russia, and the non-possession of nuclear weapons by China. One concession they will make, however, and that is the formation of a Staff Branch in any form that the War Chiefs may desire. Lastly, they require detailed reports of progress yearly from members present, and propose that a similar meeting be held in three years' time.

Thus, the proven financial economy over the past five years has won the day. To the makers of the country's budget it has proved more attractive than the arguments of the men who have to implement the system. With true political aplomb, however, the ruffled feathers of the War Chiefs have been partly smoothed by a necessary concession. The meeting adjourns. The Royal Defence Force has survived its birth, and must now overcome its adolescence to stand in manhood confident of being able to fulfil the aim which governed its foundation.

Gems, Germs and Hovercraft

By Brigadier D. W. Reid, MBE

The purpose of this article is to stimulate thought and to excite imagination over the development of hovercraft, and the application of the cushion principle. It has traditionally been the role of the sappers to seize new inventions, to foster them and then, when they have grown big enough, to let them stand on their own. In the field of hovercraft, have we followed the traditions and examples of our predecessors? I quote from an article in the *Helicopter and VTO World*—"It is particularly apparent that the American military services seem much more alive to the potentials of this new craft than do their British counterparts. If the British services want to be able to meet their future requirements from British sources, the time to show an interest is now, so that the industry can rationalize for military and civilian requirements in it design studies."

Much civilian development work is being done in UK, principally by the firms Westlands/Saunders Roe, Vickers, and Follands. All, it will be noted, aircraft firms.

Westlands/Saunders Roe, whose prototype SRN 1 has been most widely seen, were the first in the field. They are now working in terms of a channel ferry carrying sixty-six passengers. Vickers are also thinking big. Follands are working on a small vehicle with limited hover height and speed. A small firm, Britten-Norman, who are outside Hovercraft Development Limited, are working on a load-carrying craft for use in under-developed countries. There are several smaller firms working on applications of the cushion principle. It is important to realize that this principle can be used by the "DIY" man. For example, the Drewery barrow was built largely from bits and pieces of scrap and the engine was a ten-year-old two-stroke from a power saw. The total cost was something like £25.

Much more development is being done in the USA. American development has mostly been led by the Armed Services. The Navy is interested in submarine chasers, the Marines in assault craft, and the Army and Air Force have a common interest in trying to see whether the ground effect principle can be used in place of the normal undercarriage to enable an otherwise orthodox aircraft to make a ground effect take off and landing. This development if successful would largely make air strips unnecessary. The Army has interest in other applications of ground effect. Commercially, many firms are working on the principle, in various sizes, although none appear to be thinking as high and fast as UK firms. Curtis Wright have produced the air-car model 2500. This will carry four persons or 1,000 lb pay load, measures 21 × 8 ft and is powered by two 180 hp engines. Again, in America, there are many small men applying the principle in small ways.

There are two main factors which have tended to make people in England think fast and high.

(*a*) England and the continent are well roaded and well developed. In peacetime it appears hopeless to supplant the wheeled lorry under these conditions. Our eyes as a nation no longer look towards a colonial empire.

(*b*) A graph, which has been widely shown whenever and wherever hover-craft are discussed, shows lb/fuel required to carry 1 ton/1 mile graphed against speed. This graph purports to show that hovercraft fill the efficiency gap between ships, carrying heavy lifts slowly, and aeroplanes, carrying not so heavy lifts fast.

These two factors have made English designers think hovercraft in terms of strategy and not tactics or logistics.

Before considering the possible military applications of the cushion principle, it is as well to look at the principle itself and the main problems in the application of the principle.

The principle of the hovercraft, which must not be confused with vertical take-off, is old and well known. It is, quite simply, to remove surface friction by supporting the vehicle on a cushion of air. Various methods have been suggested and tried to achieve the retention of the air cushion beneath the vehicle, but it is only recently that the momentum curtain has successfully achieved this. This article is not the place for examining the technical problems of the momentum curtain and the other different systems of main-taining the cushion; enough that it can be done in a practical manner.

The principal problems, apart from the purely technical, arising from the application of the principle, are:—

(*a*) Control, (*b*) simplicity, (*c*) dust, (*d*) power and height of hover.

Control. When the vehicle is supported on a cushion of air all friction between it and the ground has disappeared. In effect, this means that the vehicle will slip sideways down a hill or, with a puff of wind, will drift side-ways. There are various ways by which this can be overcome. A sailing boat would drift sideways but overcomes this by having a centre board or a keel. If we put wheels on a hovercraft to maintain contact with the ground, we can probably produce full control. This has been tried by Follands with con-siderable success. Another method is to make the machine aerodynamic so that it is controlled like an aeroplane. This requires high speeds and will not work at low speeds. A third way is to tow the machine by a prime mover with a normal ground performance.

Simplicity. There is a limited supply of skilled persons who are capable of becoming pilots. There will never be enough for the Army to make use of the cushion principle widely if the cushion vehicle has to be driven by a pilot. It must be so simple that it can be driven by a driver just as is a lorry.

Dust. This problem requires no explanation, nor is any solution in sight.

Power and height of hover. (*a*) To propel itself along the level a hovercraft, with no ground friction to overcome, only requires a small push, which it can get from a fan or propeller thrusting against the air. When it comes to climbing a hill, much more push is required and at only low speeds pushing against air is inefficient. Again, there appear to be two possibilities to overcome this for a slow speed machine, either put a wheel on the ground and derive some power from that, this introduces severe mechanical problems, or tow the thing along with a rope.

(*b*) The power required to maintain the air cushion is directly related to the height of hover and rises sharply with any increase of the hover height. A hover height of one or two inches is simple to achieve and is sufficient on flat and level ground. At the other extreme, a hover height measured in feet requires horsepower by the hundred. It is important that at this early stage of development we do not think too big. The advantages of hovering are achieved at 1-in off the ground. The additional advantages of increasing that inch to feet are trimmings.

It is now necessary to look at the possible application of the cushion principle to army use bearing in mind the acknowledged limitations.

The Army might use hovercraft for strategic, tactical or logistic purposes and the craft to fulfil each purpose is totally different.

(*a*) Strategically, we want to move men and tanks long distances and fast. This will come in an advanced stage of development and may be realized in years to come. It may well have civilian applications. The vehicle required to fulfil the purpose will cost in the order of one or two million pounds, and the Army will certainly not get any experimental models to try out yet.

(*b*) Tactically, a machine must carry a small number of men with their arms and possibly some other armament. It is preferably armoured and it must be able to move across country and surmount natural obstacles without any preparatory work. Clearly this calls for a specialized vehicle with a specialist driver/pilot. Hovercraft development must go a long way before it can overtake the helicopter in this field.

(*c*) Logistically, the requirement is for large numbers of cheap, simple load carriers replacing the three-tonner on the L of C and dispensing with road making, road maintenance, and bridge building.

One of the principal factors in introducing a new item of equipment to the Army is that it should have a commercial use. Provided that the equipment has a commercial use it can be produced cheaply, spares are available, and men who can operate and maintain it are also available. This factor rules out the introduction of strategic or tactical hovercraft for many years to come, but does not necessarily rule out the logistic hovercraft.

Take a look at three pictures.

(*a*) A L of C in the Near East. A string of hovercraft is approaching. They each have a driver, they each carry two or three tons of pay load and have two little wheels on the ground with which they steer. They are being blown along by a small fan on top of them. They approach a hill. The driver stops at the bottom, hitches his craft on to a moving steel wire rope, a form of ski-lift, and he is hauled up to the top of the hill. At the top he releases himself and drifts on down the hill the other side. His jockey wheels are sufficient to brake him going down the hill.

(*b*) A weasel or sno-cat type of vehicle is approaching and following behind it, tied on to it, a string of pallets, each with a small engine which provides it with lift, each carrying about a ton, and each with two jockey wheels on the ground to give it manoeuvrability at rest and directional stability when being towed. The weasel itself is manned by one man. The pallets are unmanned.

(*c*) This is inside a warehouse or store-yard. A man pushing a compressor goes up to a pile of pallets, he clips his air hose on to the pallet he wants to move. This pallet rises an inch in the air and the man can then push a ton about with one hand.

These are all castles in Spain, but given drive and money behind the research, they might well be achievable within a period of months. The first two would make all sapper road making and maintenance, and bridge building, for a L of C, redundant. It would only be necessary to grade a hoverway, it need not be wider than a road, across country to the smoothness required by the hover height. Perhaps bumps of 4 to 6-in would be a reasonable roughness. In the store depot or warehouse, the use of fork lift trucks and the necessity for accurate fork lift operation has disappeared. One man can manoeuvre tons to any accuracy required.

Are the strictures in the *Helicopter and VTO World* which are quoted in our opening paragraph true? Are we as sappers living up to our traditions?

The Timber Industry of Malaya

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The Forestry, Extraction, Conversion and Seasoning of Malayan Timbers

Introduction

It should be explained that my original intention was to write a trilogy of articles concerning the forest industry of Malaya under the titles of "Forestry", "Seasoning" and "Preservation". During my study of Malayan timbers I was, however, overtaken by the more pressing need to improve preservative techniques and this aspect has therefore been the subject of a previous article in the *Journal* (June 1960). This will explain the reversal of sequence, and I now belatedly offer my observations on Malayan forestry and seasoning methods, in one final article.

I have chosen to write on this subject for two reasons. Primarily because I have a deep affection for timber in all its forms and secondly because timber, although one of man's most primitive constructional materials, is still indispensable in present-day engineering practice. From a military viewpoint it will be appreciated that timber the world over is constantly employed in engineering construction, often as a substitute for steel or concrete where temporary works are required or improvisation is expedient. Frequently, the military engineer will find that timber is the only readily available local material, and even where it is not an indigenous product, timber is one of the easier materials to transport in bulk. It is quickly convertible to required size and can be rapidly framed together into either domestic or engineering structures. Weight for weight good quality timbers often compare very favourably with the working stresses of heavier and more costly materials, which require more laborious constructional techniques.

The military utilization of timber is not the subject of my article since this field is already fully covered by our engineering manuals. I propose to discuss in four parts the long chain of operations which finally yields the forest product:

(i) The natural growth of the forest and the cultivation of timber crops;
(ii) The extraction of the forest crop by sheer muscle or mechanical means;
(iii) The conversion of logs into timbers, scantlings and boards, ready for utilization;
(iv) The seasoning of tropical forest timbers.

This article only describes Malayan forestry methods, because I have had a special opportunity of studying the forests of that country at close quarters. Much that I have written is, however, applicable to other geographical regions and in any event the underlying principle that good forestry means conservation of useful timber stocks is universal. However well forested a country may be, wholesale and indiscriminate felling will soon bring about the ruin of forest crops and permanently endanger future supplies. I have witnessed two war-time examples of such destruction; first in Northern Italy where both British and American engineers carved out great tracts of pine forests to supplement their stocks of equipment bridging, and then in Malaya, where the Japanese, who, using no bridging equipment at all, completely destroyed vast acreages of the more easily accessible and productive forests, by unplanned extraction methods.

Under the stress of total war it may not be possible to give prior consideration to the problems of selective extraction, but if opportunity permits, future conservation of timber supplies can be ensured by correct forestry methods. This fact should be borne in mind particularly during "limited" or "cold war" operations in friendly or allied territories. If we accept the importance of timber as a military constructional material then all of us should, I think, have at least a rudimentary knowledge of forestry. I hope that readers will find not only some interest in this subject but also perhaps an opportunity for practical application on a future occasion.

Part I—Forestry

The term Forestry covers a very wide range of activity. Broadly, it entails the introduction of a Forest Policy, together with such legislation as may be required; the Reservation, alienation or annexation of lands for the cultivation of forest crops; and Silviculture, the tending of the forests to ensure the highest possible yield of commercially valuable timbers. In Malaya, the first known serious attempt at the productive development of forests to encourage crops of commercial value, dates back as far as 1880. It was not until 1922, however, that the Malayan Government made its first official pronouncement on forest policy. Each state was urged to become self-supporting in its requirements for timber, the traditional building material of the country. The aim of the Government was to form productive reserves of forest area, in which timber, like any other vegetable crop, could be cultivated. It was proposed that ultimately up to 25 per cent of the total available land area be set aside for timber production.

The "availability" of land requires some explanation at this point. Of the total area of 50,700 square miles within the Federation of Malaya, 560 square miles are mangrove swamp, 11,260 square miles are above the 1,000 ft contour, and the remainder termed "available" accounts for the balance of 38,880 square miles. "Easily accessible" would perhaps be a more apt description for this land below the 1,000 ft contour, rather than "available". Although forest working is not impossible above the 1,000 ft limit, it has been generally accepted by the Forest Department that extraction from hill and mountain land is not at present economically possible due to the terrain and variation in crop conditions. The general policy is to leave the mountain forests undisturbed as "protective forests", to check landslides and soil erosion, normalize stream flows and minimize the silting of rivers. Productive forestry is therefore confined to the lowlands below the 1,000 ft contour.

The lowland area of 38,880 square miles can be further subdivided. 750 square miles are permanently unproductive being townships and habitations, tin tailings or swamp lands. 10,630 square miles alienated land, mainly for rubber, oil palm, coconut plantations and the mining of metallic ores. The remaining 27,500 square miles are available for other purposes such as agriculture and timber production. At present the area of Productive Forest Reserve in Malaya is just over 8,000 square miles with an ultimate aim of 12,500 square miles, which will come very close to the original policy of devoting 25 per cent of the country to productive forest. With such an enormous timber reserve it is difficult to conceive a timber shortage developing Malaya in the foreseeable future. However, with a rapidly increasing population, coupled with a higher standard of living which is likely to increase the consumption of timber per head very considerably, it has been forecast that soon after the turn of the present century Malaya might well have to start *importing* vast tonnages of logs annually, to satisfy her needs. In order to minimize this possibility the Forest Department have tackled the problem in three different ways. Firstly by improved silvicultural methods to ensure regeneration of the forests; secondly by the close supervision of extraction from forest reserves; thirdly by encouraging the fullest possible utilization of the forest product.

SILVICULTURE

The virgin forests of Malaya may produce up to 150 tons of grown timber per acre, but at present the average yield of sawn timber is little more than 10 tons per acre. This low yield from virgin forests is due to the fact that many species have little or no commercial value, and much of the timber is unworkable, diseased and undersized. By good silvicultural methods the forests may be "weeded", to rid them of unproductive or non-commercial species, and at the same time the more prolific, quicker and stronger growth of the valuable timber species encouraged. In addition to weeding out, intensive regeneration by either artificial or natural means is necessary if forest reserves are to maintain a high out-turn. It may also be possible by silvicultural methods to develop land which was previously thought to be worthless and establish an economic forest crop. This particularly applies to such reclaimed areas as old tin tailings, which would otherwise leave vast lowland areas abandoned.

Silviculture is then the practice of cultivating forests to the benefit of mankind, and its study can only be conducted by experiment and observation. Malayan timbers take on an average seventy years to mature from the seed, it is therefore not possible for any one silviculturist to observe the result of his experiments within his normal life span. The principle of silviculture is to provide and maintain good growing conditions for individual species of timber and to ensure the regeneration of these species as and when required. This may be achieved by the following variety of silvicultural "systems":

(*a*) *Clear Felling System.* This is normally applied to seedling crops, in high forests. Natural regeneration is obtained from advanced seedlings, by the "liberation felling", or sometimes poisoning, of mature trees distributed over the whole forest compartment. The forest canopy is thereby opened up permitting the healthy growth of selected seedlings. The canopy is either cleared in one operation or it may be cleared in successive stages.

(*b*) *Selection System.* This entails the removal of the slower growing trees to facilitate cultivation of the faster growing species. Very close and skilful supervision is required to operate this system in order that species are correctly identified. The task is made greater due to the fact that in tropical rain forests annual growth rings are not present, and careful and regular measurement and recording is necessary to determine the rate of growth. Further improvement operations are sometimes necessary such as the poison girdling of small or weaker species to assist the growth of the more valuable stems. Poison girdling is effected by cutting a 2 in deep annular ring in the bark of the tree, followed by the introduction of arsenical compounds into the channel thus formed.

(*c*) *Selective Felling.* This system is usually used on high broken ground and steep hills where access is difficult and wholesale clear-felling would be impracticable. By selective felling the forest is merely thinned out, and no tending or cultural aid is given to the remaining timber. New crops will, however, be produced in the forest by this method of no lower standard than in the virgin jungle, and it permits a certain degree of regeneration of commercially valuable timber.

(*d*) *Improvement of Growing Stock.* Where existing forest stocks are within ten or twenty years of maturity, it is sometimes an economic advantage to poison the less valuable species in the crop. This does not involve the expense of felling, nor does it improve regeneration at this stage, but the selected trees of higher commercial value grow more quickly and become more robust, yielding a higher tonnage of usable timber.

(*e*) *Cleaning, Thinning and Other Improvement Operations.* There are numerous ways in which the standing crop of timber may be improved, and the most effective is usually selected after the results of "Sampling" have been ascertained. A forest compartment may be sampled by the detailed investigation of milli-acre (1/1000th acre), quarter or half chain square lots. From such investigation, forest records are prepared indicating the age, nature and size of species, dominant timbers, commercially valuable timbers and those which are unwanted. This data is then used to prescribe a suitable silvicultural treatment. Cleaning, is the removal of inferior species allowing light and air through the canopy to reach selected saplings. Thinning, on the other hand is usually applied to forest stands where one timber or a single species is predominant. Although pure crops are rare in Malayan forests, by continual thinning either by commercial felling or poison girdling, a forest crop can eventually be produced to yield the required timbers of high commercial value. Other improvement operations usually comprise the cutting down of climbing plants which tend to strangle young regenerations, clearing the forest floor of unwanted herbage in the form of belukar and bertam (both of which tend to smother young saplings unless controlled) and poisoning of unwanted trees to prevent undesirable competition with adjacent economic timbers.

(*f*) *Natural Regeneration.* The majority of Malayan timbers are prolific seed bearers, the seeds quickly germinating on falling to the forest floor, but in certain species the seeding years may be as much as five years apart. Under natural jungle conditions they rise quickly as spindly seedlings, and then due to the dense overhead canopy die back, or are smothered by other competing ground herbage. Some seedlings do survive for many years, and under natural conditions adjacent trees will die and fall in the forest thus providing light and air for their continued growth. To secure the full benefit of natural regeneration nature must be aided by the manipulation of the canopy and the control of the undergrowth. Such assistance to nature takes the form of one or more of the operations previously described.

(*g*) *Artificial Regeneration.* The planting of forests has been going on in Malaya over the past eighty years, and some 20,000 acres of artificial regeneration are scattered over the country. However, for the production of commercial timber crops it has been established that improvement felling and regeneration of existing forest stands is the more profitable. There still remains a need for artificial regeneration for two important reasons. Firstly, enrichment planting to introduce new or different species into existing forest crops, and secondly the afforestation of degraded land such as scrub, lallang, mine tailings, abandoned agricultural land, and eroded areas.

One of the main difficulties in artificial regeneration is that Malayan trees seed irregularly and also due to rapid germination, seeds cannot be stored for more than a few days. In certain species, germination actually commences before the seed falls to the forest floor. Another disadvantage is the lack of season in the Malayan climate which means that there is virtually no dormant period during which a seedling may be safely planted out. The formation of stands of timber by the direct sowing of seed has so far proved unsuccessful. Although the normal method is to plant seeds in nurseries and later plant out in earth blocks or bamboo tubes, it has often been found more reliable to lift and transplant seedlings from natural stock. Such natural seedlings may be lifted and transplanted direct under favourable weather conditions, or alternatively they may be "tubed" in hollow bamboo pots and tended in a temporary forest nursery until conditions are suitable for transplanting.

From the foregoing it will be seen that silviculture is a long, painstaking process, the results of which cannot be fully determined for a great number of years, and setbacks and disruption by natural causes will frequently occur. These deterrents have to be accepted and overcome however, if virgin forests are to be successfully cropped and restocked to continue yielding timber on a commercial basis year after year. It will benefit mankind if military engineers of the future can give some thought to the problems of the silviculturist before indiscriminately cutting trees from the forests of the world.

Part II—Extraction

The extraction of timber, or the winning of the forest crop, follows two distinctly different patterns in Malaya, since at the present time timber is being drawn from two sources, namely the forest reserves, and from state land which is being deforrested. In the former the most stringent controls are exercised by the Forest Department through the medium of their forest officers and forest rangers. By such control the prescribed silvicultural practice can be put into operation and the timber crops thereby conserved and regenerated. Where state lands are being deforrested, however, the timber crop is stripped without regard to regeneration. After the commercially valuable timbers have been removed the land is finally cleared by various means and eventually turned over to agriculture, plantation crops such as oil palm or rubber, or possibly mined for mineral deposits. The effect of these widely differing patterns justifies further description.

When forest reserves are ready for cropping, recognized sawmillers and logging contractors make application to the Forest Department for a concession to extract the available commercial timbers. Concessions to work a given forest compartment are awarded by the Forest Officer who issues a licence for which a fee is payable. Each workman employed by the contractor in the forest must also be issued with a sub-licence in order that strict control and supervision of logging activities can be maintained. Having obtained the general concession which may be in terms of so many thousand acres for a certain period of years, the compartment is divided into smaller blocks, which will vary from 200 or 300 up to 1,000 acres. Usually the contractor is only permitted to work and complete one block at a time, but where there is a scarcity of commercially valuable timbers, two or even three blocks are sometimes made available. From a predetermined plan, the Forest Rangers mark each individual tree which is to be felled, thus controlling the species, size and location of all timber extracted. In addition to his licence fee the contractor is usually required to pay a monthly premium on an acreage basis and also an agreed price per ton of timber taken out of the forest. Forest checking stations are established on main roads near logging areas where Forest Department officials check each load for species and tonnage measuring the logs for diameter and length. Every log passing through the checking station is "chopped" or marked, with the checkers stamp.

The extraction of timber from state land is a much more simple process so far as the logging contractor is concerned. Contractors bid competitively for the logging rights over a given area. Usually the "block" is on a much larger scale than the smaller blocks of the Forest Reserve compartments, and may often be measured in square miles rather than in acres. Apart from a time limit which is imposed on the contractor for the clearing of commercial timbers there is normally no other form of control. The contractor is free to pick and choose his timbers for extraction as the buyers' market dictates. Thus for a certain period he may extract only those species which are required to meet specific orders, selecting the more easily accessible and higher yielding trees. Forest land worked in this manner is a most untidy sight, although in the short term it is a commercially more profitable system. When demands for specific species have been met the contractor will extract other trees suitable for conversion and hold these in stock as a log reserve or sometimes convert to stand as seasoning stock in his mill yard. As with timber from the Forest Reserves all logs must pass through a timber checking station where it is measured and the species noted. The contractor pays for his timber by the ton, but when working state land he normally has to pay in advance on a deposit system.

Whether the timber is being cropped from forest reserve or from state land the felling and transportation to the saw-mills presents similar problems.

Felling is carried out almost universally by means of axe and crosscut hand saw. The method of transportation will, however, vary according to the terrain or geographical location of the timber compartment, and will be described later. Due to the cheap cost of labour compared with the relatively high cost of maintaining mechanical equipment deep in the heart of the forest, often miles from the nearest road, hand tools are still favoured. Mechanical cross cut saws are undoubtedly used in certain compartments, but in all the swamp, lowland, riverine and hill forests recently visited, hand tools were in common use. A simple working platform of poles is erected above the buttress of the tree, usually about six feet off the ground and the tree is cut to fall in a given direction. In Forest Reserves this is particularly important and the tree must fall exactly opposite to the Rangers mark to ensure minimum damage to other standing or sapling crops.

Immediately the tree has fallen, the same team of men working with long crosscut saws, convert the timber into standard length logs which will vary from 14 to 28 ft or longer, depending on the girth, species or special requirements of the market. With some of the larger species the diameter of the bole is so great that transportation of the log to the saw-mill may present a difficult problem. Frequently such logs are split down the middle on the forest floor, either by further cross-cut sawing or by hammer and "feathers" (steel wedges). Good commercial species of Malayan timber often grow to 200 ft or more with even girth and clear boles throughout the length of the tree and may produce ten or more logs 20 ft in length.

The top of the tree with its foliage and branches from about six feet below the first fork is usually left on the forest floor to rot. Other than firewood collecting on forest fringes, no serious attempt is made at present to convert the branches and other waste products of the tree. However, if pulp board manufacture becomes established in Malaya a more thorough utilization of the forest product will be possible.

Having felled the tree and sawn it into logs, the contractor's next problem is to transport it to the saw-mill and as previously mentioned the method employed will depend very largely on the terrain and distance to the mill. Various methods are practised each being applicable to a particular type of forest.

(*a*) *Steep Hill Forests.* Here the gradients are normally too steep to permit the use of the usual form of logging winch lorry. Until recently a common method of extraction was by the use of bullock teams which dragged the logs to the lower inclines of the forest where gradients could be negotiated by four-wheel drive lorries. The requirement for faster output has, however, dictated the need for more modern methods, and when working steep hill-sides contractors are now using large bulldozers more frequently. The dozers clear pathways up to the fallen tree and then with their winches haul out the logs to access roadways where they are transferred to timber lorries and carted to the saw mill.

(*b*) *Lowland Forests.* The bulk of the timber comes from this type of forest where the ground is gently undulating and although tracks do not exist, rugged four-wheel drive winch lorries, usually converted from WD surplus vehicles, can pull themselves through the slush and undergrowth. Such lorries are capable of hauling the logs on to their backs by the winch cable, and when driving out through difficult stretches of forest the driver's mate runs ahead with the winch rope, fastens it round a stout tree and the lorry pulls itself along 200 ft at a time. Where the terrain is suitable, an alternative method is the use of a light railway, but due to the restricted access which this system affords, it is only popular for the working of very large compartments in relatively flat land.

(*c*) *Riverine Forests.* Such forests are a common feature along the north-east coast of Malaya the country being frequently divided by sizeable rivers. Where the river is more easily accessible than a main road, the latter being few and far between, the logs are hauled to the river edge by manpower, bullocks, winch lorry or tractor, and there formed into log rafts. The rafts vary in size, but average about six or seven logs wide by four logs long, thus giving an over-all dimension of approximately 25 ft wide by 80 ft long. The logs are held together by branches spiked across them, and stiff binding wire. In appearance the whole structure is very flimsy, and there is only just sufficient buoyancy to give a few inches freeboard. Two men with improvized sweeps guide the raft down river delivering it either direct to a river-side saw mill, or to a river port if the logs are to be exported. It is common to observe logs being towed out to sea to waiting freighters, or being loaded into lighters in sheltered estuaries for shipment to the big saw-mills in Singapore.

(*d*) *Swamp Forests.* Extraction from this type of forest presents probably the most difficult and certainly the most expensive problem. The largest of the fresh water swamp forests at present being worked is adjacent to the Malayan west coast invasion beaches of Morib. Here, a light railway track has been laid on logs virtually floating in mud and water, reaching deep into the forest, with branches off into the centres of Forest Reserve "blocks". It has taken ten years to penetrate only 8 miles into the swamp, the timber crop being reaped as the track was pushed forward: 14 lb rail is used, spiked to round cross timbers, or ties, which are in turn notched into full logs, laid in the swamp parallel to the track. Due to the nature of the water and soil the timber foundations have to be renewed annually and maintenance gangs are permanently at work on the track. It has proved economically impossible to construct any form of motor road through the swamp and no form of mechanical equipment can be employed. The writer has suggested that possibly the American "Rolligon" or a "Hovercraft" might be capable of operating under these conditions, and this is now under active consideration.

Where the railway track reaches the centre of the block being worked, loading ramps or "Betaus" are constructed of round timbers and from these, timber skidways called "Panglongs" are laid right up to the trees which are to be felled. The Panglongs are very similar to the railway track foundation, but the cross timbers are greased and no rails are laid. The sawn log is rolled on to a hardwood skid or "Sampan", which is then hauled along the skidway by the team of lumberjacks. An eight-man team, fells, crosscuts and hauls its own logs out to the rail loading platform. Small diesel locomotives with a train of crude timber bogies then convey the logs to the saw-mill situated by the main road. From here the logs or converted timber are despatched for export or internal distribution, by road transport.

Although possibly none of the transportation methods described above are particularly unusual or ingenious, it is an advantage for the military engineer to be familiar with the various factors which present themselves in different terrains. They at least serve as a guide when confronted with the problem of timber extraction from remote tropical forests.

One of the most important factors concerning extraction is the rapidity with which the felled tree can be removed from the forest floor. Newly felled green timber is liable to attack by the vigorous and strong flying Ambrosia beetle within an hour of felling. This beetle is an insect between $\frac{1}{16}$ to $\frac{3}{8}$ in. in length which bores into logs forming unsightly "shot holes" and thereby causing degrade in otherwise valuable commercial timber. These insects are attracted by a volatile chemical which is released when trees are felled, and only attack green timber with a moisture content of over 50 per cent. The name "Ambrosia" is derived from the fungus which the adult females cultivate in their bore holes to provide the main source of food for the beetle families.

If logs cannot be immediately extracted from the forest, it is normal practice to leave the bark intact as this helps to reduce the damage of attack. At the same time the presence of the bark may encourage infestation by Longhorn beetles which are also capable of causing considerable damage to the timber. For this reason, logs left in the forest for any length of time should be sprayed with a strong insecticide such as benzene hexachloride. The chemical concentrate is best diluted with a light oil, particularly where tropical rain conditions prevail or where logs are to be trans-shipped in rafts. Diesel oil or kerosene are suitable dilutents.

All too frequently the protection of logs is neglected in Malayan forestry operations with the results that the majority of species bear the disfigurement of shotholes and the accompanying blemish in the form of black stains. This is, however, not a serious structural defect unless the log is very heavily attacked. It is also worthy of note that the Ambrosia beetles die off as the timber dries out. Early and adequate seasoning is therefore an additional safeguard.

The timber having so far been planted, grown, tended, felled, protected, and extracted it is now delivered to the saw-mill ready for conversion into produce.

PART III—CONVERSION

The conversion of timber is the breaking down of the log into useable, readily handled, sizes. In Malaya this work may be carried out in saw-mills adjacent to the forest edge, or in town saw-mills. Other than the splitting of very large logs, conversion is not normally carried out in the forest compartment. Saw-mills vary greatly in size from the single circular saw unit operated by electricity, diesel or petrol engines, to the large multiple machine mills using bandsaws and circular saws driven by steam power or electric motors. The majority of saw-mills are set up solely for the purpose of converting timber for export or the local market, and only rarely are woodworking machine shops attached to the mill.

It is interesting to follow the log through the saw-mill from the time of its arrival. Most commonly, logs arrive on timber lorries still bearing their bark. They are rolled off on to ramps running parallel with the length of the saw-mill along the feed-in elevation. There may be three or four separate ramps each terminating at a light rail track carrying trestle bogies on to which the log can be manhandled ready for presenting to the saw. It is while the logs are still fresh on the delivery ramps that small gangs of labourers debark the timber ready for sawing. Very few mills have log ponds and only the largest contractors are able to contrive a stock of reserve logs. For this reason it is quite common to see timber felled in the forest one day being converted the

Photo 1. Converting to logs on forest floor.

Photo 2. Winch loading a logging lorry Ulu Trenganu.

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Photo 3. Log hauling in hill forest, Ulu Langat Reserve.

Photo 4. Manhandling log on "Panglong" in swamp forest, Morib.

The Timber Industry Of Malaya 3 & 4

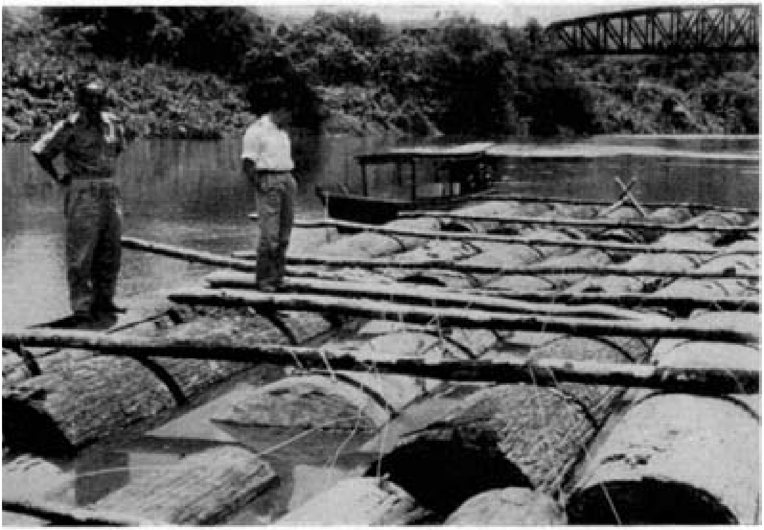


Photo 5. Log raft, Kuala Krai, Kelantan River.

Photo 6. Log rafting on Kelantan River near Kota Bharu.

The Timber Industry Of Malaya 5 & 6

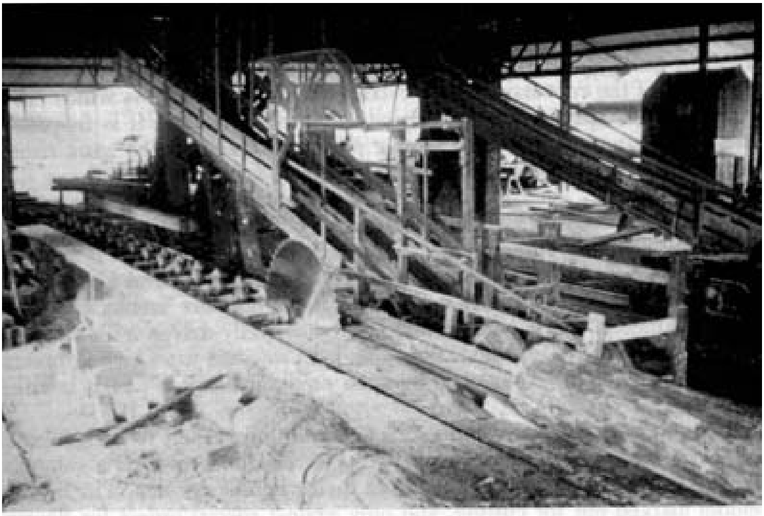


Photo 7. Circular saw and roller table. Electric power mill.

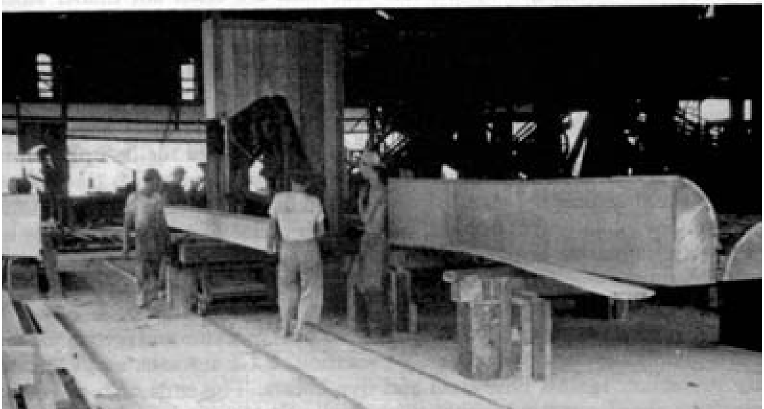


Photo 8. Band saw conversion. Trengganu saw-mill.

next, with the sap pouring from the sawn faces. So great is the present demand for timber that regrettably, saturated material is often built into structures within two days of having been a living tree.

In the larger mills it is usual to find two or three circular saws of from 48 to 72 in diameter, supplemented by a number of bandsaws. The circular saws are generally used for splitting the log into two or three pieces, the remainder of the conversion being carried out on the bandsaws which cut at a much higher speed. Where electricity is readily available it is frequently used as a method of providing motive power. However in the more remote areas, steam is employed in the larger mills and scrap timber and saw dust provides a readily available fuel. Sawdust is difficult to burn on a normal grate in the firebox of a boiler, consequently the practice is to construct a small fire-brick lined furnace adjacent to the boiler itself. Sawdust is manually fed through a manhole opening in the top of the furnace and a short steel duct carries the flames, smoke and hot air into the boiler firebox and so up the flue which is specially lengthened. In electrically-driven mills the sawn scrap is sold daily to firewood dealers and the sawdust for which at present there is no commercial outlet is dumped on spoil heaps where it is either slowly burned or left to rot down.

The production of timbers, boards and scantlings is left to the ganger in charge of each saw. A sawyer with two or three labourers form a gang and they are paid by the ton of output from their machine per day. The logs are seldom marked out for cutting, and only against special orders for flooring timber is any attempt made at quarter sawing. Normally all timber is "run of the mill", the sawyer using his judgement to obtain the highest possible yield in squared timber from the log. There is a great deal of room for improvement in both the handling and conversion technique. Progress in the latter field is discouraged by the fact that mills are often not timber stock holders and do not therefore cut the log to its best advantage to produce a stock of various sized scantlings and boards. It is common to see whole logs converted to 4 × 2 in from the heart to the sapwood, with only the wane cut down to produce 1 × ½ in battens.

Timber for the export market, frequently destined for the United Kingdom or Australia, is usually afforded special treatment. In the first place it is sawn oversize to allow for the very considerable shrinkage which takes place in most Malayan timbers, many of which contain 100 per cent or more moisture content when green. Secondly it is the practice of reputable agents to insist on a minimum air drying period in "sticks", under cover, for sawn timbers prior to shipping. This period varies from ten days for Keruing and Kempas (common medium hardwoods) to forty days for Jelutong (a very wet light hardwood used in pattern making)· As a final precaution it is common for export timbers to be dipped in a cold solution of Gammexane and water to give protection against blue stain and live borers. The ends of boards and scantlings are also treated with a thick application of pitch to prevent over rapid drying out and excessive splitting.

Although there is a flourishing trade with Japan in logs for plywood manufacture very little ply or laminated timber is made in Malaya at present. New plants are, however, on order and the Forest Department is carrying on active research into the most useful species and types of glues to be used in the manufacturing process. It is therefore likely that this aspect of the timber industry will be further exploited in the near future. There is also a need for the development of chipboard, pulpboard and fibreboard production in order to achieve a more thorough and efficient utilization of the forest crop. Far too great a proportion of the tree is left to rot in the forest, whilst saw-mill waste provides a serious disposal problem.

Before discussing the seasoning of Malayan timber, one last mention should be made of the Forest Rangers. These officials perform an important function at the saw-mill area during the conversion stage, since they ensure that only logs bearing the code mark of the forest checking station are passed through the mill. If this check were not carried out, it would be a simple matter for an unscrupulous contractor to bye-pass the checking station and thus steal timber without paying the forest dues. Logging would then indeed be a most profitable pastime.

Part IV—Seasoning and Kiln Drying

As already explained there is at present little serious attempt to season timber at the saw-mills, other than the "sticking" of export consignments. The average building contractor will generally make a token gesture by spreading his green boards and scantlings about the site to dry in the sun, but fully seasoned timber is a rare commodity. Timber suppliers and contractors alike, argue that commerce cannot afford to keep capital tied up in timber waiting for nature to complete the full process of conversion. With moisture contents in green timber ranging from 50 to over 100 per cent it is not surprising that Malayan timbers suffer from excessive shrinkage rates both laterally and radially. In spite of this, neither architects nor engineers have so far been able to convince the industry of the need to tackle the problem of controlled seasoning seriously.

Just prior to leaving Malaya, early in 1960, I turned my attention to the possibility of developing the process of kiln drying on a commercial basis. I believed this to be the most efficient method of exercising control of moisture content in timber. At the same time, I considered kilning to be economically acceptable since it considerably speeds up the natural process of air seasoning and thereby releases capital much more quickly. This final section is a brief account of my observations whilst carrying out these experiments.

In the whole of the Federation of Malaya there were only two kilns. One, a small laboratory kiln at the Forest Research Station; the other a heat exchange unit set up in a factory making parquet strip flooring. My aim was to encourage a large firm of timber and building contractors to construct a commercial size kiln with a 15-ton capacity, at their city saw-mill. The design recommended, was on the lines of the British Forest Products Research Laboratory overhead internal fan kiln, steam heated, with electric fans. The construction of the kiln presented no problem since this was undertaken at little cost by the contractors' spare yard labour, using salvaged materials. My chief interest lay in persuading the contractor that it was economically rewarding to operate the kiln and produce timber of higher quality. One of the bye-products of this particular mill was wood block flooring. This is often laid in air-conditioned buildings where relative humidity is extremely low, and unless the timber is properly seasoned considerable movement takes place. The contractors also had a serious problem with their accumulation of sawdust. Free fuel was thus readily available for consumption in the kiln boiler furnaces. I therefore had at least two strong arguing points and proceeded to demonstrate the theory of kiln drying by practical experiments.

The military aspect of this research was important since the contractor happened to be engaged on a number of major War Department contracts. It was therefore to the advantage of the service if properly seasoned timber and flooring blocks could be obtained. Whilst work on the full size kiln was put in hand, I constructed a small experimental kiln in my own DCRE yard. Its purpose was to design fast kiln drying schedules suited to a variety of timbers at different stages of moisture content, and related to the prevailing humid tropical conditions. Certain schedules for Malayan timbers published by the Forest Products Research Laboratory were in existence, but these were too lengthy and complicated to put over as economic propositions to a Chinese contractor.

For the body of the model kiln I used a large galvanized iron water tank set in a lagged wooden chest, with a removable insulated lid. The tank was placed over a rectangular sheet metal "hot box" equipped with electric heater elements and a variable speed electric blower. A valved feed pipe was led into the hot "box" from an electrically-heated steam generator, to produce the required condition of humidity. The hot humid air was blown up through gratings and baffles in the bottom of the kiln chest, escaping through outlet ducts with butterfly control flaps, set in the wooden lid. To permit effective control a wet and dry bulb hygrometer was fitted behind a plate glass observation panel in the side of the chest. This simple kiln worked extremely well over long periods of time without unnecessary attention. A full range of temperatures from 80°F to 180°F combined with a relative humidity range of from 80 to 10 per cent moisture content was possible. With such flexibility, any desired drying speed could be introduced to the timber samples in the kiln.

A selection of green timbers was brought in at frequent intervals from surrounding forests and saw-mills, covering all the most common commercial species. Boards and scantlings ranging from 6 $\times$ $\frac{3}{4}$ in to 4 $\times$ 4 in were cut to 30 in lengths and subjected to kiln drying. Sample cross-cut sections were taken from the middle of specimen billets and the green moisture content accurately determined by the oven drying method. By this means it was possible to ascertain the correct stage of humidity at which to commence the drying process. During the first series of experiments, each batch kilned was of identical species and similar moisture content. The kiln schedules applied, were roughly in accordance with the standards laid down by the FPRL. Further research was then directed at producing a simple and easily applied schedule which would suit a mixed load of commonly used timbers, completing the drying process down to 15 per cent moisture content within three, or at the most, four days. Although mixed kilning may seem unorthodox, the output of mills is often so haphazard and timber consumption so fast, that it was necessary to devise such a system in order to persuade contractors that kiln drying could be applied with economic advantage.

The underlying principle of kiln drying is that for the preliminary period, temperatures should be low and humidity of the air current high. If drying out takes place too rapidly in conditions of dry heat, excessive movement occurs in the timber with resultant warping, shakes, splitting and general degrade. However, with considerable patience and a little skill it is possible to balance these conditions and speed up the natural drying process, gently coaxing out the moisture by raising the temperature as humidity is decreased. Very good results were finally obtained from a "blanket" schedule designed to season mixed species of green timbers from about 50 to 15 per cent moisture content, in four days. This schedule was applied to Keruing, Kapur, Kempas, Meranti, Gerongang, Mengkulang, Bintangor and Jelutong; all common timbers.

Kiln temperatures were as follows:—

Timber 50 per cent moisture content reduced to 15 per cent:

Day one	120°F dry bulb	110°F wet bulb
Day two	135°F dry bulb	126°F wet bulb
Day three	150°F dry bulb	130°F wet bulb
Day four	170°F dry bulb	135°F wet bulb

Using the above schedule, kiln drying achieved in four days, results, which by air seasoning, would have taken from ten days to two months according to the species. Timber was also submitted to kiln drying at 100 per cent moisture content. Commencing temperatures were 110°F wet/105°F dry, an additional two days being required.

Not unnaturally, the fast drying of mixed species produced a small, although acceptable, proportion of degrade. Continued experiment indicated that timber first air seasoned down to 25 per cent moisture content suffered rather less degrade and could be submitted to higher commencing temperatures on the schedule. This is a point in favour of kiln drying, since Malayan timber air seasons to 25 per cent moisture content quite rapidly in the tropical heat, but due to excessive humidity it thereafter continues to dry out very slowly. Although it was possible to reduce the moisture content to 10 per cent and lower, in the kiln, little advantage is to be gained by taking it down to this level since the timber later tends to recover moisture from the air, stabilizing at between 12 to 15 per cent.

In addition to the work on kiln drying schedules, accurate records of shrinkage rates were maintained for the various types of timbers handled. These were particularly valuable to the contractor as a guide, especially when cutting green timber planks for flooring blocks, to ensure that the seasoned product held up to the full sizes demanded by the specification. Sample panels of planed timber were also produced to demonstrate the advantage of kiln drying by comparing the improved finish of seasoned timber with that of semi-green boards. A further, but less obvious, asset of kiln drying is the considerable degree of preservation it affords. By submitting timber to the relatively high temperatures of the kiln many boring insects are killed, and fungi and other diseases are rapidly destroyed by sterilization.

Although considerable interest in this experimental work was shown by all concerned, it remains to be seen whether or not the Malayan timber industry will finally accept this lead and adopt kiln drying as a standard practice. As far as I am concerned, it was a fascinating, if somewhat unusual, military exercise.

Conclusion

In concluding this short account of the Malayan timber industry, I should perhaps explain that I have deliberately avoided describing the different timber species and their characteristics. This aspect has already been covered in my earlier article on timber preservation. New species are still being discovered in the forests and research continues to determine how these new timbers may be used to advantage. There is, however, much scope for further development in the industry, particularly with regard to efficient utilization. The policy of conservation by regeneration is of little value unless the forest product is utilized with maximum efficiency.

Finally I must express my thanks to the host of forest officers, forest rangers, logging contractors, and also to the more humble denizens of the Malayan forests, for their patient forbearance in answering the endless stream of questions which my inquiries demanded.

Fusion Welding of Aluminium Alloys

By Major D. L. Jones, RE

Introduction

If the average Sapper Officer were asked "What do you know about welding aluminium alloys?" his answer would probably be something like "Not much, but I believe it is difficult, if not impossible." It is also probable that he would be unable to explain that belief. This apparent lack of knowledge of this subject exists at a time when the Corps, the Army and the engineering industries are using these lightweight alloys to an increasing extent.

They have certain qualities attractive to the engineer, and perhaps the military engineer in particular; a high strength/weight ratio, resistance to corrosion, and freedom from embrittlement at low temperatures are examples. Within the Corps these qualities are applied to bridging and rafting components, Stage II POL pipelines and installations, and hutting.

With the disappearance from the Army of many of the specialist units formerly found within the Corps, construction and repair involving aluminium alloy components may well be tasks for the "general purpose" units such as field squadrons and field park squadrons. Welding is an accepted method of joining and repairing such items in steel; if it is to be applied to similar tasks in aluminium alloy, RE officers should appreciate the implications, since many of the problems are quite different from those associated with welding steel. At the outset, it may comfort our average Sapper Officer to know that no longer need it be difficult or impossible to weld most aluminium alloys, provided the problems are known and the correct method, materials and techniques are used.

This paper attempts to outline these problems and the different fusion-welding methods available, so that the RE officer may have at least sufficient background knowledge of the subject to appreciate the need to treat aluminium alloy welding differently from steel welding. Only fusion welding is considered, since this method is most applicable to Service use.

Aluminium Alloys: Their Main Grouping and Classification

The metallurgical considerations in the welding of aluminium alloys are too extensive to discuss here; nevertheless to appreciate the fundamental problems some knowledge of the materials concerned is essential.

The comparatively low tensile strength and other mechanical properties of pure aluminium can be considerably improved by alloying the aluminium with such elements as copper, magnesium, silicon, zinc, manganese, nickel, iron and chrome. In this article, "aluminium" will henceforward be taken to mean such aluminium alloys unless otherwise stated.

Aluminium alloys can be classified as either cast or wrought, that is, shaped by extrusion, forging, drawing or rolling. Each of these two main groups can be sub-divided in two further categories, heat-treatable and non-heat-treatable. The non-heat-treatable alloys obtain their strength by cold-working. The heat-treatable alloys have their mechanical properties improved by heat-treatment, which may be in one or two stages. The first heat-treatment takes place at about 500°C and is known as "precipitation" treatment. The second, or "double" heat-treatment takes place between 120°C and 200°C; this is known as "solution" treatment. Double heat-treated alloys are also known as fully heat-treated. The higher-strength wrought alloys are usually fully heat-treated.

A summary of the British Standards nomenclature used for aluminium alloys is included at Annexure A and is useful for recognizing alloys described in handbooks.

Characteristics of Aluminium Alloys which Affect Welding

As fusion welding is a process involving heat, one would expect the thermal characteristics of the material to be relevant to the problems of welding. These characteristics are particularly important in the case of aluminium and its alloys.

These materials have low melting points; most lie between 520°C and 650°C, which is close to the first heat-treatment temperature. On the other hand they have high specific and latent heats and require as much heat per lb to melt them as steel does. Their thermal conductivity is three to five times that of steel so that pre-heating may be necessary in the region of the weld to ensure proper fusion of the parent metal. Their coefficient of expansion is also high (twice that of steel), and welds may be subjected to considerable stress during both welding and subsequent cooling. Distortion may result from these stresses unless precautions are taken, such as limiting restraint during setting-up.

Certain of the higher-strength alloys have a tendency to brittleness and subsequent "hot-short" cracking at temperatures in the solidification range. This tendency can be reduced by using a suitable filler metal (usually one with a higher alloy content than the parent metal), correct welding procedure and sequence, correct edge preparation and avoidance of restraint during setting-up.

The welding heat also has other important effects on the material. The metal deposited during welding forms a zone of material of cast structure lying between heat-affected zones of parent metal. The width of these heat-affected zones depends on five factors: the thermal input of welding, the speed of welding, the size of the work being welded, the composition of the alloy, and the arrangement of jigs, clamps etc (which can conduct much of the heat away). The first two of these affect the rate of heat entry, the last three affect the rate of heat dissipation.

Both groups of wrought alloys are softened by the welding heat which thus affects their properties. In the case of fully heat-treated alloys, the effect is analogous to removal of the second heat-treatment. Cast alloys are scarcely affected unless they have been heat-treated.

Since the extent of softening depends on the area heated, it follows that a welding method giving a more local effect, of less magnitude, is to be preferred. The restoration of the alloy's original properties or at least the limitation of their destruction is one of the fundamental problems in aluminium welding and one which until comparatively recently made the welding of aluminium hardly worthwhile.

Aluminium and its alloys have a strongly adherent natural oxide film which is a great advantage in most applications of these metals, as it resists corrosion. During welding, however, this oxide hinders the consolidation of the metal on fusion, and when broken down reforms almost instantaneously in air. The method of dispersing the oxide film, and of preventing its reforming, forms one of the essential differences between various welding methods.

The final relevant characteristic of aluminium and its alloys to be considered is its ready absorption of hydrogen when molten. Modern production methods have reduced the amount of absorbed gas in the unwelded metal to a low level, but the flux coatings of covered electrodes and flux paste may be prolific sources of hydrogen due to their hygroscopic nature. The hydrogen evolved from the moisture and from the metal itself during welding and solidification may lead to gross porosity. This may weaken the welded joint and may also entrap slag residues near the surface, giving rise to subsequent corrosion. Porosity can also be caused by dirt and grease on the surface of the metal, poor edge-preparation, dirty or contaminated filler wire, or poor welding technique.

Preparation and Setting-Up of Work

In general, preparation of the work consists of cleaning and edge-preparation. Cleaning is essential to prevent porosity oxide and inclusions. It is particularly important with broken castings. The surface must be freed of grease or oil, using solvent degreasers such as carbon tetrachloride, trichlorethylene, or chemical cleaners. Such compounds can give rise to dangerous fumes under the heat of welding and all traces of them must be removed before welding starts. The metal is therefore thoroughly washed in hot water.

Excess oxide, dirt films, filmings etc must be removed from joint-edges by scratch-brushing. Emery cloth is not suitable for this purpose, as particles of abrasive may become embedded in the material.

Edge preparation may be important in the prevention of distortion, hot-short cracking, and porosity, and to obtain good penetration. Less preparation is required for arc-welding methods than for gas welding, as complete penetration is more easily obtained. Details of the edge-preparation for various types of work are outside the scope of this article; in general it can be said that no special edge preparation is necessary on material up to $\frac{3}{16}$ in thick. It is essential that the edges, whether butt or bevelled, should be free from burrs, which prevent a good fit-up and may trap dirt.

The work must be set up with the minimum of restraint if the risk of cracking within the weld zone is to be reduced. Jigs help to reduce buckling caused by shrinkage, as they confine the welding heat to the narrow zone along the joint edges by absorbing heat. However, this can also lead to excessive chilling, with a consequent risk of cold cracking, unless the jigs are carefully designed. For example, the risk of chilling can be reduced by using asbestos pads between the jig and the work.

Backing strips are often used to limit penetration, particularly with small gauge material. If the strip is to be removed after use, it is usually made of mild or stainless steel, though temporary backing strips of aluminium are sometimes used and machined off afterwards. Whenever aluminium backing strips are used in electric welding, the current should be increased by 10 per cent, to compensate for the additional chilling effect caused by the higher thermal conductivity of the aluminium.

Summary of Factors Affecting Aluminium Welding

At this point it may be of value to summarize the factors affecting the welding of aluminium and its alloys as follows:—

1. Alloys require either heat-treatment or cold working to develop their mechanical properties.

2. The thermal characteristics of the material make a high thermal input necessary during welding, with subsequent risk of distortion, cracking and loss of mechanical strength due to the destruction of the properties obtained by heat-treatment or cold working.

3. The dispersal of the surface oxide film, and the prevention of its re-forming during welding, are essential to good fusion in the weld.

4. Aluminium and its alloys are very prone to porosity due to hydrogen absorbed during manufacture and from flux.

5. Cleanliness, correct edge preparation when necessary, and setting-up the work so as to reduce or eliminate stressing during heating, are all important factors in the production of a weld free from porosity, oxide inclusions, contraction stresses and tearing.

Welding Methods

The accepted methods of fusion-welding aluminium and its alloys are:—

1. Gas welding.
2. Metallic-arc welding.
3. Carbon-arc welding.
4. Atomic hydrogen welding.
5. Inert-gas shrouded arc, of two types:—

(*a*) Argon arc or Tungsten Inert Gas (TIG) process.

(*b*) Consumable or continuous electrode, known also as the Inert Metal Arc or Metallic Inert Gas (MIG) process.

The carbon arc and atomic hydrogen methods are unlikely to be of importance in the future and will not be described here.

Although accepted methods, neither gas nor metallic arc welding (as used on steel) are wholly satisfactory, for a variety of reasons. This is probably why welding aluminium was generally considered difficult or impossible, at least until comparatively recently when the inert-gas shrouded arc methods were developed.

Both gas and metallic-arc processes are much slower than either of the inert-gas shrouded arc processes and since this means a wider heat-affected zone it has an appreciable effect on the strength of the weld. This particularly applies in the case of gas welding. Although both methods can be used for positional welding, they demand a high degree of skill from the welder;

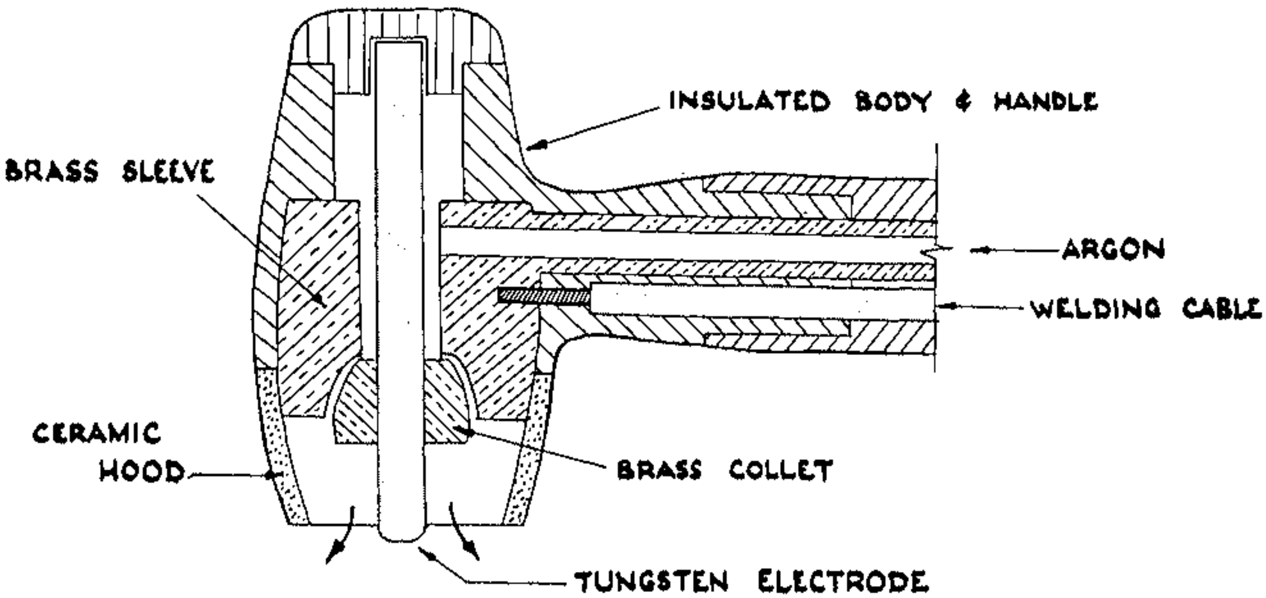


Fig. 1. DIAGRAMMATIC SECTION THROUGH AN AIR-COOLED T.I.G. TORCH.

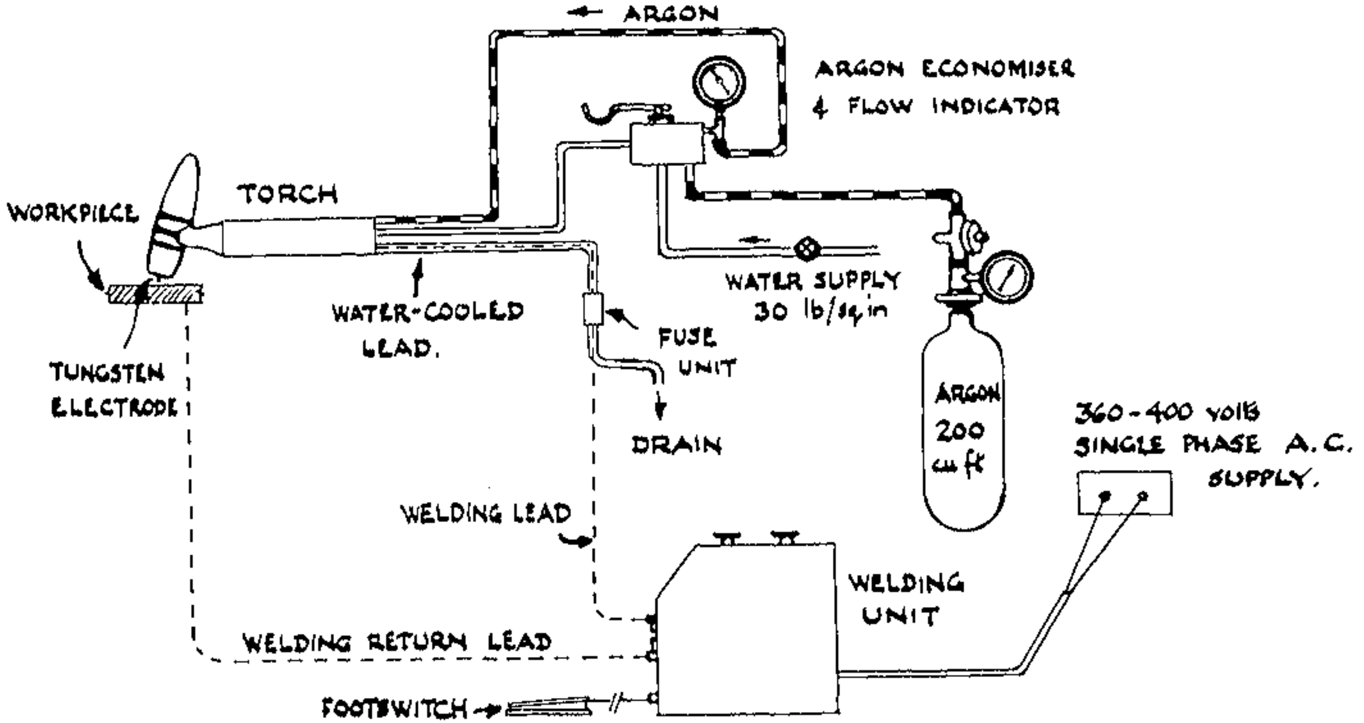


Fig. 2. DIAGRAM OF TUNGSTEN INERT GAS PROCESS.

nothing is easier than burning holes in aluminium unless the welder is really competent. To add to his trials, the welder often has his view of the work obscured by fumes given off by the flux which is used in both gas and metallic-arc welding to remove the oxide film and to prevent further oxidation during welding.

This necessity for flux is the other main cause of the problems associated with aluminium welding in the past. The most effective fluxes contain hygroscopic salts which give corrosive flux residues, or slag. It is absolutely essential to reduce the risk of porosity by keeping filler-rods dry and to remove the corrosive slag. This involves vigorous scrubbing in hot water, followed by dipping in nitric acid and further thorough washing in hot water if slag-entrapment is unlikely. As filler welds are more prone to slag-entrapment than butt welds, they are avoided if possible; this can impose a serious restriction on the designer.

It is very difficult to give post-weld heat-treatment to complete components in the field; the loss of strength in welds made by these two processes may be quite unacceptable. The difficulties resulting from the use of flux are obviously a serious disadvantage of both methods. For these reasons, neither gas nor metallic-arc welding methods are recommended for Service use.

The flux problem can be eliminated by using an inert-gas shroud round the arc to shield the welded area from contamination by atmospheric oxygen and nitrogen, thus preventing the re-formation of the oxide film once it has been dispersed by the arc. There are two methods employing this principle. They are the Argon-arc process, also known as the Tungsten Inert Gas (TIG) process, and the Metallic Inert Gas (MIG) process. The inert gas used in Great Britain is argon, but helium is more usual in America. Both TIG and MIG processes give sound joints with good penetration, reduced heat-affected zone and reduced distortion as compared with gas welding. The capital outlay is higher than that required for the older welding methods, but this should be considered in the light of the increased welding speeds and the sounder and cleaner welds that are produced. Of the two methods, MIG is more likely to be used in the future for military use, for reasons which will be discussed later. As both methods are probably less familiar to the reader than gas or metallic-arc welding, they will be described in rather more detail.

In the TIG process, an AC electric arc is struck between a non-consumable electrode and the workpiece, the filler wire being added separately. The electrode is supported centrally in a ceramic or water-cooled nozzle through which the protective argon flows, preventing oxidation of both the electrode and the weld pool. A section through a typical air-cooled torch is shown at Figure 1. A diagram showing the equipment used in the process is shown in Figure 2. Although theoretically DC can be used, in practice AC is invariably used as it combines the advantages of reasonable penetration and effective dispersal of the oxide film with only moderate heating of the electrode. However, AC does require some means of starting and stabilizing the arc, such as a surge injector or superimposed high-frequency current in the welding circuit. The torches used may be air-cooled for currents up to 150 amps, but for thicker work requiring higher currents (300–600 amps) they are water-cooled, as are the cables. The coolant for the torch may be water, soluble oil or permanent-type anti-freeze, generally depending on climatic conditions. With anti-freeze, a closed cooling system is required, of course. The argon used must be pure (99.9 per cent).

Filler rods are necessary for joints in non-heat-treatable material thicker than $\frac{1}{8}$ in, and for all heat-treatable materials unless the process is used automatically, when higher currents can be used. The correct choice of filler rod is essential; the table at Figure 3 shows the effect of varying rod composition on the mechanical properties of a simple butt joint made in aluminium-magnesium alloy. A filler rod with a higher magnesium content than the parent metal gives a weld with a strength and ductility very similar to those of the unwelded parent metal.

FILLER ROD	0·1% PROOF STRESS tons/sq in	TENSILE tons/sq in	ELONGATION % ON 2 in.
Pure Aluminium	6·5	15·5	19·0
AL + 2% Mg	5·9	16·6	20·5
AL + 3½% Mg	6·7	16·2	21·5
AL + 5% Mg	6·4	16·5	21·0
AL + 7% Mg	6·5	17·4	30·0
AL + 5% Si	6·0	14·4	11·0
Parent Metal	6·8	17·2	33·0

Fig.3. Table showing effect of Filler Rod composition on strength of a butt weld between ½" thick plates of alloy containing 5% Magnesium.

The process can be manual or automatic. Manually, it is a two-handed process, using techniques similar to gas welding. A reasonably high degree of skill is therefore required by the welder. A careless operator could contaminate both weld and electrode by allowing the electrode to touch the weld pool; he can also contaminate the weld by using too high a current, causing the tungsten to burn off. The tungsten will also oxidize and deteriorate unless it is cooled in argon after the arc has been extinguished.

The welds produced by this method are clean, homogeneous and of high quality. The high rate of heat-input, concentrated on a small area, results in a smaller heat-affected zone and less risk of distortion. It is thus very suitable for welding gauge-thickness material, and material up to ¼-in thick. It achieves all this with none of the troublesome complications arising from the use of flux. From the military point of view, it has the disadvantages of requiring bulky and expensive equipment (it will not work on the present WD standard AC transformer), a fairly high degree of skill from the operator, and lack of flexibility, inasmuch as many joints accessible to a metallic-arc electrode may be quite inaccessible to a TIG torch.

These disadvantages do not apply to the process known variously as the Inert-Gas Consumable (or Continuous) Electrode, Inert Metal Arc or Metallic Inert Gas (MIG) process. This comparatively recently developed process employs an arc struck between the workpiece and a filler wire which acts as both filler and electrode and is fed continuously at a pre-determined rate through the welding torch nozzle. The arc is protected by an argon gas shroud as in the TIG process. Direct current varying between 145 amps and 450 amps, depending on the thickness of the material being welded, is supplied from a standard drooping-characteristic welding set. Current densities obtained are of the order of 100,000 amps/sq in (compared with 7,000 amps/sq in obtained with metallic-arc welding). A constant arc length is maintained by one of two methods, the "self-adjusting arc" process, or the "controlled arc" process. In the former the electrode is fed at a pre-set constant speed and the arc voltage varies with momentary changes in the distance of the torch from the work; in the latter, the arc voltage is pre-set and the wire feed speed automatically varies to maintain that arc voltage.

A schematic diagram of the equipment is shown at Figure 4. The electrode wire is coiled on a reel and fed through a motor-driven device giving control over rate of feed. It then passes through a flexible tube which conducts argon to a trigger-operated welding-gun. The gun trigger operates both gas and electrical controls. It can be either air-cooled or water-cooled, like the TIG torch. Electrode wire diameters vary from 0.03 to $\frac{3}{32}$ in; these are suitable for welding material from 16 SWG to 2 in thick. It is essential to use only wire specially prepared and spooled by the manufacturers, who strip the thick, porous oxide film and substitute a thin, hard film which does not readily absorb moisture. This reduces the risk of porosity.

Other conditions necessary to obtain good welds by the MIG process are adequate shrouding by high purity (99.98 per cent) argon, correct arc length and torch angle (to avoid incorporation of weld splutter in the weld), and absence of air leaks in the equipment. Provided these are fulfilled, it is quite normal to obtain butt welds with a tensile strength efficiency of 85–90 per cent relative to the annealed parent metal. The high heat intensity obtained permits high welding speeds (as much as three times those obtained with the TIG process) and limited heat-affected zone. The risk of distortion is reduced accordingly. The method gives better penetration than the TIG process, and good root fusion in fillet welds.

Once he has mastered the appropriate control settings for particular types of work, the operator can produce good welds more easily by this method than by any other, as less manual dexterity is required. Manually it is a "one-handed" process and reasonably good for welding where access is difficult. It is very suitable for positional welding owing to the spray form of metal transfer across the arc; this is caused by the high current density. Automatic welding can be carried out by this process, making it possible to

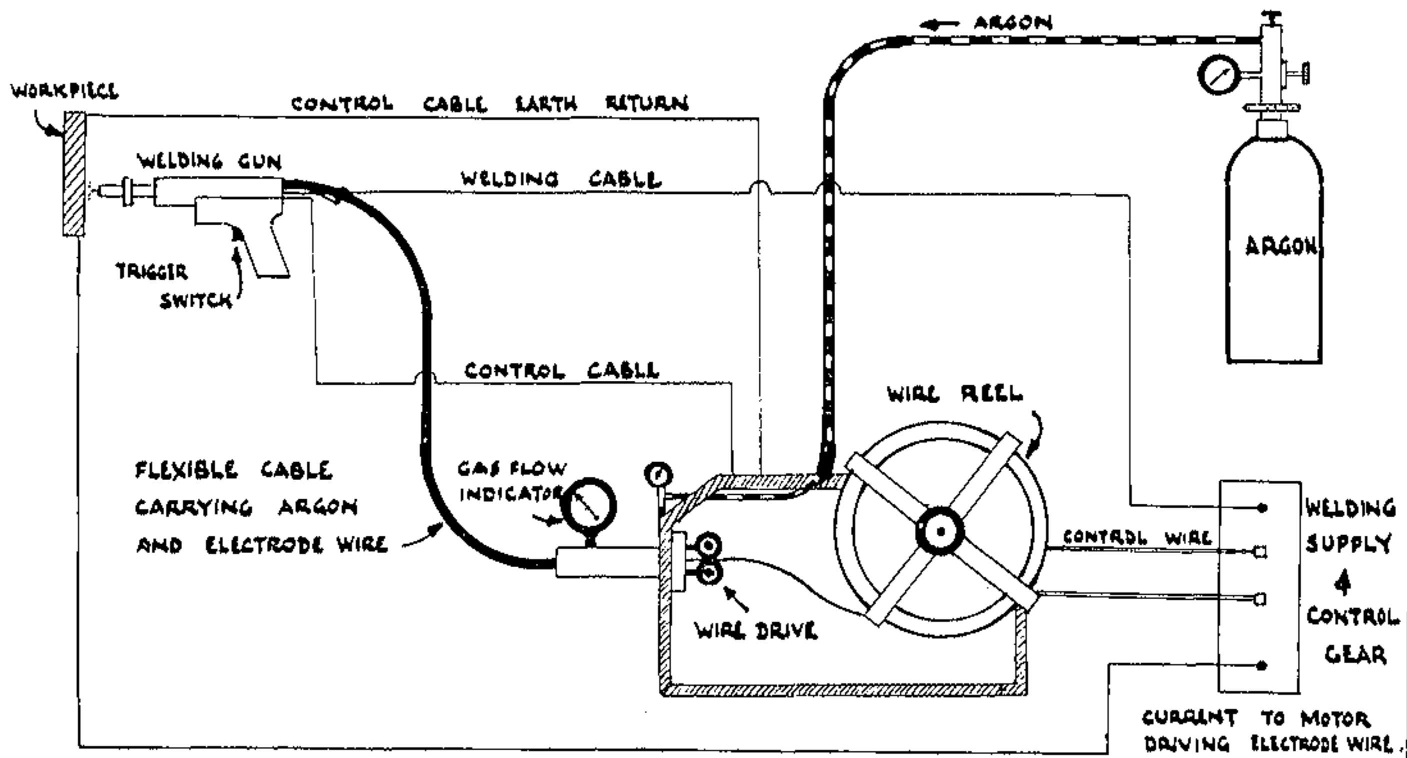


Fig. 4. DIAGRAM OF METAL INERT ARC PROCESS.

use even higher currents. The wide range of wire sizes which can be used in the process give it flexibility over a wide field of application. Normally the conventional machine is not used on material thinner than $\frac{3}{16}$ in but recent developments are bringing gauge-thickness materials within the range of the process. There are at least two developments of the process which are of interest to the military engineer and these are described below.

Developments of the MIG Process

Some of the manufacturers of welding equipment have produced small hand-guns for the MIG process; originally they were intended for use on gauge-thickness metal, but have proved very versatile and in fact can be used to weld any size of aluminium sheet, plate or section currently in use in the service. An example of these small hand guns is the Sigmette, produced by Quasi-Arc Ltd., which can be used on material from 18 SWG upwards, as it uses the "short arc" technique. The gun and circuit is illustrated in Figure 5.

The gun weighs only 3 lb 1 oz and is very compact, making its use possible in confined spaces inaccessible to other torches. It carries a 1 lb spool of filler wire, which gives it good balance and makes positional welding comfortable. A choice of three different wire-feed motors is available, the choice depending on the wire sizes and plate thicknesses to be welded. The motor is easily removed from its housing in the gun handle, using only a screwdriver. An inching button in the gun handle positions the wire initially. At the start of the weld, the action of pulling the trigger starts the gas flow and causes the wire to feed slowly. As soon as the arc is initiated, full wire speed is rapidly established. The control cabinet weighs 19 lb 2 oz and can be carried in one hand. It contains relays to operate the welding current contractor and to start the gas flow. The standard cable supplied is 30 ft long, which permits a reasonably wide radius of operation between control and gun.

Although the process appears easier to use than it is in fact, it requires only about a week's training to convert any reasonable electric welder into a completely proficient Sigmette operator. Because of the varying sizes of wire it will take (from 0.03 in diameter upwards), it is a flexible process. It is also versatile; by using carbon dioxide instead of argon, and the appropriate steel filler-wire, it can be used very successfully for welding mild steel plate of quite appreciable sections. These welds can, of course, be guaranteed free from slag inclusions, and this makes possible the *in situ* repair of high-tensile structures. Finally, by using argon and steel wire, it can be used for cutting aluminium, though this application cannot be considered normal.

Although the Sigmette requires DC, the characteristics of the DC welding sets in service use are not completely suitable for it; on the other hand, the correct DC equipment for the Sigmette is extremely good for normal welding.

Another development of the MIG process which is of particular interest to military engineers is an automatic pipe-welding machine developed for use on aluminium oil pipelines in Canada. Aluminium is a very useful material for pipelines, as its lightness makes possible higher laying speeds with any given labour force, and it is corrosion-resistant. Laying speeds are normally dependent on pipe-jointing methods. Manual welding by the older methods is too slow, does not produce high quality welds and requires very skilled operators. The use of conventional aluminium pipe couplings at each joint means a considerable quantity of yet another item to be provided

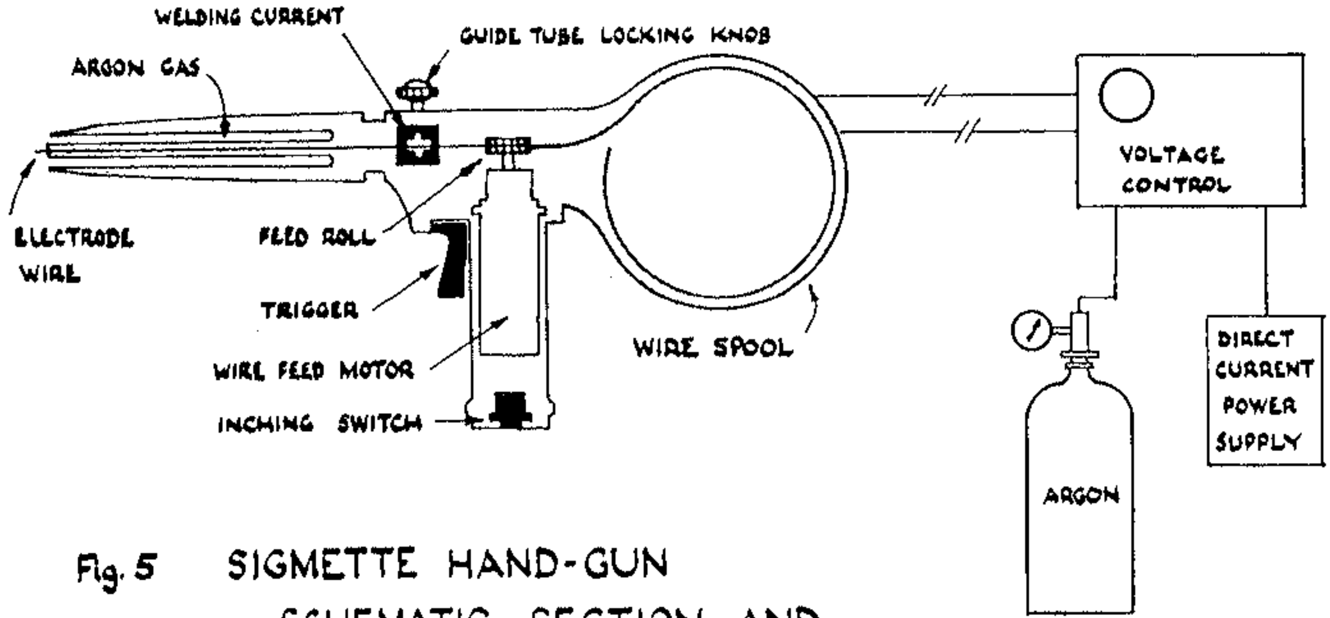
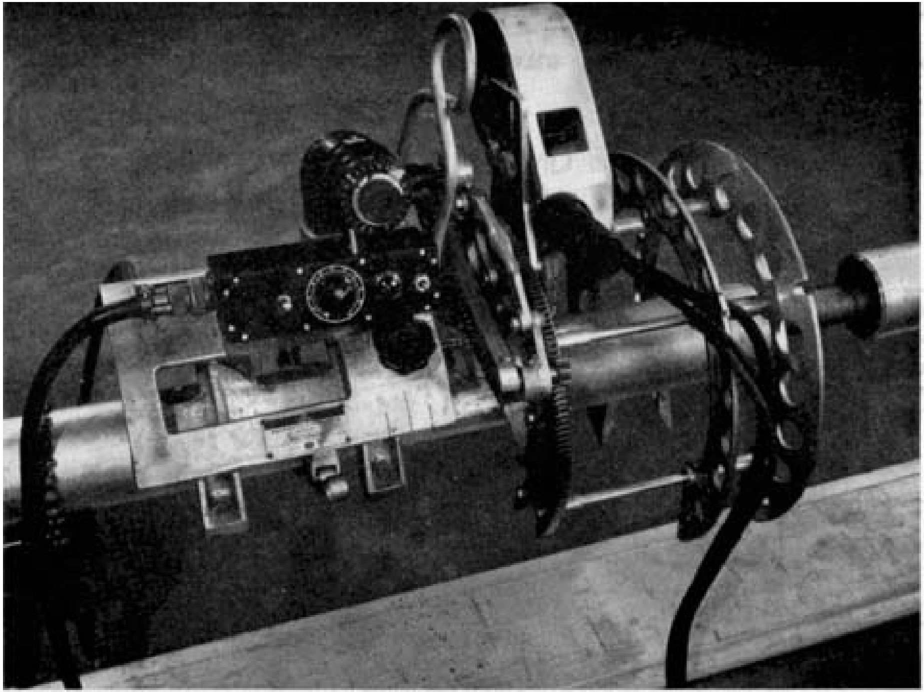


Fig. 5 SIGMETTE HAND-GUN — SCHEMATIC SECTION AND OPERATING CIRCUIT.

[NOTE: THE GUN IS GREATLY EXAGGERATED RELATIVE TO THE OTHER COMPONENTS]



(By courtesy of Aluminium Laboratories Ltd.)

Photo 1. Light alloy pipe-welding machine mounted for use, showing control panel, torch-rotating gear, welding torch, wire-drum and wire-drive motor, torch cable and gas-duct.

Development Of The MIG Process 1

(By courtesy of Aluminium Laboratories Ltd.

Photo 2. The pipe-welding machine in use in the field, with its generator and ancillary gear on the truck nearby.

Development Of The MIG Process 2

and handled, and does not guarantee prevention of leakage of the product in the pipeline. The automatic pipe-welding machine described below uses the MIG process and appears to provide the answer.

The machine is shown in photographs 1 and 2. The ancillary equipment is carried on a truck. The machine is available in several sizes, each handling a range of pipe sizes, such as 1½ to 4 in diameter, or 4 to 8 in diameter. The former machine weighs about 35 lb, the latter about 60 lb. The machine consists of a portable aluminium mechanism which clamps to the pipe by quick-release toggle-chain and rotates a special torch around the pipe in accurate alignment with the pipe axis and the joint plane. Attached to the torch is the drum containing the consumable electrode wire. Mounted on the machine platform is the operator's control panel. The ancillary equipment is separate and consists of a DC welding-power source, an argon supply, a secondary welding-circuit contactor, a 115-volt 50- or 60-cycle control circuit power supply and a relay enclosure. All this can remain on a truck near by. The torch uses 0.035 in diameter wire and has a highly effective self-regulating arc operating at current densities of the order of 200,000 amps/sq in. The torch can be rotated in either direction and the normal procedure is to use as many rotations round the pipe in one direction as another, so that when the weld has been completed the torch cable is completely unwound. In action, the machine is quite spectacular.

A small portable edge-preparation tool is supplied with the machine; the other device supplied is a combined backing-and-alignment tool consisting of three stainless steel cylinders mounted on a shaft to form an expandable mandrel. This enables accurate alignment of the pipes to be achieved, with subsequently higher joint efficiency.

Details of the machine's performance are impressive. It welds 4 in diameter pipe in four passes in 40 sec using a welding current of the order of 180 amps at an arc voltage of 18–20 volts. A typical argon consumption rate is 30 cu ft/hr, though this would have to be increased by 50 per cent on windy days. Like all gas-shrouded processes, this method requires screening of the arc from the wind, though welding without wind screens has been successfully carried out on days when wind speed was normally 20 m.p.h., gusting to 50 m.p.h. It is claimed that an average jointing rate of twenty joints an hour can be achieved; for how long this could be maintained is open to conjecture.

Tests on pipe joints made by the machine have given very satisfactory results and show only a small reduction in the strength of the material, particularly if non-heat-treatable alloy is used. The machine is comparatively simple, robust, and portable, and requires the minimum of maintenance; these are all important military characteristics. A more compact power source would probably be necessary before it could be adopted as a military equipment for use in the field.

With the present-day need to keep to a minimum all import tonnages of stores for the maintenance of any field force overseas, the use of aluminium for all Stage II POL pipelines assumes an even greater importance. In this connexion, the local production of pipes by helically welding aluminium plate is an idea obviously worth pursuing. A special machine for shaping and welding the pipe automatically would be required, and judged by the performance of the pipe-jointing machine described above (which would then be complementary to the pipe-making machine), the welding process selected should be the MIG.

Safety Precautions

Before leaving the subject of the TIG and MIG processes, it is important to mention safety precautions. All the standard safety precautions used in the arc welding of steel are important and apply also to the inert-gas shrouded processes. In these processes, however, the welding currents for aluminium are usually higher than for steel of the same gauge, and additional protection against radiation from the more intense arc is essential. For example, darker welding glasses are required. No areas of skin should be exposed to direct or reflected arc radiation; as soldiers frequently work stripped to the waist in tropical climates, this point is of particular importance to the officer. The importance of removing all traces of chemical cleaner owing to the emission of dangerous fumes has already been mentioned; those containing trichlorethylene break down to give phosgene, for example.

Weldability of Alloys

At its simplest, "weldability" denotes the ease by which a metal or alloy can be welded, but in general it is now used as a measure of weld efficiency, that is, the comparison of the properties of the welded joint with those of the unwelded parent metal. The weldability of a particular alloy of aluminium will depend on three or possibly four things: the type and composition of the alloy itself, the composition of the filler rod (if used), the welding process used, and the skill of the welder (in some processes particularly).

Of the wrought alloys, only pure aluminium and the lower-strength non-heat-treatable alloys can be gas or arc-welded without much difficulty. Alloys containing more than $3\frac{1}{2}$ per cent of magnesium (N5, N6, N7) require more skill when welded by the gas process, but are easily welded by TIG or MIG. The heat-treatable alloys are liable to crack if heated under restraint, whatever welding process is used, and care may be required in joint design. Those containing small quantities of magnesium and silicon (H9, H10, H20 and H30) are weldable by MIG and TIG and can have high weld efficiencies, particularly if heat-treatment of the welded assembly is practicable. It is possible, but difficult, to weld some of the high-strength alloys such as H15, using parent metal filler, but fusion welding of these alloys is not at present recommended.

Most cast alloys present no problems but heat-treatable cast alloys are not normally welded unless they can be subsequently heat-treated.

The Design of Welds in Aluminium

Before preparing a design, whether for fabrication or repair, the engineer should consider the method of welding he intends to employ, taking into account the material, its type and thickness, the design of the joint, the rate of production, the conditions of service (the effect of corrosion, the nature of the stress, etc), and the skill of the welders. In designing a joint, various points have to be considered. For example, a joint involving the least amount of metal means that the total heat input can be quite small, and therefore that welding can be carried out at high speeds. The joint must be readily accessible, to permit satisfactory joint preparation and the use of jigging arrangements, and to facilitate any post-weld finishing operations and the removal of flux, if this has been used. If possible, the joint should be so placed that roughly the same amount of heat is absorbed by the metal on each side of it.

The butt joint conforms best to these requirements, in components of equal size and thickness. Lap and fillet welds should be avoided in gas or metallic-arc welding, owing to the risk of flux inclusions, but can be used in the TIG or MIG processes.

In general, the properties of a weld are approximately those of the parent metal in the annealed condition, and this loss of strength must be borne in mind during design, since post-weld reheat-treatment of welded assemblies is seldom practicable.

Problems Facing the Military Engineer

The military engineer concerned with welding aluminium has certain peculiar problems of his own. These can be grouped broadly into men, materials, and equipment. Each will be discussed below.

In this connexion, "men" means military welders. Generally, the average military welder has more experience in welding steel than aluminium. It may be difficult for him to produce sound welds in aluminium using the gas or metallic-arc methods he usually uses on steel, owing to lack of practice, insufficient skill, or lack of familiarity with the problems and techniques involved in welding aluminium. In the case of the Regular Army tradesman, ensuring that he is familiar with the problems, techniques and methods involved can be achieved by adequate training. Mobilization of the Reserve Armies may involve the use of welders who in civilian life are perfectly capable of welding steel but are unfamiliar with aluminium. Both Regular and Reserve welders, in most cases, are likely to be lacking in practice in welding aluminium. The best solution to this problem appears to be the adoption of a method requiring the minimum of further training and experience, yet giving sound welds and having reasonable flexibility. Of the accepted methods, MIG offers most advantages in this direction, and there would appear to be a need for some easily portable equipment similar to the Sigmette. This equipment is adequate for virtually all Service needs, and is furthermore versatile since it can also be used for welding steel.

The material itself raises two problems for the military engineer, who frequently is dealing with jig-welded assemblies designed to take particular loads. In many of these, such as bridge or raft components, there is a need for close tolerances in order to achieve interchangeability of parts. This may be difficult to obtain in view of the appreciable shrinkage which is possible in members which have been repaired by welding. This shrinkage can be reduced by using inert-gas shrouded methods; otherwise, parts may have to be designed to work on larger tolerances, since the jigs necessary to ensure perfect fits are far too bulky to be acceptable outside a base workshop.

The loss of strength in a member repaired by welding can be as high as 40 per cent if gas or metallic-arc methods are used. Whether it is acceptable or not depends on the design and function of the particular member. The loss of strength is much reduced when MIG or TIG methods are used but may still be unacceptable. In some cases the part may have to be scrapped and replaced; in others it may be strengthened by splicing in new sections, either by welding or by using alternative methods which do not use heat, such as bolts or rivets. Such repairs should be designed by an engineer, not a tradesman.

Welding equipment in the Army has to be as flexible and as versatile as possible. It is perhaps unfortunate that few, if any, of the existing service equipments are ideally suited for welding by the MIG or TIG methods, which give the best results on aluminium. This need for versatility should not be allowed to debar the adoption of a particular equipment for service use, even if its application is limited (as in the case of the pipe welder) provided that application is likely to occur on a large enough scale.

Conclusions

Welding aluminium by the older methods of gas and metallic-arc welding calls for a higher degree of skill than the average military welder is likely to achieve without considerable and constant practice. Even when the welders are competent and experienced, the resulting welds appreciably weaken the material. The use of flux in these two methods raise problems of corrosion, porosity and slag inclusions.

The thermal and metallurgical properties of aluminium and its alloys raise problems such as loss of strength, risk of cracking and distortion, which the engineer concerned with any repair or fabrication involving welding must bear in mind when designing joints and deciding on the methods and materials to be used.

Of the available welding methods, the metallic inert gas using argon is the best, producing very sound welds in practically any aluminium alloy, without any of the problems associated with flux, at high speed and requiring the minimum of preparation and practice from the operator. Particular developments of the process such as the small hand guns like the Sigmette, and the pipe-welding machine, would appear to have definite military applications.

Notes on British Standards Nomenclature of Aluminium Alloys

1. *Introduction*

The nomenclature outlined below is used in the following British Standards:—

(*a*) BS 1470–1477 (dealing with various forms of wrought material).
(*b*) BS 1490 (dealing with ingots and castings).
(*c*) BS 499 (glossary of terms relating to welding and cutting of metals).

2. *The nomenclature consists of:*—

(*a*) A letter indicating the type of alloy (i.e. casting, non-heat-treatable wrought, or heat-treatable wrought).
(*b*) A letter indicating the form of the material (eg sheet, tube, plate, etc.).
(*c*) A number indicating the composition of the alloy.
(*d*) One or two letters indicating either:—
(i) degree of temper (non-heat-treatable wrought alloys).
or (ii) condition of heat treatment (heat-treatable alloys).

3. *Type of Alloy*

The type of alloy is indicated as follows:—

(*a*) LM—casting alloys.
(*b*) N—non-heat-treatable wrought alloy.
(*c*) H—heat-treatable alloy.

4. *The form of the material*

(i) When the prefix LM is followed only by a number it indicates that the casting alloy is in ingot form.

(ii) The form of a wrought material is indicated by one of the letters below:—

S sheet and strip
C clad sheet and strip

P plate
PC clad plate
E bars, rods and sections
F forgings and forging stock
T drawn tube
B bolt and screw stock for forging
V extruded round tube and hollow sections
R rivet stock
G wire

5. *Composition of alloys*

(*a*) Cast alloys are numbered 1 to 24 in BS 1490.

(*b*) Wrought materials are arranged in BS 1470–1477 in numerical order corresponding approximately to increasing strength. The grades of pure aluminium are 1A, 1B, and 1C, in descending order of purity, and the wrought alloys follow from 2 onwards.

6. *Condition of the alloys*

(*a*) Non-heat-treatable alloys have their condition of temper indicated as follows:—

O annealed
OD annealed and lightly drawn
¼H, ½H, ¾H, H } the various harder tempers in the case of sheet and strip, plate, drawn tube, wire and rivet stock.
M as manufactured, ie as rolled, extruded, drawn or forged.

(*b*) The condition of heat-treatable casting alloys is indicated as follows:—

M as cast
W solution treated only
P precipitation treated only
WP solution treated and precipitation treated.

(*c*) These letters have similar meanings when applied to heat-treatable wrought alloys, which are described as follows:—

M as manufactured
O annealed
OD annealed and lightly drawn
T solution treated, requiring no precipitation treatment
W solution treated, will respond to precipitation treatment
WP solution treated and precipitation treated
WD drawn after solution treatment
P precipitation treated only

7. *Examples*

The following examples will illustrate the system of nomenclature:—

(*a*) LM 18 casting alloy No 18, in ingot form
(*b*) LM 12-WP alloy No 12 in the form of a casting which has been solution and precipitation treated, ie fully heat-treated
(*c*) NS 3–¼H non-heat-treatable wrought alloy No 3 in the form of sheet or strip, and in the quarter-hard temper
(*d*) HT 10-W heat-treatable wrought alloy No 10 in the form of drawn tube which has been solution treated and which will respond effectively to subsequent precipitation treatment thus completing full heat-treatment.

Moving by Air

By Major T. C. White, RE

There is nothing very difficult about moving a field squadron by air. Given enough aircraft, enough time, and sufficient timber and screws, everything can be packed up and firmly despatched to the other end wherever that may be. Whether this operation is carried out to the best possible effect is open to doubt because it is insufficiently practiced.

The days when endless numbers of Dakotas were available are over, and even the plentiful Globemasters that supported the parachute brigade into Jordan in 1958 may not always be forthcoming. Scant study of the white papers of recent years, and indeed the events both operational and training which have taken place in Africa and the Arabian Peninsula in the past four years show that air movement is with us in a big way. Air portability is no longer the prerogative of the parachute squadron and the AFG 1098 for a field squadron should now be related to the manner in which it will fit into Beverleys and Britannias rather than into 3-ton trucks. Better still it should be related to the aircraft that will follow the Beverleys and the Britannias; the Argosies, Belfasts and the Belvederes. But what do these even look like? The following paragraphs may whet the appetites of those who have never made an operational air move.

The sequence of moving a unit by air is interesting in itself. Take the case of a squadron moving as part of a brigade group. The brigade will have a staff table showing in terms of freight, vehicles and personnel, those parts of each unit that would normally move by air. The field squadron will figure in this table and will almost certainly be shown split down to troops. Tailored to fit the particular operation in hand this table is then presented to a joint Army/RAF conference of Movementeers who will set it against the available aircraft; plan the move as a whole; and allocate aircraft to the Army. This allocation is detailed in an air movement table, which shows the numbers and types of aircraft, the loads they will carry, and the detailed movement of each plane. The brigade will then allocate these aircraft to its units, and issue a detailed movement plan in the form of an air loading table. This table shows in terms of men, vehicles and freight what each unit will carry in each aircraft, and it is at this stage that the unit commander must make his own plan. He does so leaning heavily upon the shoulder of his UEO—Unit Emplaning Officer—who is good at figures and knows something about aircraft and their capabilities; but more of him later.

It is seldom that a troop and its freight ever travel together in one aircraft. A typical situation is that the men will be carried in three separate aircraft and the stores and vehicles (probably only the Landrover and the Ferret) will be split between another two. These aircraft may be of perhaps three different types, all with varying speeds and ranges, and some may consequently have intermediate stops on their journey; they may have to take off from separate airfields and have to land at different places in the country of destination. It is against this confusing background that the detailed movement plan within the unit must be made.

One problem is that of "split" aircraft; these are aircraft where the load is divided between two or more units. What can easily happen is that the field squadron is allocated freight space on an aircraft in which all the passenger space has been allocated to another unit. On the principle that no one should ever lose sight of his own kit it is essential that at least one man is got into that aircraft. This is normally done by persuasion with the other unit concerned, and they take a man off only to discover that they have to fit him on to another aircraft somewhere else. Thus a chain reaction is started that can easily end up with the brigade postal officer going in with the leading company. This is but one example of many last-minute adjustments that may have to be made. The basic problem of course is to get the right number of men and the right quantity of stores to the other end to get a specific job started, or to cope with the unexpected. The importance of accurate estimation of the amount of freight required is obvious. Changes of freight weights are unpopular, and the nearer to the time of the move the more unpopular they become. The ideal unit will produce at the airfield their weight allowance correct to the nearest pound, because being underweight is just as unpopular as being overweight. In order to do this a "cushion" of some sort is required to which last-minute adjustments can be made. This cushion must not be so large as to waste aircraft space should none of it have to be forsaken, and it can therefore only be worth two or three hundred pounds at the most. The cushion should be something that is likely to be available at the other end. If an extra compressor is required at the last moment then the UEO must go, cap in hand, and ask for more weight allowance; but who forgets a compressor? The right answer is achieved by the right estimate in the first place of what is required to do the job and no subsequent alterations being made. Easy, you may say? It is easier when a truck can be sent back to base for something that has been forgotten than when there is no truck and no base.

Once the squadron commander has made his movement plan it is the UEO who carries it out. The UEO must be fully versed in all matters of air movement and should certainly have attended a UEO's course at Old Sarum. He must know the capabilities of aircraft in current use and something of the relationship between altitude, temperature, fuel load and payload. It is disconcerting for the RAF to be confronted with a row of blank faces when they start talking about ambient temperatures and reduced all up weight. He must know something of load distribution in aircraft and how the common items of equipment are loaded and lashed down. He should know how the RAF make their final calculations to determine the safety of each aircraft and its load before it is allowed to fly. He must know how to calculate the number, strength and distribution of lashings required to hold down any piece of equipment in the air, and finally he must know the documentation procedure in great detail. With this basic knowledge the UEO is in a position to keep his unit in a state of constant readiness to move by air.

For a troop to be at forty-eight hours notice to move by air is not unusual, but this entails a high degree of readiness, particularly in the troopstore. Every piece of equipment that is liable to be moved must be boxed or packaged, marked in the right way, and accurately weighed. A carpenters' tool kit for instance will have on each corner of its box (which weighs almost as much as the tools inside) a triangular marking in the unit colour. This identifies the box quickly when it is mixed up with another units' kit. It will also have a serial number painted on it; every item loaded must have a serial number, and each troop or company must have its own block of numbers. Finally it will have its troop identification sign and, most important of all, its weight painted on three sides. Weights are frequently subject to change, and although there are many temporary ways of indicating the weight, the only really safe way is to paint it on every package. Each box should have a list of contents inside it and it is as well to have this annotated with the weights of the major individual items. Thus if one of these items is removed for some reason then the new weight of the box may be calculated without having to find a pair of scales. The troop will maintain a freight list showing the detail of all its boxes; the contents, the weights and the dimensions. Thus it is but a moment for the troop commander, once he has decided exactly what is to be taken, to make a firm bid for freight allowance. All this takes considerable time and effort to keep up to date, because much of the equipment will be in daily use, and weighing and checking must often be done at night. The UEO in his turn will keep copies of all freight lists in the squadron, including of course the headquarters and park troop, and it is his job to see that they are all kept up to date. He must also know the number of men that are available to move at any time, and this entails the maintenance of an eligibility roll. Each theatre or formation will have laid down the residual service that a man must have before he is eligible to move to an operation. Thus the number of men available to move will continually alter. The UEO must also ensure that the unit is capable of loading its own equipment efficiently into whatever aircraft it is given. Each troop must have its own vehicle loading team who must know how to load a vehicle into various kinds of aircraft, and how to lash it down correctly. Lashing diagrams are published for most vehicles, and these show in detail how the equipment should be secured. The NCO in charge of each team must know these by heart. The drivers must be trained too. It is not easy to back a vehicle into an aircraft and position it in exactly the right place first time. Drivers need practice at this which is something that can be done in unit locations by building a suitable mock-up. If all these things, and a good few more that have not been mentioned, are kept up to date, then the UEO should have a reasonably straightforward job fitting the unit into the space allotted in the air loading table. Nevertheless this task may take anything up to eight hours continuous office work, and it is at this time that the UEO must be relieved of all other duties, and given a high-powered assistant to check figures and to help with the documentation. An education sergeant is a good bet if one can be found. This little team is all important at this stage and it should be given every facility that it requires; not the least of which is an adding machine (bought from the COs fund).

It is worth considering at this stage who is the most suitable person to be the field squadron UEO. It certainly should not be the second-in-command who will be administratively overloaded anyway prior to an operational move, and during the move itself will in all likelihood be acting as OC. The arguments are many, but they resolve themselves into the desirability of having a really experienced troop commander as UEO, against the undesirability of having a troop commander tied up in this sort of job at all. There can obviously be no set answer to this problem, but it is not necessarily an easy appointment to fill. The tendency to give the job to the most recently joined subaltern together with those of "security" and "hygiene" will fail to secure a dividend.

Up to eight hours may seem a long time to prepare the paper side of such a move, but there are all sorts of troubles that may be run into. For instance there may be difficulties in deciding the exact number of men to fly, for although the eligibility roll gives the theoretical number, there are always some imponderables; such as the number of men who are on leave and will not be back in time to move; the size of the commander's reconnaissance party which tends to get bigger as time goes on; and the size of the rear- and sea-move parties which tend to grow as their responsibilities become apparent. Items of stores issued at a late hour on a formation basis can cause a headache too; extra jerrycans, sand channels, chaguls and even an extra day's rations, and all to be carried within the unit freight allowance. With all the will in the world the best laid plots are subject to change and it is not unknown for the unit freight allowance to be cut by the odd thousand pounds or so at the last moment. This is the UEO's nightmare. Having worked out the detail the UEO must then prepare the load manifests which show in great detail exactly what is carried in each aircraft. The weight, size, and contents of each package are shown on this form, as is the name of each passenger and any individual priorities in passengers or freight. This is an important document and it must be accurate. It is used to load the aircraft and it is virtually the pilot's voucher for what he is carrying. About ten copies are required. Only the bare essentials of the paper work have been mentioned here because the documentation of an air move is a subject in itself. That there is too much paper work involved there is no doubt, and various new systems are being tried out in order to reduce it.

Now for the business of how stores are boxed or packed ready to move. During a recent move of part of a field squadron approximately one-eighth of the total freight carried was packing material; timber, screws, hinges, metal banding and so on. For a field troop that is allowed say 4,000 lb. of freight this represents 500 lb. of equipment lost. This is not making the best use of those aircraft that are available. The aim must be to get the maximum number of men and the greatest weight of equipment into the minimum number of aircraft.

The first thing to realize is that each package must be able to withstand being dropped from the tailboard of a 3-ton truck to the ground at least three times during its journey (unloading parties are sometimes produced by other units), and at least once from the loading doors of an aircraft. One of the best available articles is the air move hamper made of strong wicker work which has the great advantage of being reasonably light—they are also extremely useful for large-scale picnics. This, however, does not lend itself to the great variety in shapes of sapper loads. It is extremely hard to come by and seems to be "going out". There has recently come into service a collapsible plywood box. This is also light but a degree too collapsible. Two ejections from the rear of a three-tonner with one of these boxes full of clothing proved fatal. And again these do not lend themselves to sapper loads. We are left then with timber boxes or crates, made to measure for each load, and miles and miles of steel banding. Wooden boxes are convenient. They can be made exactly the right size and shape and they can be strongly made. They can be made with lids that can be nailed or screwed down, or they can be hinged and have hasps and staples and padlocks. All this may not seem very important at first glance, but if there is an intermediate stop in a units' progress from one place to another and some work is required there (and when is it not required?), it is infinitely important to be able to get at some items of equipment quickly. It is just as important to be able to pack these items up again with ease and speed, preferably without having to use the hammer which is inside the box anyway. This is all very fine and secure, and looks simply splendid when the unit is inspected in its air move order—row upon row of nice symmetrical packages, enough to gladden the heart of any quartermaster. But a wooden box built to carry say a hundred minefield marking lamps may weigh about twenty pounds and the lamps themselves will weigh not much more than a hundred pounds. This is obviously wrong, and there must be some altogether new ideas to get over this problem. What about some light alloy "shopping baskets" for such things as section and tool kits? Some form of light plastic netting would carry rolls of tracing tape, clothing and other expendable stores. A quick-release light-weight chain worked on a ratchet principle would be ideal for bundles of picks and shovels, compressor drills and the like. Steel banding is out of date; it is too slow to secure and is not easily re-used.

There is a phobia in the services for boxing and parcelling anything that is capable of being boxed or parcelled. Two years ago wireless batteries were being boxed in sawdust or rubber pads for air move. Now they are carried unboxed. Why should wireless sets and a number of other things not be carried in the same way? A wireless set that is seen to be a wireless set will be handled with reasonable care by a soldier, but a set that is in a box is just another box and must take its chance because after all it may just be cotton waste. What is the best way to carry office stationary? Surely not in the steel office boxes and wooden crates that are used at present. No commercial firm would waste the money (and weight is money to them) on such a method of packing small quantities of material. Something on the principle of the composite ration box might be the answer. Strong cardboard has flexibility and positively enjoys taking a beating. The whole of a squadron office, less perhaps the typewriter and the duplicator, could be moved in empty ration boxes with tremendous saving in weight, and replacements should not be difficult to come by. These are but a few ideas; there are many that could be tried.

In conclusion; perhaps there should be a good deal more air-mindedness than there is at present. Air movement is an art in itself and it deserves special study by the arms and services, supplementary to the work done by The Army Air Transport Development Centre. The packaging of an RE section and a battalion water point deserve as much, if not more, study as the packaging of items that come out of an ESD or the air dropping of a bulldozer. The sapper UEO has a special task in that he has to explain away strange shaped packages which have not previously appeared in the day to day business of the staff officer but which now must form a part of his education. Never does the weight of an anti-tank mine become so apparent to a staff officer than when he discovers the small number of mines that can be transported from a tropical airfield several thousand feet above sea level!

It was a surprise to me too.

Towards United Europe
A Problem of Measurements

By Major D. M. R. Esson (RE Retd.)

In 1793 Great Britain embarked upon a War with France which was to last, with two short interruptions, for twenty-two years. It was in truth a struggle between two great civilizations, transformed from the drawing rooms and salons where sages might meet and discuss their differences, to a hundred bloody fields stretching from the snow-clad steppes of Russia to the wet and windy heights of the Peninsular, and the oceans beyond. Our only War Aim was the overthrow of Napoleon, the embodiment of the Revolution Militant. With the ideals of those who stormed the Bastille there was much sympathy; with their methods there was abhorrence; yet to obliterate their domestic achievements there was virtually no attempt.

Enthroning Reason with orgies in Notre Dame and insisting upon her worship with the aid of the guillotine, the leaders of the Parisian terror proceeded to issue decrees whose object was to demonstrate the futility and uselessness of anything connected with the "ancien regime", and the exaltation of the new. In accordance with this doctrine the currency was decimalized, the system of weights and measures replaced, traffic ordered to keep to the right of the road, and the calendar reorganized. The successes of their principal soldier impressed the substance of these decrees on much of Europe: and once the change had been effected there was little desire to revert to the old system. The decimalization of the currency and the introduction of the metric system was universal throughout Western Europe by the time of the Congress of Vienna (1814–1816); but the right of the road rule, impressed yet further by the arms of Germany, for example in Czecho-Slovakia in 1939, has still not spread to Sweden. The reorganization of the calendar was, however, a complete failure.

But the Straits of Dover are still too wide an obstacle for the passage of Gallic Revolutionary principles, as they were for Hitler, and as they probably are for Channel Tunnellers and bridge builders. And yet for all our resistance to change, whether this is rational and balanced or stupid and obstinate, many thinking people admit the force and logic of the French argument, and attempts have been made in the past, and are still being made today, to put some sort of order into our monetary and measuring systems.

A fundamental principle of any measuring system is that it should progress regularly, both upwards and downwards. An examination of the metric system generally will show that the steps are $\frac{1}{1000}$, $\frac{1}{100}$, $\frac{1}{10}$, 1, 10, 100, 1000. This is, of course, a geometric progression. When our financial system is examined with reference to this principle it looks absurd: $\frac{1}{2}$, 1, 12, 240 is not a geometric progression, nor does it approach one. But in the

Middle Ages[1] the upper denomination of currency was the mark of 13s 4d, and the lower was the half-farthing: the progression then ran $\frac{1}{8}$, 1, 12, 160: the true theoretical progression from $\frac{1}{8}$ to 160 would be $\frac{1}{8}$, $1\frac{3}{8}$, $14\frac{1}{2}$, 160. From this the divergences are relatively small.

The larger the number of sub-multiples of any unit of a measurement system the better, and here our own illogicallity shows some marked advantages. The factors of 10 are 2 and 5, but the sub-multiples of 12 are 2, 3, 4 and 6. The use of tens as digits for our counting system stems from the five fingers of each hand, but in polydactylous communities 12, 144 and 1728 are used instead of 10, 100 and 1,000 without any disadvantage. Our own quantity surveyors when they wish to compute an area or volume from dimensions in feet and inches use these dimensions reciprocally, expressing the answer as $x + \frac{y}{12} + \frac{z}{144}$. Once practice has made perfect, the rationalization of $\frac{y}{12} + \frac{z}{144}$ into some easier expression comes quite naturally. If the system of carrying milk in bottles is investigated the crates will be found to fall into three categories, half-a-dozen, a dozen and a score: 6, 12, 20. If the crate is considered to have both length and breadth, then square crates must be ruled out, but any dimensioned crate which does not approach a square in size will use more material for its construction than is necessary. Thus economic sizes must be of the form $x\ (x + 1)$. These are $2 \times 3 = 6$; $3 \times 4 = 12$; and $4 \times 5 = 20$. An extension of this will produce two numbers 56 and 72, each of which is half of the important 112 and 144, the number of pounds in a hundredweight and the gross. When these considerations are borne in mind our own system wears a different aspect.

In 1799 the question of decimalizing our coinage was first mooted and HM Government appointed a committee to go into the question.[2] This question has been "under consideration" ever since: in fact the affair puts the celebrated case of *Jarndyce v. Jarndyce*[3] into the shade! Royal Commissions, Select and Departmental Committees reported in 1853, 1856, 1868, 1918, and 1951 with varying conclusions, until finally in 1960 the Beaver Report,[4] published jointly by the British Association for the Advancement of Science and the Association of British Chambers of Commerce, was issued. This recommended that the Government should take an early decision one way or the other, and urged that the longer the delay, the greater the cost of change, if there were to be a change.

Some positive steps have already been taken in decimalizing the coinage: the florin, a tenth of £1, was introduced in 1849, while the half-farthing was withdrawn in 1844, and the farthing itself in 1960. Whilst large numbers of half-pennies have been minted in recent years, but very few pennies, the increase in the price of the London evening papers from $2\frac{1}{2}d$ to $3d$ eased the demand for the smallest coin: and now that the national newspapers have also increased their price the enormous number of half-pennies may become an embarrassment to the banks. It is never wise to prophesy, but with present inflationary tendencies it could well be that the present decade is the halfpenny's last. If these trends continue, the decimalization of the coinage will be

[1] See The Paston Letters, etc.
[2] *Hansard, H. of L.* (10 Nov 1960), Vol 226, No 7, cols 480–96.
[3] Dickens: *Bleak House*.
[4] *Decimal Coinage and the Metric System—Should Britain Change?*

effected for us without any positive effort in that direction well within the next hundred years!

The advantages of change are the simpler manipulations of figures in everyday life, the savings in office work, the utility of financial computing machines for arithmetical calculations, and the ease of teaching children: but the disadvantages include the divisibility and flexibility of the present system, its relationship to weights and measures, the imponderables of transition, not the least of which would be the opportunity for smart Alicks to "ring the changes" on the simple-minded, and finally, the very difficulty of teaching children which improves their competence at mental arithmetic.

When questions of length are considered the origins of the British and metric systems arise. The English yard was fixed by King Edward I in 1305: he arranged that 5½ yards would equal the Saxon land rod (our old favourite rod, pole or perch), which was of 15 Saxon ft (13.2 in). This was the unit in which the country had been first assessed for tax in 1085 by William the Conqueror's Domesday Commissioners. Edward's yard was re-established in 1855 by the Exchequer, and handed over in 1866 to the Standards Department of the Board of Trade, who still keep it. In the six and a half centuries of its existence this yard has altered in length by less than a tenth of 1 per cent.[1] The metre was originally intended to be a ten millionth part of the length of an arc of longitude between the equator and the pole. The surveyors were not, however, up to modern standards and the length of the French standard metre kept in Paris is a little short of the originally intended length. However, the relationship between these two units was established in 1866 as 1 yd = 0·914 391 80 metre.[2] Further determinations in 1895 and 1922/24 established the metre as being 39·370 113 and 39·370 147 in.[3] On the basis of the 1866 determination the United States fixed their inch in terms of the metre, legalizing the conversion factor of 1 metre = 39·370 000 in.[4] Rounding off these ratios and taking a convenient value, 1 in = 25·4 millimetres: this is correct to 2 parts in 10,[6] and it follows that the British and American inches coincide to within 4 parts in 10.[5,6]

The avoirdupois pound is not of such venerable antiquity as the yard. It dates from the days of Edward III, and was a measure used by the famous medieval wool trade. It was established in the Armada year on its present basis of 7,000 grains = 1 lb, and is now a platinum cylinder kept at the Board of Trade. The French standard is the kilogramme. This is defined as 1,000 times the weight of a cubic centimetre of water at 4°C (39°F). The conversion factor between the two is 1 lb = 0·453 592 43 kilogramme.

The pint, the measure of honest beer, began life in two different forms: the wine gallon of Queen Anne contained 231 cu in, whilst the ale gallon had 282 cu in. During the burning of the Houses of Parliament in 1834, immortalized by Dickens,[6] these standards were destroyed. Consequently a new single standard of 10 lb weight of water at 62°F (167°C) and under an atmospheric pressure of 30 in of mercury was introduced: this occupies 277·42 cu in. The French standard, the litre, is defined as 1,000 cu cm of water at

[1] *Fifty Years of British Standards*, p 21.
[2] A. R. Clarke: *Comparison and Standards of Length*, 1866.
[3] B.S. 350: 1944, p 6.
[4] *Acts of Congress of USA*, 1866, *c* 301, Vol XIV, p 339 (28 July 1866).
[5] B.S. 350: 1944, p 6.
[6] Quoted in H. St G. Saunders: *Westminster Hall*, p 297; also L. Hogben: *Mathematics for the Million*, p 300.

0°C and 760 mm of mercury. The conversion between these two measures is given by 8 pints = 1 gallon = 0·543 458 litres.

In 1960 the metre was redefined internationally[1] as 1,650,763·73 times the wave-length in a vacuum of the orange line of krypton-86, which corresponds to the transition between the energy levels $2p_{10}$ and $5d_5$ of the krypton-86 atom.

The Beaver report[2] considered the introduction of the metric system in the United Kingdom. The Committee found that it was used for scientific, pharmaceutical and optical purposes, but little else. Since it was in general a legal system, it might be possible to introduce it piecemeal, but there had been no sign that this was likely. Although, again, many people thought it would be a good thing, the Government would be required to pay the cost of conversion and no one wished to make the first move. In the export field, and in imports too, it would appear that our traders suffer from no real disadvantage; but it may be opportune to remark that due to the impossibility of obtaining spares HM Submarine *Seal* was of little use to the Germans after her capture in 1940;[3] and it may well be that for small scale importations our system operates as an unseen tariff wall.

The Beaver Report[4] also considered the rationalization of the British system, and recommended the decimalization of as much of it as possible. In particular, it urged the replacement of the hundredweight (112 lb) by the cental (100 lb), a legally-known measure since 1878, the long ton (2,240 lb) by the short ton (2,000 lb), the abolition of apothecaries and troy weight, and that all fractions of the inch should be decimalized.

In 1960 it became apparent that our weights and measures legislation required an overhaul, and a bill to give effect to the Government's wishes was introduced.[5] From the measuring point of view the essential points are: the yard is defined as 0·914 4 metre exactly, and the lb as 0·453 592 37 kilogramme exactly;[6] an advisory commission of nine members is established to advise the Board of Trade on weights and measures;[7] the measures and weights lawful for use in trade are listed;[8] and the metre, litre and kilogramme are each defined as "the meaning from time to time assigned . . . being the meaning appearing . . . to reproduce in English the international definition of the metre (litre or kilogramme)".[9] The yd/metre and the lb/kilogramme conversion figures were based on the recommendations of the National Standards Laboratories of the United States, the United Kingdom, Canada, Australia, New Zealand and the Union of South Africa.[10] It is of interest to note that whilst the metric and some of the British system subdivisions are decimalized, sub-divisions of the inch may be $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{12}$, $\frac{1}{16}$, and $\frac{1}{100}$; and of the gill may be $\frac{1}{2}$, $\frac{2}{3}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$ and $\frac{1}{6}$.[11]

This, then, is the position as it is today. The two systems are undoubtedly in Western Europe to stay, and neither can be ousted by the other. But can

[1] B.S. 350, Part 1, 1960, p 6.
[2] *Decimal Coinage*, pp 28–51.
[3] *The Sunday Express*, 5 March 1961.
[4] *Decimal Coinage*, pp 52–57.
[5] Weights and Measures Bill, 1961, 9 Eliz 2.
[6] Ibid s 1.
[7] Ibid s 7.
[8] Ibid 3rd Sch.
[9] Ibid 1st Sch.
[10] *Decimal Coinage*, p 54.
[11] Weights and Measures Bill, 3rd Sch.

we make life easier for those who perforce must use each others system? Having worked at one time for a consulting engineer whose interests lay in South America I consider that their method of marking up drawings was very satisfactory: on one side of a dimension line was written the metric measurement, on the other the British equivalent, using the conventional numbering of each thus: $\xleftarrow{\quad} \frac{51' - 7''}{15.723} \xrightarrow{\quad}$ Already our jam pots, etc., mark both the British and metric weights, thus a jar of Branston pickle is marked 11½ oz (327 grm). It may not sound right, but there need not be any difficulty in practice in mixing the two systems. I have frequently specified a steel channel as 7 × 3½-in at 18·28# × 3.465 m. Nor is this habit confined to overseas business; if one examines a Kellogg's Corn Flakes packet, it will be found that the nutrients per ounce are given in milligrammes. On the other side, British and American oil, motor and aviation industries have broken so deeply into Continental markets that in/lb units must be employed when spare parts are required for the various equipments. The most interesting case is that of the International Civil Aviation Organization,[1] who now accept both units as of equal standing: after attempting to standardize on the metric system, it was found that in 1958 no single aircraft company had exclusively metric aircraft!

These are technical problems of practical reality; they are not the pawns of philosophers' prattle. If the United Europe we desire is to become a fact, these two measuring systems must run in double-harness: time, utility and practice will then determine which, if either, must die.

Are Training Regiments Dull?

By 2ND LIEUTENANT N. J. ROBERTS, RE

No—at least the six months that I spent at No 1 Regt Cove were by no means humdrum.

I arrived there in March last year, eager but green from Sandhurst. Yes! here I was within three months of leaving the RMA, "up at the sharp end!" !

The first things that struck me were the gardens—I think that they kept maturing bulbs in the armoury (I am sure it wasn't true).

I was put in charge of the new recruits during their first week or two in the Sappers, and as this job was not the most exacting, I was easy game for those odd little extra jobs and "excursions" which a lot of people fight shy of, but which I find are usually rather interesting. These "extras" form the basis of my tale.

March 28-April 9 Stocktaking board:—Sounds a bit pedestrian and I counted everything from cordage to canoes, but I learnt what some of those funny sounding bits of equipment looked like and there was always the possibility that I might uncover a vast fraud involving thousands of tin nails or something.

[1] *Decimal Coinage*, p. 35.

May 5-May 31:—I attached myself to the French Army under "Echange au pair", which experience I found enthralling—a week at Angers on the Loire at "L'Ecole d'Application du Genie", then two weeks on exercise with the French Engineers in the Massif Central, where we built a "piste" (no—it's a jeep track) through thick forest, bridging a fast flowing stream in the process using reinforced concrete.

We did various other pieces of training all of them applicable only to Algeria. It was of course quite an eye-opener for me to observe the French attitude to everyday military tasks; but I think that after some time I absorbed some of their approach to life; and perhaps best of all, learnt how to argue throughout a meal without getting indigestion, and to absorb an "orders group" between courses. I was lucky, I came home after the exercise; the Frenchmen went straight to Algeria. I had two or three days in Paris at either end of my attachment which of course were very enjoyable.

June 10:—I took the recruits to Bagshot Park for a day's religion and this was such good value. I found the buildings very beautiful and quite obviously little changed since the young Connaught lived there many years ago—What good sense the padre talked; we enjoyed every minute.

During my time at Cove I had the pleasure of being a sort of ADC extraordinary to both Lady Sugden and Lady Campbell on the occasions when General Sir Henry Sugden and then General Sir Douglas Campbell came to inspect passing-off parades. I enjoyed these two episodes very much indeed. I suppose that after many years it becomes second nature to perch with coffee cup balanced upon overalled knee making polite conversation eyeing one's watch. "Mustn't get 'em there late for the parade, I'd be shot—but I mustn't be too early."

20 June–2 July:—They made me non-shooting team captain of the Regimental team at Bisley. What a surprise, never having fired a potentially dangerous shot in my life or admitted to any taste for the sport in particular. I soon became very interested, however, and I was very fortunate in having a most talented team under my protection. They won cups right, left and centre and even won me a silver spoon. I can't think why. The memories of those long hot days in the sun and ice cold gins and tonic on the verandah of the clubby Officers' Mess there are very dear to me now. My only grouse was that both my Bisley articles for the "Journal" and "The Sapper", extolling the wonders of my team, were printed under quite unasked for noms de plume—namely Major Goodall and RSM G. Young—now I know how Peter Simple feels.

5 July:—I went down to Salisbury in the good company of three sergeants to watch a fairweather Beverley airstrip being constructed. Having got there we found that they had finished it the day before, a day ahead of schedule—"oh! well back we go", but at 5¼d a mile why should I worry!

9–10 July:—I was "nominated" as a Marshal at a motor cycle trial at Borden—you learn something everyday and I went go-karting in the evenings while I was there which I enjoyed.

14–25 July:—Good Lord, I'm on an Audit Board now. The AB 397 I had to sort out didn't remind me one bit of the accounts exam at Sandhurst. "What's this! Azaleas 4s 6d, Rose Cuttings 8s 6d". They didn't call No 1 the garden city for nothing.

26 July–4 September:—I was very fortunate to be asked to crew on Myles Wyatt's "Bloodhound". We went to the Azores and back via Spain,

3,000 miles in all which was immensely good fun. I thought that we wouldn't get there at one stage and would miss the seemingly tiny islands altogether. But in his own magical way, Myles made a direct hit on San Miguel out of the stormy seas. The Azores were very beautiful, but though I was sorry to leave there, the scent of England was very strong in my nostrils after a week or two.

I left the Training Regiment on 9 September and there ends my tale. I hope that I haven't bored you, but I felt I had to write all this down even if only for the edification of any other young officers who go to a Training Regiment. I know I owe a lot to my Commanding Officer for without his help, life could have been very much less interesting.

A Civil Servant's Diary, 1841-46

By Henry Parris

Research Fellow at the University of Manchester

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Major-General Sir Charles Pasley (1780–1861) was a distinguished officer of the Royal Engineers who passed the last few years of his working life in the Civil Service. Educated at the Royal Military Academy, Woolwich, he was commissioned in 1797. From 1799 he saw much active service in the wars against Napoleon. In 1812 he became the first Director of the Royal Engineers Establishment at Chatham, a post he continued to hold until 1841. The man appointed to succeed him—Lt.-Col. Sir Frederic Smith—was Inspector-General of Railways at the Board of Trade. Pasley, reluctant to retire on half-pay, applied for Smith's post and got it. From the present point of view, the important thing about Pasley is that he kept a diary, which gives a detailed picture of life in the Civil Service in the early Victorian age.

His Work

How hard did Pasley have to work? Was he like the fountains in Trafalgar Square? In one sense, he was not hard pressed. He acted as Public Examiner to the East India Company's School at Addiscombe throughout his time in the Railway Department of the Board of Trade. Sometimes he was away from London for weeks at a time supervising an important salvage operation for the Admiralty, namely, the raising of the wreck of the *Royal George* at Spithead. But he was ready to work extremely hard when necessary, as it often was. On 14th December 1845, for instance, he was "obliged after writing all day to go to York by the night mail." He returned to London the next day, and on the 16th, attended important speed trials on the Great Western. On 11th May 1846, he was on duty in Devonshire. He spent the night at Exeter and went next day to Liverpool. After carrying out various inspections there, he went on the 13th to Manchester and the next day, by rail, coach and chaise, to Berwick-upon-Tweed via York. Thence he went to Edinburgh, returning to

Newcastle by the mail-coach seated beside the driver. After sleeping at Derby, he got home on the 17th. On 31st July 1846, he went to Nottingham for an inspection. The following day he was in Sheffield and Manchester, where there were lines to inspect. Although he got wet through in a thunderstorm, official callers at his hotel in the evening prevented him getting to bed. The next day was a Sunday, but he managed to fit in another inspection between church and bathing at Fleetwood. On the Monday he went by boat to inspect lines in Furness. After one more inspection, he returned to London on the Tuesday. On 2nd October 1846, he set out from Cumberland for Hull, reaching Normanton at 3 a.m. on the morning of the 3rd. After two and a half hours on the station, he got a train to Hull, made his inspection, and then went on to Darlington. There were further lines to see in County Durham and Northumberland before he returned to London on the 6th. Well might he say, as a man over sixty-five, "If I were in bad health, my days and previous nights work would make me ill. Thank heaven, they do me no harm."

An inspection on Sunday has already been mentioned, and the diary shows that Sunday work was quite normal. On Sunday, 2nd June 1844, he went into the office, only to find that his clerk had "locked up everything". A week later, he was looking at third-class carriages—a matter which was important at that moment because of Gladstone's legislation on cheap trains which was under consideration. On the other hand, the entry "Look in at Board of Trade" under the date, Sunday, 30th November 1845, should probably be taken as evidence of curiosity rather than industry. For that day, at the height of the Railway Mania, was the closing date for the deposit of plans for Bills for the coming session. The scenes enacted at the Board of Trade were among the most extraordinary ever witnessed in Whitehall. Some 600 sets of plans were handed in, the last as midnight was striking, and in the small hours, crowds stood on the pavement, watching the endeavours of late-comers to persuade the officials to receive the documents. Sometimes Pasley would call on a colleague on Sunday to discuss official business. Sometimes he would have papers sent to his home to work on. All in all, his diary leaves the reader with an impression of great industry and conscientiousness.

Relations with Ministers

The Board of Trade was a small office; the entire staff in 1840 was only thirty. Pasley was not at the top of this modest tree. Between him and the President and Vice-President[1] were two joint Permanent Secretaries and the Superintendent of the Railway Department. Nevertheless, there is abundant evidence of direct contact between him and his political chiefs. Take, for example, the following series of entries:

18th March 1842. "Have an interview and explanation with Lord Ripon—afterwards see Mr Gladstone."

19th March 1842. "See Lord Ripon this afternoon . . . [he] takes my paper to look over."

20th March 1842. "When I go to the office, Mr Laing[2] informs me that Lord Ripon has seen and approved of my papers and his notes."

[1]Ripon was President of the Board of Trade, 1841–43; Gladstone was Vice-President, 1841–43, and President, 1843–45; Lord Dalhousie was Vice-President, 1843–45, and President, 1845–46; Sir George Clerk was Vice-President, 1845–46.

[2]Samuel Laing, Law and Corresponding Clerk in the Railway Department, 1840–44; Law Secretary to the Railway Board, 1844–45; see D.N.B.

24th March 1842. "See Mr Gladstone."

26th March 1842. "See Mr Gladstone at Board of Trade."

On 5th May and 2nd July 1842, he was present at conferences between Ripon and representatives of companies. On 23rd May 1842, he and his colleague, Laing, took some papers into Ripon and "as our opinions are diametrically opposed, Lord Ripon takes the correspondence home with him." In September, Pasley found him reluctant to exercise his powers under the Railway Regulation Act, 1842, to make a compulsory purchase order in favour of a company, since he was "cautious and averse to taking people's land." In November, he was advising his chief about the state of a new line over which the Queen proposed to travel and recorded: "he is afraid of it . . . [but] afterwards becomes cold and resolute.

Pasley's view of Ripon was on the whole favourable and contains few reminders of his weakness when Prime Minister in the eighteen-twenties. The sketch of Gladstone, on the other hand, is unfavourable and presents a marked contrast to the Gladstone of legend. "He is irresolute. He seems to be an extinguisher on everything decided," wrote Pasley. He can hardly have been sorry when, in August 1844, Gladstone delegated railway business to Dalhousie. Up to that time, Pasley had noted altogether twenty-nine interviews with one or other of the political heads of his Department, at the rate of almost one a month.

The Railway Board

When Gladstone handed over railway business to Dalhousie, a new body was set up within the Board of Trade, with the confusing title of the Railway Board. It was to last for less than a year and Pasley's diary shows clearly what its defect was. The whole episode throws light on the "ministerial" and "board" pattern of administration in the nineteenth century. While Dalhousie remained responsible as Minister for railway business, he had also to preside over the Railway Board, the other members of which were civil servants—Pasley, G. R. Porter, Laing, and Donatus O'Brien.[1] The Board met frequently during its brief life, got through an immense amount of work, and published numerous reports. These last bore the signatures of each member of the Board, thus giving the impression that the official members had more than an advisory role. It only needed rumours of dissension within the Board to get about for critics to say that Dalhousie was no longer a responsible minister in railway affairs, but merely the creature of a Board, the majority of whose members were not in Parliament.

The diary shows conclusively that such criticism was unjust, and also that the rumours originated with Pasley himself. At a meeting in October 1844, Dalhousie expressly reserved the right to call on Pasley to sign a report with which he disagreed or else resign. So much is clear from later evidence, though at the time, Pasley recorded only, "Lord Dalhousie lays down the law respecting Board proceedings in a most despotic manner." There the matter rested until 13th November 1844, when the diary reads:

"Request an interview with Lord Dalhousie. State that at the Board meeting where he laid down the law, he had acted under a misapprehension of my feelings and meaning, and that his sort of reprimand, just if I had really

[1] G. R. Porter, first head of the Statistical Department of the Board of Trade, 1834–47; Superintendent, Railway Department, 1840–44; Senior Member, Railway Board, 1844–45; Joint Permanent Secretary, Board of Trade, 1847–52; see D.N.B., Donatus O'Brien, General Secretary, Railway Board, 1844–45, and Railway Department, 1845–46.

intended to refuse or dispute his authority, was not called for and had hurt my feelings. Twice he declared that he retracted nothing, and that I had it in my power to resign, but that if he had hurt my feelings he was sorry for it. We shake hands."

But Pasley's differences with his colleagues on the Board were not at an end. "My views opposed by O'Brien," he wrote; "the thing in question a trifle but as usual decided against me." He suspected Laing of keeping back documents relating to the South Eastern Railway and noted that Porter and he opposed Laing when the Board was drawing up a report on that company's plans. After seeing Dalhousie in December 1844, he wrote: "from an expression of his, anticipate another scene." Two months later, he found it necessary to "speak rather warmly to Lord Dalhousie."

Pasley did not keep these disagreements to himself, and in February 1845, his indiscretion was brought home to him:

"Lord Dalhousie states at the Board that Sir Robert Peel [and the Government] had been embarrassed by the question having been put that two members of the Board, namely, General Pasley and Mr Porter, had been against the others; he would ask no questions but hoped that no member of the Board would give any hint."

Pasley thereupon admitted that he had already discussed the Board's proceeding with friends; when Dalhousie "used the word 'reprimand', alluding to what had before passed between us, I might have replied warmly but stopped short." It is clear that as head of the Railway Board, Dalhousie was master in his own house, not merely *primus inter pares*. But it was a cumbersome mode of procedure, which gave his critics unnecessary opportunities and brought no compensating advantages. It is no wonder that as soon as opportunity offered, Dalhousie dispensed with it. Pasley recorded its last meeting:

"Lord Dalhousie has his last Board meeting. Explains his feelings and proceedings. Shakes all the members most cordially [by the hand] . . . . I am now persuaded . . . that he is sincerely cordial with me. I am restored to my first position, which is much pleasanter than to be member of a Board, where the chief *at first* withheld all confidence."

Relations with Colleagues

The above will have given the impression that Pasley was not an easy man to work with. As a military officer of high rank who had been for many years at the head of an important establishment, it was naturally difficult for him to adjust himself to a subordinate position in a civilian department, most of the members of which were much younger than himself. Porter was the most usual object of his wrath. Primarily the head of the Statistical Department of the Board of Trade at £800 a year, Porter received an extra £200 to superintend the Railway Department also. The implication was that he should give it only one-fifth of his time. This, combined with the fact that Laing and Pasley, although nominally his subordinates, enjoyed free access over his head to the political chiefs of the Department, rendered his position anomalous. Pasley wrote:—

"Have an explanation with Mr Laing and Mr Porter. See Mr Gladstone. I object to Mr Porter being the Superintendent. Mr Laing confirms what Sir F. Smith told me, that Porter is a sinecure (sic). The arrangement of the Railway Department must be altered."

Two days later, he talked with Gladstone "about the false position in which I am placed by Mr Porter, a sinecurist." As time went on, things at first got worse; "Mr Porter insists upon being the chief and uses a much higher tone than he did at first." But the inception of the Railway Board, which led to Porter's being styled Senior Member instead of Superintendent, had the result of improving Pasley's view of his colleague. In March 1845, he wrote: "I approve of Porter. He is a very useful member of the Board."

More important were Pasley's relations with the Assistant Inspector appointed in the summer of 1844, Capt. Coddington, R.E. Pasley, not unnaturally, treated him as an assistant—"send Capt. Coddington to inquire into an accident," for example. But Coddington, observing that Pasley enjoyed direct access to Dalhousie, two Permanent Secretaries and Porter notwithstanding, thought the principle should be carried one stage lower, namely, to himself. As Pasley wrote:

"An explanation with Coddington. His feelings are hurt, because I prevented him from acting independently of me, he being my Assistant. He complains that his opinions are set aside by me, I having objected to his sending in independent reports."

and, a month later,

"Captain Coddington and I have a difference of opinion. He wishes to be considered on a par with me, and to communicate direct with Lord Dalhousie, not only in my absence but at all times. I speak to his Lordship, who seems as usual to make difficulties."

Whatever difficulties he made on this occasion, it was Dalhousie who settled the question by treating the two as equals and dealing direct with Coddington. Such a course might have led to unnecessary trouble for him had they put in contradictory reports, in which case he would have been the lay judge between conflicting experts. But, although the matter was not satisfactorily settled in principle, no difficulty in practice seems to have arisen.

It is pleasing to mention, before turning from Pasley's relations with the men in his office, that he never recorded the least criticism of his personal clerk and draftsman, Finlay Mackenzie, whom he rewarded with a silver watch.

Social relations outside the office supplemented official relations within it. Ripon entertained Pasley at dinner, once in company with Gladstone, and on another occasion with MacGregor, one of the joint Permanent Secretaries, and Gladstone's private secretary, the future Sir Stafford Northcote. Pasley dined with the MacGregors and himself entertained Coddington. Laing and O'Brien visited Dalhousie at Deal Castle, his official residence.

Relations with Railway Companies

More important were Pasley's social relations with the officials of railway companies. The question had been raised when the first factory inspectors were appointed; could an inspector preserve his impartiality after accepting an invitation to dinner? Pasley had no inhibitions in the matter. At a dinner given by the London and South Western Company, the company's engineer, Joseph Locke, toasted him, and he proposed in reply, "Success to the company." He launched and dined with Saunders and Brunel, secretary and engineer respectively of the Great Western. As the guest of the South Eastern and Croydon Companies he sat on the right of the Chairman, and drank champagne. His note continues: "Come home at a late hour. Fall in the street near Mansion House"—whether as a result of the champagne does not appear. When inspecting the Bristol and Exeter he enjoyed "a collation of salmon, fowls, roast lamb, &c., &c." and more champagne. He attended a party given by Creed, secretary of the London and North Western, and a "splendid entertainment" given by Peto, the great contractor, after inspecting one of his lines. While inspecting a Kent line, he dined and stayed with the engineer who had built it. On another occasion, he took his young son with him on an inspection. After a drink with the Great Western secretary—champagne again—he notes, "Mr Saunders takes care of George." Had the wine proved too much for him? Did so much good fellowship bias Pasley's judgment? There is no evidence that it did, and there is something to be said on the other side. The powers of the Board of Trade over railways were few and weak. Much of its achievement in this field was the result of persuasion rather than legal power. For example, in Pasley's day, and for long after, there was no statutory basis for the enquiries which were held into every important railway accident; yet the companies invariably co-operated. Perhaps Pasley's social gifts contributed to the establishment of good relations between his Department and the companies.

Relations with the Press

Pasley was similarly uninhibited in the expression of his political views, in spite of his official position. He was not a party man. When Lord John Russell's attempt to form a Government in December 1845, broke down, he wrote:

"Sir Robert Peel in again, which gave me great pleasure. He has broken up the parties—so much the better—I hate bigoted Tories and bigoted Whigs, but respect the former more than the latter because they defended the country and overthrew Buonaparte, to whom the latter truckled and might have made us a province of France."

As for the Radicals, he agreed in discussion with Joseph Hume that "commerce &c., railways, steam, brought nations better acquainted, and rendered the desire of war less violent, and would render wars less frequent." But on one issue—Ireland—he felt very strongly, and made it an exception to his usual rule of "not interfering in the internal politics of the country, which as a military man not possessed of landed property, I considered unbecoming and unnecessary." In July 1843, he wrote to *The Times* deploring the weakness of the Government's Irish policy. Although the letter was not meant for publication, it was a remarkable effusion. He wrote of the "unaccountable supineness of the present Ministers of this country, whose measures are a disgrace to them as individuals and collectively, [and] through them, to the nation." He called on an M.P. "to applaud his proceedings in Parliament", and spoke on Ireland at a dinner, "reprobating O'Connell and the inactivity of the government." So far was he from wishing his words unspoken that, on looking into the press, he regretted finding no report of the dinner, "as I should have wished my sentiments to appear." In October 1843, he went over to Dublin on duty. His note for the second day of his visit includes the following: "Dine at the Irish Academy Club. Very pleasant. Declare my anti-repeal sentiments." The following day, he dined with the Lord Mayor and made another political speech. On his return to London, he noted a conversation with an M.P. about O'Connell: "he agrees with me in wishes, but doubts the power." In February 1844, he spoke once more at a dinner, but found "less sympathy with anti-repeal sentiments." Pasley never seems to have felt that these dabblings in politics were wrong, or even dangerous.

What did prove dangerous was Pasley's attitude to the press, not about politics, but about the apparently innocuous subject of his conduct at an inquest. Like other nineteenth century civil servants, he was subject to personal attacks in the press, and was sensitive to them. He affected to despise railway journalists: "What blackguards these fellows are!" he wrote, after the most celebrated of them had said he had been "laughed at" for his conduct of a particular enquiry. But he was attacked in the daily press—the *Morning Post* and *The Times*—as well.

Summoned to give evidence at an inquest on a fatal accident in January 1846, he involved himself in a technical argument with the company's engineer, in which he strongly criticized the design of some engines by Robert Stephenson. On the way back to London he met two reporters, one of them from *The Times*: "It does not strike me that they will report my evidence accurately. One of them reads his notes to me, which appear to be very carefully done." *The Times* report did in fact turn out to be inaccurate and he saw Dalhousie about it, who, however, cared "little about such bad reporting." Any criticism of so distinguished an engineer as Robert Stephenson was, of course, news, and so Pasley can hardly have been surprised to "receive an ill-natured attack upon my evidence from a blackguard railway editor." But it made him decide to write to *The Times*, and his letter was published, giving his own version of his evidence. As a result, he received a letter from Dalhousie

"in which he finds fault with my having published a letter in *The Times* to combat the errors in the report of my evidence . . . in short, it is a sort of reprimand, which I despise."

In his reply, Pasley gave

"his Lordship clearly to understand that, as a British officer, and a gentleman, I am the guardian of my own honour, and that I will not ask his permission to publish anything in defence of my own character."

The incident closed with a further letter from Dalhousie, justifying his course of action, but Pasley did not think it worth copying in his diary.

Control Over Railways

The diary affords glimpses of law in the making. In March 1842, Gladstone received two deputations in reference to the Government's Railway Regulation Bill, then before Parliament. The resulting Act contains a curious provision, unrelated to the rest of the measure, removing the maximum weight limit for passenger coaches to which many companies were subject by their private Acts. It was added to the measure, apparently casually, by the Government when the Bill was in its final stages. Pasley gives the inside story. In a dispute as to the terms on which a company could use another company's line, an objection was raised

"to their railway carriages being beyond the legal weight . . . [which] is 4 tons, load included. The actual weight of railway passenger carriages is 4 tons, 3 or 5 cwt., load not included, and of mail carriages . . . 4 tons, 10 cwt., load not included. Lord Ripon expresses his regret that this circumstance was not brought forward before, as the weight of carriages has been legislated upon and it seems absurd that the law should have been evaded or set aside."

When Pasley looked into it, he found that carriages above the legal maximum weight were widely used—even by the company that had raised the objection! The heaviest, he found, were almost twice the permitted weight. But the heavier carriages were stronger, and so safer. Hence it was not desirable to enforce the law. Against this background, the repeal of the maximum weight provision is easily comprehensible.

Equally revealing is what Pasley has to say about the interpretation of the law by the Department. The Railway Regulation Act of 1842 gave the Board power to postpone the opening of a new line. But a company which had powers to build a line with more than one track sometimes completed one first and sought to open with single line traffic. The Department could postpone such a proceeding on grounds of safety; but if it acquiesced, did it thereby forfeit its claim to inspect subsequent tracks as they were completed? In other words, were they new lines within the meaning of the Act? Could the Board by order suspend their opening? The wording of the Act was not clear and the legal point remained unsettled. It was of some importance. Had the Department done nothing, companies might well have acquired a right to multiply the tracks of existing lines without further inspection, at least where they could do so without seeking fresh powers. On the other hand, had a collision occurred on one track of such a line, while the second remained unopened by order of the Board of Trade, the company would try to persuade the public that the Board rather than itself was to blame. This was the possibility uppermost in Pasley's mind when he heard that

"Lord Dalhousie has prevented the second line of rails of the Maidstone branch of the South Eastern from being used. Thus the Department for Public Safety opposes it by causing one line to be used instead of two. If a collision occurs, blame will attach to him."

The Courts years later upheld Dalhousie. But law was not Pasley's strong point. He had been exercising powers under the 1842 Act for almost four years before he realized that it gave the Board no power to authorize the opening of a line, but only to postpone such opening in the interests of safety.

Towards the end of his life, Dicey perceived that "the imposition upon the government of new duties . . . almost implies, and certainly has in fact promoted, the transference to departments of the central government . . . of judicial or quasi-judicial functions."[1] Pasley shows us this process in operation seventy years earlier. The 1842 Act authorized the Board to confer by Order powers to alter the construction of earthworks and to substitute level crossings for bridges. Pasley shows us Ripon and Gladstone presiding over enquiries into such applications and the objections to them, and his own part in preparing reports on such cases. Later, he gives a picture of Dalhousie hearing an appeal against a decision of the Board. The opening of a line in Cumberland had been postponed. Pasley happened to call on Dalhousie just after he had heard a protest from members of the company: he

"says that Lord Lonsdale and Mr George Stephenson were insolent to him and said, 'What could Royal Engineers possibly know about railways?' and therefore, though he would not otherwise object to compromising or

[1] A. V. Dicey "Development of Administrative Law in England", *Law Quarterly Review*, xxxi (1915), p. 149

meeting the [company] halfway, he does not like being bullied into concession."

Lord Lonsdale's political influence was great enough to encourage Dalhousie to find a way of yielding gracefully. He sent Pasley to make a second inspection—Coddington had made the first—and, as a result of Pasley's report, revoked the postponement order.

Departure from Official Life

Pasley's disappearance from Whitehall was a tragi-comedy. An Act of 1846 set up a new body, the Commissioners of Railways, to take over the duties of the Railway Department of the Board of Trade. Pasley was over sixty-five, and he might have taken the opportunity to retire. But the idea of a normal retiring age was as yet unfamiliar to civil servants. Left to himself, Pasley would probably have emulated such a man as Sir John Barrow, who had the year before, at the age of eighty, at last given up the post of Permanent Secretary at the Admiralty after holding it for nearly forty years. Pasley's first reaction was to see the new set-up as a personal opportunity; he would be one of the new Commissioners. Lord John Russell had replaced Peel as Prime Minister, and so Pasley had a new set of Ministers to deal with. He wrote to Lord Clarendon, the new President, and saw Milner-Gibson, the new Vice-President, of the Board of Trade. He also saw Wood, the Chancellor of the Exchequer. He declared his ambition to them all and wrote the Prime Minister a letter which began as follows:—

'My Lord,

As the appointment of President and Commissioners of the new Railway Department of government will depend upon your Lordship, I beg leave respectfully to offer myself as a candidate for the office of one of the two paid Commissioners who are to form a part of the proposed establishment."

After some weeks of silence, he heard that a brother officer of the Royal Engineers had been named as a Commissioner and concluded—rightly, as it turned out—that his own chances were at an end.

His first resolve he had expressed in the form of a motto: *aut commissium* [?] *aut nihil.* Now he lowered his sights. Perhaps he could carry on as Inspector-General, but with a higher salary. He had an interview with the Prime Minister to "explain that my feelings have been hurt . . . and that my being set aside for" another Royal Engineer officer "who has no military services to boast" and no greater professional knowledge "is a mystification to me, especially as I have served nearly five years in the Railway Department." Russell replied

"naturally enough that he cannot enter into personal feelings respecting any appointments in the public service, whether law, church, or others. I then tell him that I consider the duties of Inspector-General of Railways to be equally important with those of the Commissioners and that if his Lordship will increase my salary to that of the Assistant Commissioners, viz. £1,500 a year, it will remove all feelings of disappointment from me, and at the same time, take away the sort of slight, which will attach to me in public estimation, because if the public know that an officer has been selected for an appointment of £1,500 a year in preference to me, they will consider it an imputation or a disparagement to me, because, however unjustly it may be in particular cases, the merit of individuals and the importance of appointments in the same branch of the public service is estimated by the amount of salary; also that, as a military officer, my income dies with me, and I owe it to my family not to neglect their interest. His Lordship replies that he can make no promise, but that he must consult the Chancellor of the Exchequer and Mr Strutt."

Pasley, of course, wasted no time in seeking an interview himself with Strutt,[1] who at first struck him as "frank, open and friendly." He also denied being consulted about the appointment of Pasley's rival. But Pasley reversed his view a week later, when he wrote: "Mr Strutt behaves in what I consider a treacherous manner; promises to lay my statement before the Chancellor of the Exchequer, and returns saying that the Board of which he is chief has recommended, and the Minister approved, my ceasing to be employed."

Strutt offered him the chance to see the Board, but Pasley declined since he could "only tell them what I have told him, that I was hardly and unjustly treated in being dismissed from government employment."

And in spite of a weary round of interviews, and the writing of more letters to men in high places, that was that. Shaw Lefevre, MacGregor's fellow joint Permanent Secretary at the Board of Trade, advised him:" that there is no use to resist. Asks me what means I will take. I say certainly not through Parliament. But I will not allow the slur put upon my character by their turning me off without cause assigned to pass unanswered."

His attempts to get a fresh military appointment failed, and he was left to derive what consolation he could from the award of the K.C.B. His career was at an end.

Pasley's diary is very much a record of working life. Nevertheless, odd sentences here and there give a few glimpses of the man himself. He accounts for two mistakes in handwriting by saying "my pen really seems to be intoxicated." He amuses himself by referring to his spouse as "my YF." His reaction to his son's poor showing in French was to "threaten to send him to a boarding school." He occupied some of his many long hours of travelling with mathematics, but noted sadly, "stupid at maths. In future, not try it in railway carriages . . . maths incompatible with railway carriage." With satisfaction he recorded that "the very savoury tomato sauce made last week by our cook [was] a great saving and better than that bought in Regent Street." One day, finding himself alone in the house with his son, he took the opportunity to "tell him my early history of which he was quite unaware." Invited to dine at Lord Ripon's for the Queen's Birthday, he found "all the party in uniform or court dress but me" and crowned his misfortunes by giving someone half a sovereign for a sixpence. Above all, he lost things—his purse, proofs of Parliamentary papers, a silver pen holder, a memorandum book, seals and keys. But such glimpses are few and, as a revelation of character, the diary would be poor reading.

[1]Edward Strutt, M.P., was President of the Commissioners of Railways 1846–48.

The Queen's Engineers

As reported in the Corps Note of this edition of the *Journal* Her Majesty the Queen visited Rochester on 30 March last in connexion with the celebration of the five hundredth anniversary of the granting of a Charter to the City by King Edward IV in 1461. During the afternoon, the Queen, accompanied by the Engineer-in-Chief, inspected a Royal Engineer Guard of Honour in the gardens of the Great Keep of Rochester Castle, built in Norman times by Bishop Gundolphus.

Rochester's age as a Chartered City, with an elected Mayor and entrenched civic rights, is a venerable 500 years. Our close connexion with the Sovereign, however, exceeds that time by nearly 400 years. William the Norman brought with him as his Chief Engineer for his invasion of England in 1066 one Humphrey de Tilleul, a redoubtable military engineer, who distinguished himself in the assault landing at Hastings. After the defeat of the Saxon King Harold, Humphrey de Tilleul was ordered to fortify Hastings Castle which was also placed in his safe custody. As time went by, however, he could no longer endure the separation from his wife and he returned without leave to Normandy. He was not alone in this defection; ancient chronicles say that many Norman knights were torn assunder by the force of two contending loyalties. They could not tamely abide in a strange land with William whilst their wives in Normandy were throwing themselves into the arms of the men. "Family Separation" problems seem to have troubled even William the Conquerer's Adjutant General. Humphrey de Tilleul's absence without leave did not, however, invoke the King's displeasure and history has treated him kindly. His name heads the list of "Distinguished Engineer Officers" enumerated on Boards displayed at the Royal Military Academy, Sandhurst.

His relief as King's Chief Engineer was Gundolphus, a monk with no family ties nor matrimonial problems. He had been brought over to England from a Monastery at Bec by Lanfranc when he was made Archbishop of Canterbury. His first commission by William was to build a fortress that would overawe Saxon London. His work still stands today as the White Tower, or Keep, of the Tower of London with its great halls and Chapel of St John and its guardian ravens. He was made Bishop of Rochester and he built Rochester Castle and started the construction of the present Rochester Cathedral which today houses many Corps Memorials and each year the Royal Engineer Memorial Service is held within its ancient walls. He died aged 84 years on 7 March 1108 and he was buried by Archbishop Anselm of Canterbury in his Cathedral Church.

Bishop Gundolphus heads the nominal roll of senior serving engineer officers maintained on the walls of the office of the Engineer-in-Chief at the War Office. Humphrey de Tilleul's name is absent from this famous scroll. The title of the senior serving engineer officer has changed from time to time, but the appointment has persisted from the time of Bishop Gundolphus until today except during the troubled period of the Wars of the Roses (1455–1471) under the following titles:—

1078–1642 King's (or Queen's) Chief Engineer
1642–1660 Parliament's Chief Engineer
1660–1707 Chief Engineer of England
1707–1802 Chief Engineer of Great Britain
1802–1904 Inspector General of Fortifications
1904–1943 Director of Fortifications and Works
1943 to date Engineer-in-Chief.

No other Regiment or Corps in the Army can claim a lineage such as this.

By a Royal Warrant of George I, given in 1716, the Artillery and Corps of Engineers were constituted as separate establishments, and by a Royal Warrant of 1787 the title of Corps of Engineers was changed to that of Corps of Royal Engineers and the Corps was authorized, together with the Royal Regiment of Artillery, to take the Right of the Line when parading with other Corps of the Army. On 10 July 1832 King William IV granted the Corps permission to wear on their appointments The Royal Arms and Supporters and the mottoes "Ubique" and "Quo Fas et Gloria ducunt", and the Royal Arms remain today as the Corps Badge.

In 1757 officers of the Corps of Engineers were for the first time given military rank in the Corps. Before that time they had held commissions in other Arms of Corps of the Army besides an engineer appointment. The senior officer to be so commissioned was Colonel (later Lieut-General) William Skinner who, in addition to being the Chief Engineer of Great Britain at the time, was made Colonel of the Corps. He was followed by Major-General James Bramham and after him the Master-General of the Ordnance, whose Board of Ordnance administered the Gunners and the Sappers, automatically assumed the appointment of Colonel of the Corps of Royal Engineers until the appointment lapsed in 1855. Amongst the Masters-General of the Ordnance to be Colonels of the Corps were such famous men as the Earl of Chatham and the Duke of Wellington.

For the past century a member of the Royal Family has been Colonel-in-Chief of the Corps. HRH Field Marshal The Duke of Cambridge assumed this appointment on 10 May 1861, and he took his duties most seriously.

He had much to say in the setting of examinations for Gentlemen Cadets passing from the Royal Military Academy, Woolwich into the Corps. He personally carried out Annual Inspections of the Corps at Chatham. He frequently dined in the Headquarters Mess, some of the more important occasions being on 24 October 1871 when Sir John Cheape, on behalf of the officers of the late Honorable East India Company Engineers, presented silver plate to the Mess to commemorate the union of John Company's Engineers with the Corps of Royal Engineers in 1862; on 26 July 1883 at a Guest Night on the occasion of Lord Napier of Magdala's promotion to Field-Marshal; on 22 November 1887 on the occasion of his own Jubilee (50 years) in the Army and on 8 November 1898 when Kitchener was Guest of Honour in the Mess after his victorious Nile campaign. He laid the foundation stone of the Crimean War Memorial Arch at Chatham in 1860 and the foundation stone of the Royal Engineer Institute (now housing the Headquarters of the SME) in 1872. He was present when the Prince of Wales (afterwards King Edward VII) unveiled the Gordon Statue at Chatham in 1890. He took the chair on occasions at the Annual Corps Meeting. In 1875 he became Patron and President of the Royal Engineers Institute Committee. He was a Commodore of the Royal Engineers Yacht Club. He set up the Royal Engineers Band Committee in August 1861 and laid down that no extraordinary expenditure was to be undertaken without reference to him. He also had to be shown each year the annual Band Accounts. As Commander-in-Chief of the Army he asserted that "The British Grenadiers" was the only March of the Corps in common with the Royal Artillery and the Grenadier Guards and "Wings", first adopted as the RE quick march in 1870, was suppressed until after his death when the War Office officially authorized "Wings" as the Corps march in 1902.

The Duke of Connaught was commissioned into the Royal Engineers in January 1868 and although he later transferred to the Gunners he maintained a close connexion with the Corps throughout his life. In May 1905 he visited Chatham as Inspector General, and in 1932 he unveiled the 1914–18 War Memorial between the Crimean and South Africa War Memorial Arches at Brompton Barracks.

Many Sapper officers held Palace appointments during Queen Victoria's reign. Lieut-Colonel Sir John Cowell, KCB was Master of the Queen's Household, and with Major H. C. Elphinstone, VC, CB, CMG, was a Governor of the Royal Princes. Lieut-Colonel Sir F. I. Edwards, KCB was Private Secretary to the Queen from 1878 until her death. Colonel S. Waller was Extra Equerry to the Queen from 1885 to 1890. Captain P. C. Harvey, RE, is the Army Equerry to our present Queen.

The Prince Consort frequently called upon the services of Royal Engineers officers, the most outstanding possibly being Captain Francis Fowke whose designs for the Great Exhibition and for the South Kensington Museums achieved world wide fame. He also designed the Albert Hall, a memorial to his Royal Patron, but he died before the work was finished. Another Sapper officer, Major-General H. D. Y. Scott, completed the great domed roof.

By the Queen's command the Royal Engineers' Band played at the great State Dinner given at Buckingham Palace on the occasion of her Jubilee in 1887.

After the death of the Duke of Cambridge in 1904 His Majesty King Edward VII became Colonel-in-Chief of the Corps and the reigning Monarch has graced us with this honour ever since. The King visited Chatham shortly after becoming Colonel-in-Chief and the following year he unveiled the South African War Memorial and lunched in the Headquarter Mess afterwards.

During his visit to his troops in France in December 1914 His Majesty King George V presented the Victoria Cross to Captain W. H. Johnston, RE. In 1918 he became Patron of the Royal Engineers Old Comrades' Association and in 1923 he granted a Royal Charter to the Institution of Royal Engineers and graciously consented to be its Patron. On 11 March 1926 he visited Chatham, lunched in the Headquarters Mess and presented to the Royal Engineers Museum the original sketch map of the position taken up by Lord Wellington at the Lines of Torres Vedras, made by Lieutenant J. L. Hulme, RE in November 1810. Thirty years later his grand-daughter, our present Queen and Colonel-in-Chief, visited Chatham on the hundredth anniversary of the incorporation of the Royal Sappers and Miners into the

Corps of Royal Engineers, and last March, accompanied by the Engineer-in-Chief, she inspected a Guard of Honour formed by her Royal Engineers drawn up in the shadow of the great Keep of an historic Castle built almost 900 years ago by Gundolphus the first accredited King's Chief Engineer.

The following names are displayed on the walls of the office of the Engineer-in-Chief at the War Office:—

KING'S CHIEF ENGINEERS

Bishop Gundolphus	1078
Waldivus, Ingeniator	1086
Geoffrey, Ingeniator	1131
Allnoth, Ingeniator	1158
Magister Albertus, Ingeniator	1200
Peter, Ingeniator	1226
Richard Magister, Ingeniatorum	1287
Brother Robert de Ulmo Attilator	1300
John Gruynard	1354
Nicholas Merbury	1414
William Pawne	1509
Sir Richard Lee, Kt	1540
Sir William Pelham, Kt	1575
John van Cranvelot	1603
Bernard Johnson	1620
Captain Thomas Rudd	1627
John Lanyon	1627
Lieut-Colonel John Paperill	1628
Cornelius Drebel	1630
Sir Godfrey Lloyd, Kt	1640

PARLIAMENT'S CHIEF ENGINEERS

John Lyon	1642
Major Morgan	1643
Peter Manteau van Dalem	1647
Eval Tercene	1654
Nathanial Nye	1657

CHIEF ENGINEERS OF ENGLAND

Sir Charles Lloyd, Kt	1660
Sir Bernard de Gomme, Kt	1661
Colonel Sir Martin Beckman, Kt	1683
Vacant, 1702–11	

CHIEF ENGINEERS OF GREAT BRITAIN

Brigadier-General Michael Richards	1711
Major-General John Armstrong	1714
Lieut-Colonel Thomas Lascelles	1742
Vacant, 1750–7	
Lieut-General William Skinner	1757
Major-General James Bramham	1781
General Sir William Green, Bart	1786

INSPECTOR-GENERALS OF FORTIFICATIONS

General R. Morse	1802
General G. Mann	1811
Major-General Sir Alexander Bryce, Kt, KCH, CB	1830
Major-General R. Pilkington	1832
Lieut-General Sir Frederick W. Mulcaster, KCH	1834
Field-Marshal Sir John F. Burgoyne, Bart, GCB	1845
Major-General E. Frome	1868
Major-General Sir John W. Gordon, KCB	1869
Lieut-General Sir Frederick E. Chapman, KCB	1870
General Sir J. Lintorn A. Simmons, GCB, GCMG	1875
Lieut-General Sir Thomas L. J. Gallwey, KCMG	1880
Lieut-General Sir Andrew Clarke, GCMG, CB, CIE	1882
General Sir Lothian Nicholson, KCB	1886
Lieut-General Sir Robert Grant, KCB	1891
General Sir Richard Harrison, KCB, CMG	1898
Lieut-General W. T. Shone, CB, DSO	1903

DIRECTORS OF FORTIFICATIONS AND WORKS

Brigadier-General R. M. Ruck	1904
Brigadier-General F. Rainsford-Hannay, CB	1908
Major-General Sir George K. Scott-Moncrieff, KCB, KCMG, CIE	1911
Major-General Sir Phillip G. Twining, KCMG, CB, MVO	1918
Major-General Sir William A. Liddell, KCMG, CB	1920
Major-General Sir Henry F. Thuillier, KCB, CMG	1924
Major-General Sir Philip G. Grant, KCB, CMG	1927
Major-General R. L. B. Thompson, CB, CMG, DSO	1931
Major-General D. S. Collins, DSO	1935
Major-General G. B. O. Taylor, CBE	1939
Major-General W. Cave-Browne, CBE, DSO, MC	1940
Major-General A. G. B. Buchanan	1941
Brigadier H. E. Hopthrow, CBE	1943
Brigadier E. J. B. Buchanan, DSO	1945
Brigadier D. Harrison, CB, DSO	1946
Brigadier H. de L. Panet, CBE	1947
Brigadier L. D. Grand, CIE, CBE	1949
Major-General L. D. Grand, CB, CIE, CBE	1951
Major-General D. C. T. Swan, CB, CBE	1952
Major-General G. A. T. Pritchard, CBE	1955
Major-General J. H. Amers, OBE	1958
(Appointment lapsed 15 March 1959)	

ENGINEERS-IN-CHIEF

Major-General C. J. S. King, CB, CBE	1941
Major-General H. B. W. Hughes, CB, DSO, OBE	1944
Major-General Sir Eustace F. Tickell, KBE, CB, MC	1945
Major-General A. D. Campbell, CBE, DSO, MC	1948
Major-General G. N. Tuck, CB, OBE	1952
Major-General J. C. Walkey, CB, CBE	1954
Major-General H. C. Sugden, CB, CBE, DSO	1957
Major-General T. H. F. Foulkes, OBE	1960

The ranks and decorations shown are those held on appointment after which certain promotions took place. For instance Major-Generals Dudley, S. Collins, Charles J. C. King, G. Brian, O. Taylor, A. Douglas Campbell and Henry C. Sugden subsequently received Knighthoods and the first two of these officers became Lieut-Generals.

General Sir J. Lintorn A. Simmons became a Field-Marshal.

Chief Royal Engineer

In 1936 His Majesty King Edward VIII was pleased to revive the office of Chief Royal Engineer, and since that date the office has been held by:—

General Sir Bindon Blood, GCB, GCVO	1936
Lieut-General Sir Ronald E. Charles, KCB, CMG, DSO	1940
General Sir Guy C. Williams, KCB, CMG, DSO	1946
General Sir Edwin L. Morris, KCB, OBE, MC	1951
General Sir Kenneth N. Crawford, KCB, MC	1958
General Sir Frank E. W. Simpson, GBE, KCB, DSO	1961

THE NAMES OF THE FOLLOWING DISTINGUISHED MILITARY ENGINEERS ARE INSCRIBED ON BOARDS AT THE ROYAL MILITARY ACADEMY, SANDHURST:

Humphrey de Tilleul	Fl	1066	Brigadier-General Michael Richards		1673–1721
Waldivus Ingeniator	Fl	1086	Captain George Carleton	Fl	1728
Nicholas Merbury	Fl	1415	Brigadier-General Christian Lilly	d	1738
William Pawne	Fl	1480–1518	Jonas Moore		1691–1741
Thomas Pettyt	Fl	1510–1558	Major-General John Armstrong		1673–1742
Sir Richard Lee		1513–1575	Colonel Thomas Lascelles		1670–1751
Sir Josias Bodley		1550–1618	Benjamin Robins		1707–1751
John Rosworme	Fl	1630–1660	Lieut-Colonel Justly Watson		1712–1757
Sir Charles Lloyd	d	1661	Major-General David Watson		1714–1761
Sir Godfrey Lloyd	Fl	1640–1667	Colonel James G. Montresor		1702–1776
Sir Bernard de Gomme		1620–1685	General Lord Heathfield		1717–1790
Captain Thomas Phillips		1635–1693	Major-General William Roy		1726–1790
Colonel Jacob Richards		1660–1701	Major-General Sir Archibald Campbell		1739–1791
Colonel Sir Martin Beckman	d	1702	Colonel James Moncrief		1744–1793
Major-General Holcroft Blood		1660–1707	Lieut-General Sir Adam Williamson		1736–1798
Sir Henry Sheeres	d	1710	General George Morrison		1704–1799
Wolfgang W. Romer		1640–1713	Captain Leonard Smelt		1719–1800
Brigadier-General Lewis Petit		1665–1720	Lieut-Colonel Sir John Call		1732–1801

Major-General Patrick Ross		1740–1804	Major-General Sir J. Carmichael Smyth		1799–1838
General Hugh Debbieg		1731–1810	Major-General Sir Thomas Anbury		1765–1840
General Sir William Green		1725–1811	Captain Rt Hon Thomas Drummond		1797–1840
Lieut-Colonel John Squire		1780–1812	Lieut-General Sir William Nicolay		1771–1842
Major William Nicholas		1785–1812	Major-General Sir Thomas Jones		1783–1843
Lieut-Colonel Sir Richard Fletcher		1768–1813	Colonel Sir George Chas. Hoste		1786–1845
Major-General Sir Charles Shipley		1755–1815	Lieut-General Sir Fred W. Mulcaster		1772–1846
General Robert Morse		1743–1818	Major-General Sir Howard Elphinstone		1773–1846
General Sir David Dundas		1735–1820	Lieut-Colonel Sir Philip Gipps		1791–1847
Captain Sir Thomas Hyde Page		1746–1821	Major Sir William C. Harris		1807–1848
Colonel Colin Mackenzie		1753–1821	Lieut-General Sir R. Chapman		1776–1851
Major-General Sir Charles Holloway		1776–1827	Major-General Thomas F. Colby		1784–1852
Major James Rennel		1742–1830	Colonel Richard Z. Mudge		1790–1854
General Gother Mann		1747–1830	Brigadier-General Sir William Tylden		1790–1854
Colonel Henry A. Morshead		1774–1831	Colonel Richard Burton Tylden		1819–1855
Major-General Sir Alexander Bryce	d	1832	Lieutenant Duncan Charles Home, VC		1829–1857
Major-General Robert Pilkington		1765–1834	Lieutenant Phillip Salkeld, VC		1830–1859
Lieut-Colonel John By		1782–1836	Lieut-General Sir Charles F. Smith		1786–1858

Major-General Sir William Reid	1791–1858	Colonel Sir Henry Yule	1820–1889
General Frederick R. Thackeray	1776–1860	Field-Marshal Lord Napier of Magdala	1811–1890
General Sir Charles Pasley	1780–1861	Major-General Sir Edward Ward	1823–1890
Colonel Richard Baird Smith	1818–1861	Major-General Sir Howard Elphinstone, VC	1829–1890
General Sir James Caldwell	1770–1863	Colonel Sir Oliver St John	1837–1891
Major-General Sir Joshua Jebb	1793–1863	Major-General Sir Frederick Abbott	1805–1892
Major-General Joseph E. Portlock	1794–1864	Major-General Sir Alex Cunningham	1814–1893
Captain Francis Fowke	1823–1865	General Sir Frederick Chapman	1816–1893
Major Patrick Stewart	1832–1865	General Sir Lothian Nickolson	1827–1893
Lieut-Colonel Thomas F. de Havilland	1775–1866	Major-General Percy Smith	1838–1893
Lieut-General Sir Harry David Jones	1791–1866	Colonel Robert Armstrong	1839–1894
Captain James Vetch	1789–1869	General Sir George T. Chesney	1830–1895
Major-General Sir John W. Gordon	1805–1870	Lieut-Colonel Sir Edmund Henderson	1821–1896
Field-Marshal Sir John Fox Burgoyne	1782–1871	General James Walker	1826–1896
General Sir Charles G. Ellicombe	1783–1871	Major-General Sir James Browne	1840–1896
Lieut-General Sir William T. Denison	1804–1871	Lieut-General Sir William F. D. Jervous	1821–1897
Major-General Sir Henry M. Durand	1812–1871	Colonel John R. M. Chard, VC	1847–1897
General Sir John M. F. Smith	1790–1874	General Sir Wilbraham Lennoy, VC	1830–1897
General Sir John Cheape	1792–1875	General Sir Arthur T. Cotton	1803–1899
Lieutenant Sir Francis Bondhead	1793–1875	Captain Sir Douglas Galton	1822–1899
Lieut-General Sir Henry James	1803–1877	Colonel Sir Charles Nugent	1827–1899
Major-General Sir Andrew S. Waugh	1810–1877	Lieut-General Sir Gerald Graham, VC	1830–1899
Lieut-Colonel John Pitt Kennedy	1796–1879	Lieut-General Henry Wray	1826–1900
Major-General Sir Thomas A. Larcom	1801–1879	Colonel Sir Francis Marindin	1838–1900
Colonel Anthony W. Durford	1830–1879	Lieutenant R. J. T. Digby Jones, VC	1876–1900
Colonel Robert *Home*	1837–1879	General Sir Aeneas Perkins	1834–1901
Captain James Dundas, VC	1842–1879	Lieut-General George E. L. S. Sanford	1840–1901
General John A. Ballard	1829–1880	Lieut-General Sir Andrew Clarke	1824–1902
Lieutenant Thomas Rice Henn	1849–1880	Major-General Herbert T. Siborne	1826–1902
General Sir William E. Baker	1808–1881	Major-General Frederick Hime	1836–1902
Colonel Sir Henry Atwell Lake	1801–1881	Field-Marshal Sir John Lintorn Simmons	1821–1903
Captain William John Gill	1843–1881	Lieut-General Charles B. Ewart	1827–1903
Lieut-General Sir Robert M. Laffan	1821–1882	Major-General Sir Edmund Du Cane	1830–1903
General Sir Henry D. Harness	1804–1883	Lieut-General Sir Robert Grant	1837–1903
Major-General Henry Young D. Scott	1822–1883	Major-General Charles E. Webber	1838–1904
Major-General Charles George Gordon	1833–1885	Major-General Sir Charles W. Wilson	1830–1905

Lieut-General Sir Thomas Gallway	1821–1906	Major-General Douglas Scott	1848–1924
Colonel Mark S. Bell, VC	1843–1906	Major-General Sir George Scott-Moncrieff	1855–1924
General Sir Edward Stanton	1827–1907	Lieut-General Sir Ronald Maxwell	1852–1924
Lieut-General James J. Mc L. Innes, VC	1830–1907	Captain Sir Montagu Ommanney	1842–1925
General Sir Edward C. S. Williams	1831–1907	Captain Riall Sankey	1853–1925
Major-General William S. Trevor, VC	1831–1907	General Sir Charles Warren	1840–1927
Major-General Sir John C. Ardagh	1840–1907	Lieut-General Sir Herbert Chermside	1850–1929
Lieut-General Sir Richard Strachey	1817–1908	Major-General Sir Gerard Heath	1863–1929
Lieut-General Sir Richard H. Sankey	1829–1908	Colonel Sir Thomas Holdich	1843–1929
General Sir James F. M. Browne	1823–1910	Major-General Sir S. Robert Rice	1858–1929
Lieut-Colonel Sir Fleetwood I. Edwards	1842–1910	Brigadier-General Lord Thomas of Cardington	1875–1930
Colonel Claude R. Conder	1848–1910	Brigadier-General Sir F. Gordon Guggisberg	1869–1930
Major Philip Cardew	1851–1910	General Sir Richard Harrison	1837–1931
General Sir Alexander Taylor	1826–1912	General Sir Reginald C. Hart, VC	1848–1931
Major-General Robert W. Duff	1831–1913	Colonel Sir E. Percy C. Girouard	1867–1932
General Sir H. N. D. Prendergast, VC	1834–1913	Rt Hon Lord Sydenham of Coombe	1848–1933
General Sir Edward P. Leach, VC	1847–1913	Lieut-General Sir Fenton J. Aylmer, VC	1862–1935
Major William H. Johnston, VC	1879–1914	Lieut-General Sir George H. Fowke	1864–1936
Captain Theodore Wright, VC	1883–1914	Lieut-Colonel Sir Matthew Nathan	1862–1939
General Sir Frederick R. Maunsell	1828–1916	General Sir Bindon Blood	1842–1940
Colonel Sir C. Scott-Moncrieff	1836–1916	Major-General Sir Sydney D. A. Crookshank	1870–1941
Colonel Sir William S. S. Bisset	1843–1916	Lieut-General Sir George M. W. MacDonogh	1865–1942
Colonel Sir Charles M. Watson	1844–1916	Major-General Sir Philip G. Grant	1869–1943
Field-Marshal Earl Kitchener of Khartoum	1850–1916	General Sir Hugh J. Elles	1880–1945
Major Lance G. Hawker, VC	1890–1916	Lieut-General Sir George F. Gorringe	1868–1945
Brigadier-General John A. Tanner	1858–1917	Lieut-General Sir Edwin H. de V. Atkinson	1867–1947
Field-Marshal Lord Nicholson of Roundhay	1845–1918	Major-General Sir William A. Liddell	1865–1949
Colonel Sir Henry McCallum	1852–1919	General Sir George M. Kirkpatrick	1866–1950
Major-General Sir Geoffrey Twining	1862–1920	Brigadier-General Sir Samuel H. Wilson	1873–1950
Lieut-Colonel Gerald Smyth	1885–1920	Major-General Sir Ernest D. Swinton	1868–1951
Captain Sir William Abney	1843–1920	Lieut-Colonel Sir John R. Chancellor	1870–1952
Major-General Sir Reginald Curtis	1863–1922	Colonel Sir Charles F. Arden-Close	1865–1952
Lieut-General Sir Bevan Edwards	1834–1922	Major-General H. B. W. Hughes	1887–1953
Colonel Edmond Grove-Hills	1864–1922	Major-General H. L. Pritchard	1871–1953
Lieut-General Sir Montague Harper	1865–1922	Major-General Sir Theodore Fraser	1865–1953
Lieut-General Sir Henry Settle	1847–1923	Major-General Sir Henry F. Thuillier	1868–1953

Major-General Sir John E. Capper	1861–1955	Lieut-General Sir Gifford Le Q Martel	1897–1958
Lieut-General Sir J. Ronald E. Charles	1875–1955	General Sir Guy C. Williams	1881–1959
Brigadier General Sir James Edmonds	1861–1956	Major-General C. Coffin, VC	1870–1959
Lieut-General Sir Gordon N. MacReady, Bart	1891–1956		

Colonels and Colonels-in-Chief of the Corps

Officers of the Corps of Engineers who were Colonels of the Corps:—

Lieut-General William Skinner 1757
Major-General James Bramham 1781

Masters-General of the Ordnance who were Colonels of the Corps of Royal Engineers:—

Charles Duke of Richmond 1786
Charles Marquis of Cornwallis 1795
John Earl of Chatham 1801
Francis Earl of Moira 1806
John Earl of Chatham 1807
Henry Earl of Mulgrave 1810
Arthur Duke of Wellington 1819
Henry Marquis of Anglesey 1827
William Viscount Beresford 1828
Sir James Kempt 1830
Sir George Murray 1834
Richard Hussey Lord Vivien 1835
Sir George Murray 1841
Henry Marquis of Anglesey 1846
Henry Viscount Hardinge 1852
Fitz Roy James Henry Lord Raglan 1852
(Appointment lapsed 6 June 1855)

Commander-in-Chief as Colonel of the Corps of Royal Engineers:—

HRH George Duke of Cambridge 1861

Reigning Sovereigns as Colonel-in-Chief of the Corps of Royal Engineers:—

His Majesty King Edward VII 1904
His Majesty King George V 1910
His Majesty King Edward VIII 1936
His Majesty King George VI 1936
Her Majesty Elizabeth Alexandra Mary,
By the Grace of God, of the United Kingdom
of Great Britain and Northern Ireland and
of her other Realms and Territories Queen,
Head of the Commonwealth, Defender of the Faith 1952

Correspondence

Colonel A. P. Smith, OBE, MICE,
HQ 27 Engineer Group TA,
Duke of York's HQ,
King's Road,
London, SW3

To The Editor,
The RE Journal

27 April 1961

Sir,

MILITARY ENGINEERING MANAGEMENT IN SMALL WARS

1. Colonel Adams' article in the March number of the *Journal* is misleading. His table of functional organization would, if translated literally into a Staff Tree, produce an enormous Works Staff more suitable for World War II than for any likely theatre of war today, except perhaps BAOR.

2. (*a*) In the very small war we must now study, the Chief Engineer of the Force—henceforward called The Force Engineer—must deal with Ops and Works in the same HQ. On the works side, a large part of his duties will be harnessing the Civil resources of a friendly "host country" to operations.

(*b*) The Force Engineer's prime functions will be:—

(i) RE Intelligence—Ops and Works.
(ii) Planning—Ops and Works to fit the user requirement.
(iii) Construction—Ops and Works
(iv) Maintenance—of Works constructed.
(v) Operation of Utilities—Railways, Ports, RE Workshops, E and M Installations.

Works includes Planning and Progress on C, E and M sides. RE Ops Staff must be separate from Works Staff to follow the G and Q branches of the Force Staff.

(*c*) So then the staff table of the Force Engineer and his principal staff sections will be

Force Engineer
Deputy Force Engineer (if allowed)

RE Int	Ops	Works Planning	Construction and Maintenance	Tn	E & M Utilities

3. Each of these sections will be very small and will not be able to carry its own staff of expert engineers or draughtsmen. So there will have to be a pool of specialist sections at the service of the principal staff sections. The specialist sections would include most of the following:—

(i) Design—Arch and Civil.
(ii) E & M—Design, Construction and Maintenance.
(iii) Resources—Supply, Procurement and Accounting, Works Plant and Workshop Production.
(iv) QS.
(v) Cost Accounting and Work Study.
(vi) Clerical Services.
(vii) Personal Services.

I consider that Colonel Adams' Technical Services Section is a dangerous heresy not suited to a small war because it mixes Staff Liaison with QS, Recources and Cost Accounting. Staff Liaison, or Planning as I prefer to call it, is a prime and continuing function of the Force Engineer and a senior member of his staff.

4. *E & M.* (*a*) Colonel Adams makes special mention of E & M. I expect a small E & M staff with mixed duties to work well as it has done in small wars in the past. They will have three main functions:—

(i) Harnessing the E & M resources of the host country.
(ii) Organizing E & M works on a "do-it-yourself" basis by normal Field Squadrons.
(iii) (Together with Resources) procuring plant for units.

The E & M staff will have to provide specialist teams to support our hosts and "Barry Bucknells" to egg units on to have a go.

(*b*) I personally do not see plant and horsepower per man as an E & M problem. Engineer mechanical plant, including cranes and vehicles, are tools which the Combat Engineer must learn to use in peace time.

(*c*) Organizing field and base repair of plant and the spares supply required is a problem particularly if we have to rely on locally acquired heavy plant, local plant repair workshops and local fitters. We shall have to come to terms with REME over this for DME will have the upper hand as the Force Commander's advisor on mechanical maintenance.

(*d*) The Corps badly needs experienced Field Squadron officers to take E & M or TSO Courses in order that the full possibilities of civilian E & M advance are applied to the development of plant and of E & M prefab kits for use by the Combat Engineer. A technically minded Combat Engineer officer should find this far more satisfying than E & M in Works Services.

CONCLUSION

5. In small wars, as I see them, we shall be unable to organize a Force Engineer's Staff on the principle that each Staff Section and Division has singleness of purpose. So the Force Engineer will need a small team of all rounders backed by small specialist sections. The division of duties among the staff proposed has been worked out in more detail if readers are interested.

Yours faithfully,
(Sgd) A. P. SMITH, Colonel.

Colonel M. B. Adams,
Headquarters,
School of Military Engineering,
Chatham, Kent.
5 May 1961.

The Editor,
The RE Journal.

Dear Sir,

I am delighted to see that one officer had read enough of my article to see how management principles might be applied to present problems and Colonel Smith has gone further than I was able in linking up other Corps activities with pure construction.

I only intend, however, to comment on one aspect of his solution and that is E & M. If E & M is left as the responsibility of a specialist staff with mixed duties we cannot make progress. If we are going to have the right plant fit to operate where it is required, electrical and mechanical engineering must cease to be a specialist knowledge and become a normal skill of a reasonable percentage of officers in field units. The rate of mechanization is increasing each year and we will not get the best out of it unless mechanical engineering, and to a lesser extent electrical engineering, ceases to be relegated to an inferior supporting role.

Yours faithfully,
M. B. ADAMS.

General Sir Kenneth N Crawford KCB MC

Memoirs

GENERAL SIR KENNETH N. CRAWFORD, KCB, MC, FRSA CHIEF ROYAL ENGINEER AND COLONEL COMMANDANT ROYAL ENGINEERS

KENNETH NOEL CRAWFORD, who died suddenly on 5 March 1961, was the son of Henry Leighton Crawford, CMG, of the Ceylon Civil Service. He was born on 25 June 1895 and educated at Clifton College and the Royal Military Academy, Woolwich, receiving his commission in the Royal Engineers on 10 February 1915.

During the 1914/18 War he served in Salonika, Bulgaria, Serbia, Gallipoli and with the Egyptian Expeditionary Force under General Allenby in Palestine. In 1919 he went to South Russia with a special force. He was awarded the Military Cross and he was mentioned in despatches.

He returned from Russia to the SME, Chatham for a two-year Supplementary Course. From 1922 to 1928 he served as Adjutant, 49 (West Riding) Divisional Engineers (TA) and later as Adjutant, the Depot Battalion at Chatham. Whilst holding this latter appointment he qualified for the Staff College, Camberley, and later spent two years there as a student.

In 1930 he was posted as a Major to India where he stayed for six years and served successively as Garrison Engineer, as Brigade Major of an Infantry Brigade and as GSO II Lucknow District, being made a Brevet Lieut-Colonel in January 1935.

In 1936 he was posted to Canterbury to command 59 Field Company for a year before becoming Chief Instructor in Fieldworks and Bridging at the SME, Chatham. On promotion to substantive Lieut-Colonel he was posted to India again in 1938 to become CRE Bengal and Assam District.

He did not, however, stay long in India and in July 1939 he was appointed GSO I 5 Division with the rank of Colonel and accompanied the Division to France in September of that year. In January 1940 he was made Commandant, The Army Gas School with the rank of Brigadier and later in the same year Director of Chemical Warfare. From October 1941 until December 1942 he was Brigadier General Staff, Northern Ireland. He then returned to the War Office with the rank of Major-General to become Director of Air in which capacity he was charged with the Army's interests in Land/Air warfare and for the organization and equipment of British Airborne Forces and certain Allied Airborne Forces based in the United Kingdom. His duties took him to all theatres of operations where our Airborne Forces were employed and, during the invasion of Normandy, he flew in the aircraft towing the glider carrying Major-General Gale, the Commander of 6 Airborne Division. He also flew with Bomber Command on many operations in support of the Army. He was the first General Officer to qualify as a parachutist.

In March 1946 he was appointed General Officer Commanding British Troops in Greece with the rank of Lieut-General, having under his command III (British) Corps and the British Military Mission. He returned home a year later to become Deputy Chief of the Imperial General Staff and during this appointment he visited the long range weapons establishment at Salisbury and the rocket range at Woomera, Australia. In September 1949 he became Controller of Supplies (Munitions) Ministry of Supply. In 1952 he was promoted to the rank of General and from then until his retirement on 29 October 1953 he was Chairman of the Royal Ordnance Factories Board of Management.

After his retirement General Crawford joined the boards of several industrial concerns. He was at one time Director of Westlands Aircraft Limited and at the time of his death he was Chairman of Edwin Dank ((Oldbury) Limited and Penman Company Limited. He was also a Fellow of the Royal Society of Arts.

He was appointed Colonel Commandant, Royal Engineers, on 11 September 1951 and on 1 October 1958 he succeeded General Sir Edwin Morris, KCB, OBE, MC, as Chief Royal Engineer. He was Chairman of the Royal Engineers Benevolent Fund from 1952 to 1958. From 1952 until 1960 he was Honorary Colonel of 10 Parachute Battalion (TA).

As a young man he was a fine rugby footballer. During the 1920/21 season he and the late Brigadier D. Morris were the half-backs of the Corps side. Crawford played for the Army in 1921 and for Kent. He was President of the Army Rugby Union from 1948 to 1953. He was also a good shot and a keen golfer.

In 1921 he married Doris Margaret, eldest daughter of Joseph Parker, CSI. They had two sons and a daughter.

Tributes

The following tribute by General Sir John Whiteley, GBE, KCB, MC, is reprinted, by permission, from *The Times* of 10 March 1961:—

"The sudden death of Kenneth Crawford will have come as a shock to his many friends in the Army, in the other Services and in other walks of life. The years seemed to have had so little effect on the sturdy darting figure so familiar in former days on the football field.

His achievements speak for themselves and, remarkable as they were, it was the quality of the man which his friends will remember. His versatility showed up in his career as in his interests. There was the immense contribution made in the war as Director of Land-Air Warfare, then as Deputy Chief of the Imperial General Staff and later as Controller of Supplies (Munitions). No sooner had he left the Army than he took up other activities in business, in welfare work and as Chief Royal Engineer. He was never idle.

He was the same to all men. The same Kenneth arguing with a Minister of the Crown or with a subordinate. The same charm of manner, the same smile, the same firmness, the same friendliness given without stint and, always, the same inflexible integrity. He must have had a temper but in 45 years I never saw him lose it.

He gave and derived great pleasure in his many recreations but Rugger perhaps came first and many were the enjoyable hours given to the service of the Army Rugby Union.

He was blessed with a supremely happy family life and the sympathy of his friends will go out to his widow and his sons and daughter in their grievous loss."

General Sir Richard Gale, GCB, KBE, DSO, MC, writes:—

My first meeting with K. N. Crawford was in Bareilly in 1931 in India, where he was Brigade Major to the Bareilly Infantry Brigade, a foretaste of his wider service career.

When, in 1942, the Army Council decided to up-grade the appointment of Director of Air to Major-General I was to meet KN again, and thereafter to work in the closest co-operation with him for many years. With characteristic enthusiasm, which we were all to see so much of in the future, KN threw himself into his new job. In no time he was master of the problems, not only of airborne matters, but also of air support and the whole range of army/air requirements. As an example, he worked for months on the possibility of making use of Bomber Command in direct support of the Army on important and critical occasions: it was in fact due to his initiative and drive that this support was obtained and given with spectacular results. In the airborne world he soon appeared at the Parachute Training School at Ringway, where he underwent training and did his jumps; though he was never an operational parachutist he proudly wore the emblem of his training on his sleeve. He threw himself into all the arguments and all the problems of airborne operations, training and equipment. At the Airborne Forces Experimental Establishment his lively personality, his keen eye and his vivid imagination gave added enthusiasm to those on the job.

He was essentially a practical soldier and, though denied the actual command of troops in the field as a General, he displayed all the finest qualities of a commander. He visited the operational theatres and satisfied himself first hand on points of importance and controversy.

It is difficult to put into words adequately how much the Army owed to KN in all matters pertaining to army/air co-operation. I believe he was respected and liked as much by those wearing light blue as by those, his brothers, in khaki."

A Memorial Service was held for General Sir Kenneth Crawford in the Chapel of the Royal Hospital, Chelsea, on Friday, 7 April 1961, the Reverend L. V. Headley officiated. The Queen was represented by General Sir Cecil Sugden, GBE, KCB, Quartermaster-General to the Forces.

In the words of the Bidding those attending were gathered together to remember before God, Kenneth Noel Crawford, to render thanks for his service and his example, for the inspiration he gave to others, for his great leadership among those who stood between us and slavery in time of war, for his moral courage, for his devotion to the cause of civilization and humanity, and to commend his soul to the everlasting care of God the Father of us all.

Among those present were:—

Lady Crawford (widow), Mr Michael Crawford and Mr Philip Crawford (sons), Squadron Leader and Mrs T. P. D. La Touche (son-in-law and daughter), Brigadier V. R. W. Crawford (brother), Miss R. Crawford (sister), Mr and Mrs D. Hagarth Brown (brother-in-law and sister), Mrs F. R. Leighton Crawford, and Mrs S. Creed (sisters-in-law), Mr Edward Crawford, Miss Anna Crawford, Mr Henry Crawford, Mr and Mrs G. Donaldson, Miss Fiona Crawford, Miss Sally Faunce, Mrs George Crawford, senior, Mr and Mrs George Crawford, Mrs M. Clifton, Group Captain and Mrs H. M. A. Day.

Field Marshal Viscount Slim, Mr H. F. Ellis-Rees (representing the Secretary of State for War), Lieut-General Sir John Cowley (representing the Army Council) and Lady Cowley, the Hon Harry Morgan Grenville, Lieut-General Sir Ronald and Lady Scobie, Major-General Sir Eustace Tickel, Air Chief Marshal Sir Leslie Hollinghurst and Major-General K. T. Darling (representing Parachute Association), Major-General Sir Douglas Campbell (President, Institution of Royal Engineers), General Sir Richard Gale (representing The Parachute Regiment) with Colonel W. G. S. Mills, General Sir Robert Mansergh (Master Gunner, representing Royal Regiment of Artillery), Major-General Sir Ronald Penney (representing Royal Corps of Signals), General Sir Frank and Lady Simpson, Lady Sugden, General Sir John Whiteley, General Sir Edwin and Lady Morris, General Sir Brian Robertson, General Sir Sidney and Lady Kirkman, General Sir Geoffrey Bourne, Lieut-General Sir Harold Pyman, Lieut-General Sir William Stratton, Lieut-General Sir Lionel Bond, Lieut-General Sir Edward Grasett, Air Marshal Sir Geoffrey Tuttle, Major-General Sir Drummond Inglis, Sir Norman Hulbert, M.P., Sir Charles

Dodds, Sir Owen Wansbrough-Jones, Sir Eric and Lady Speed, Sir George and Lady Briggs, Sir Thomas Spencer (representing Major-General E. H. Leavey, United States Army).

Sir Herbert Creedy (Lord Kitchener National Memorial Fund), Colonel Sir Ralf Emerson, Sir Victor Negus (Hunterian Trustees, Royal College of Surgeons), Sir Clifford and Lady Norton, Lieut-General R. G. Stone, Major-General J. M. Kirkman, Major-General G. N. Russell, Major-General L. F. de V. Carey, Major-General N. A. Coxwell Rogers, Major-General G. P. L. Weston (representing Airborne Forces), Major-General H. P. W. Hutson, Major-General R. E. Lloyd, Major-General C. G. B. Greaves, Major-General J. C. Walkey (representative Colonel Commandant, RE), Major-General T. H. F. Foulkes (Engineer-in-Chief, War Office, and representing Old Cliftonian Society) and Mrs Foulkes, Major-General A. J. H. Dove (Royal Engineers' Association), Major-General R. Ll. Brown (Army Rugby Union), Major-General G. N. Tuck, Major-General G. H. Addison, Major-General L. E. C. M. Perowne, Major-General H. Bainbridge, Major-General R. L. Bond, Major-General W. S. Cole, Major-General and Mrs A. C. Duff, Major-General S. W. Joslin, Major-General I. S. O. Playfair, Major-General C. R. Price, Major-General and Mrs J. F. D. Steedman, Major-General D. C. T. Swan, Major-General R. W. Urquhart, Major-General Ll. Wansbrough-Jones, Major-General B. T. Wilson, Major-General S. H. M. Battye, Major-General G. W. Duke, Major-General B. K. Young, Major-General W. Cave-Brown, Major-General C. G. Woolner, Major-General G. G. Waterhouse, Major-General R. F. B. Naylor.

Major-General S. W. Kirby, Major-General A. E. Davidson, Major-General D. Harrison, Brigadier A. J. Deane-Drummond, Brigadier and Mrs. A. H. Dowson, Brigadier and Mrs. A. P. Lavies, Brigadier and Mrs A. G. P. Leahy, Brigadier L. J. Harris, Brigadier P. N. M. Moore, Brigadier E. F. Parker, Brigadier J. V. B. Jervis-Read, Brigadier J. C. Winchester, Brigadier M. W. Prynne, Brigadier N. H. L. Chesshyre, Brigadier J. G. Carr, Brigadier and Mrs A. H. G. Dobson, Brigadier A. C. Lewis, Brigadier and Mrs E. C. R. Stileman, Brigadier C. P. R. Johnston (secretary, Army Benevolent Fund), Brigadier and Mrs P. St B. Sydenham, Brigadier and Mrs G. F. H. Alms, Brigadier A. M. Anstruther, Brigadier W. E. van Cutsem, Brigadier E. Rait-Kerr, Brigadier R. H. Bellamy, Brigadier H. W. Kitson, Brigadier J. H. S. Lacey, Brigadier J. R. B. Turner, Brigadier G. J. Eaton-Matthews, Brigadier S. A. Stewart.

Brigadier D. M. Rycroft, Brigadier C. C. Swift, Brigadier and Mrs G. H. C. Pennycook, Brigadier A. R. Aslett (representing Army Sport Control Board), Brigadier Lewis, Brigadier C. D. Steel, Brigadier and Mrs H. T. S. King, Brigadier and Mrs. W. F. Anderson, Brigadier W. H. H. Aitken, Brigadier J. H. D. Bennett, Brigadier A. G. Bonn (Richard Costain Ltd), Colonel H. A. J. Darlow (Haig Memorial Homes), Lieut-Colonel J. W. Richardson (London manager, Westland Aircraft), Major S. S. Hawkins, Colonel A. R. Mais, Colonel W. M. Blagden, Colonel D. Maud, Colonel F. H. Foster (representing 44th Division Engineers) and Mrs Foster, Colonel and Mrs W. Garforth, Colonel A. P. Smith, Colonel K. W. Merrylees, Colonel K. H. Stevens, Wing Commander and Mrs A. T. Laing, Colonel W. B. Whishaw, the Rev W. M. Howitt, Colonel R. Colvill, Colonel R. C. R. Stevenson, Lieut-Colonel H. W. B. Stephens (School of Military Engineering), Lieut-Colonel J. H. Frankau, Colonel and Mrs R. W. C. Smailes.

Lieut-Colonel and Mrs B. S. Jarvis, Colonel A. H. Bell, Colonel C. W. Woods, Lieut-Colonel A. E. Younger, Colonel H. Elson, Colonel H. Cartwright Taylor, Colonel F. J. Rice, Colonel W. G. S. Mills, Lieut-Colonel R. E. Young, Commander A. W. Preston, Colonel F. A. Sudbury, Colonel E. G. Goldring, Colonel R. E. Owen, Colonel E. M. Hall, Commander B. S. Mallory, Colonel E. H. L. Smith, Colonel J. W. Clark, Group Captain and Mrs M. Newnham, Colonel T. Burrowes, Colonel E. F. Kyte, Colonel A. M. Field, Colonel H. E. M. Cotton, Colonel E. H. M. Clifford, Colonel M. B. Adams, Lieut-Colonel C. Pritchard, Major G. P. Bulman, Mr H. Imrie Swainston (representing Lieut-Colonel Mark Alexander, officers and other ranks 49th West Riding Division, Royal Engineers (TA) and Mrs Swainston, Mr. O. N. Williams, Mr K. H. Tuson (Mackness and Shipley), Mr F. L. de Winton and Mr. E. S. Keyworth (representing Lloyds Bank), Mr and Mrs T. Russell-Cobb.

Mr J. L. Fletcher, Mr R. E. Lapeau, Mr H. C. Plevin, Mr N. Newton, Mrs M. Hilton, Mrs D. Perkins, Captain J. Faro, Mrs N. K. Porter, Mr G. C. Killpack, Mr A. Stammers, Dr E. Cook, Dr A. Mennie, Mr E. C. Wheeldon, Mr E. Mensforth, Mr T. W. Pollock, Mr L. W. Rea, Mr H. McNeil, Dr C. Johnson, Colonel Richards, Mr J. D. Pratt, Mr S. Barrett, Dr D. W. Henderson, Mr W. R. Yexley, Mr and Mrs L. B. Linley-Howlett, Mr N. L. Nichols and Mr E. J. Pitchford (Woolwich branch, Royal Engineers' Association), Dr and Mrs Digby Roberts, Major R. A. Moss, Captain P. N. Ewall, Captain J. D. English, Mr W. Armstrong, Mr A. J. Edney, Mr F. H. Slingsby, Major F. R. Dore, Mr E. W. Cook, Mr John Kirwan Taylor, Mrs R. G. S. Hobbs (representing vice-president, Rugby Union), Chelsea Pensioners and members of the Royal Engineers.

Among those unable to attend were:—

Field-Marshal Sir Francis Festing, General Sir Nevil Brownjohn, Lieut-Generals W. G. H. Pike, Sir William Dobbie, Sir Kenneth McLean, Sir Francis Nosworthy, Major-Generals S. Lamplugh, R. P. Pakenham-Walsh, R. K. Millar, Sir Henry H. C. Sugden, Sir Horace Roome, F. V. B. and Mrs Witts, R. W. Ewbank, Brigadier J. T. S. Tutton, Colonel Sir Frederick Neill and Sir John Keeling.

BRIGADIER-GENERAL R. L. WALLER, CMG

Richard Lancelot Waller, who died at Sherborne on 9 March 1961 at the age of 85 was the son of Major-General W. N. Waller of the Royal Artillery. He was educated at Sherborne and, after passing through the Shop, he was commissioned into the Corps on 4 November 1894.

After his training at Chatham he was posted to South Africa. He was at Ladysmith and he was awarded for his services in the Boer War the Queen's Medal with two clasps and the King's Medal with two clasps. He returned with 20 (Fortress) Company from South Africa to Chatham in 1902 and two years later he was posted, on promotion to Captain, as an Assistant Instructor in Fortifications at the School of Military Engineering, Chatham. In 1904 he was sent to Abyssinia on a boundary commission. After a short spell on his return spent at Colchester with 9 (Field) Company he was sent in 1911 as Instructor in Military Engineering at the Australian Military College. Here he met and married in 1912 Clare Cicely, the daughter of E. Grace Esq of New South Wales by whom he had a son and daughter. His wife and daughter predeceased him.

He served with distinction in the 1914/18 War in Gallipoli and in Palestine and he was awarded the CMG. In the early part of 1916 he was CRE 52 Division and the following year he was made Chief Engineer of No 3 Sector of the Suez Canal Defences. In 1917 he was Chief Engineer XX Corps. He held this appointment until 1920 when he became CRE Alexandria District, but the following year he returned to Palestine again as Chief Engineer.

On returning home he was posted as CRE Salisbury Plain Area and 3 Division at Bulford. After a period on half pay he was appointed Chief Engineer Scottish Command in 1927 and from July 1928 until his retirement in November 1931 he was Chief Engineer Southern Command. On retirement he became the Bursar of Sherborne School.

The Headmaster of Sherborne School writes:—

"Brigadier-General R. L. Waller came to Sherborne, his old school, as Bursar in 1931, and held that post until his retirement in 1945. These were not easy years: the period of depression, and later the 1939/45 War made difficult the ordinary maintenance of buildings and, still more so, any extensive new building. General Waller's experience proved of great value in this difficult time, and among improvements introduced must be mentioned a filtration plant in the swimming baths. Those who were privileged to serve with him will remember him as a man of decided views, who, at the same time, was always courteous and kindly in his dealings with everyone, and who was a devoted servant of his old school which he loved so well."

Major General AW Sproull, CB CBE FCGI

MAJOR-GENERAL A. W. SPROULL, CB, CBE, FCGI

Alexander Wallace Sproull, who died on 12 March, was born at Honolulu, the son of Alexander Macdonald Sproull on 24 December 1892. He was educated at St Lawrence College, Ramsgate and at the City and Guilds College where he graduated with First Class Honours in engineering. He joined the Royal Engineers (Special Reserve) in 1914. During the First World War he served in France in 1915, where he was wounded, and with 127 (Field) Company of 22 Division from November 1915 until 1918 in Macedonia. From 1919 until 1923 he was employed as a Staff Captain in the Directorate of Fortifications and Works, the War Office, being granted a regular commission in the Corps in 1921.

In the summer of 1923 he was sent on a special Electrical and Mechanical Course arranged by the War Office before undergoing a years' Supplementary Course at the School of Military Engineering, Chatham. This was followed by a second Electrical and Mechanical Course of a year after which he was posted as Assistant Electrical and Mechanical Officer at Headquarters Eastern Command. A year later he became Assistant Inspector of Royal Engineer Stores at Woolwich.

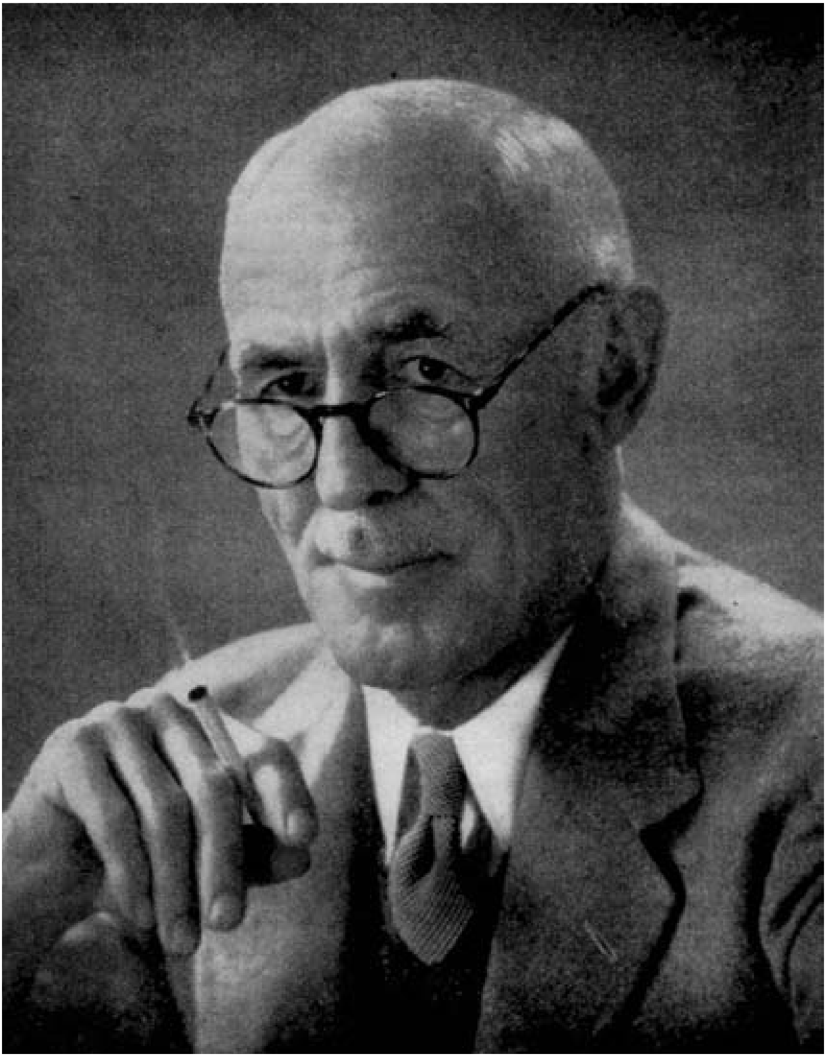
In March 1931 he was posted to Malaya to command 41 (Fortress) Company in addition to electrical and mechanical duties at Pulu Brani. After only two years overseas he was posted once again back to the War Office as a Deputy Assistant Director of Works. He stayed in this appointment for three years and in February 1937 he became Inspector of Royal Engineer and Signal Stores at Woolwich. Later in the year he was promoted to become Deputy Chief Inspector.

Shortly after the outbreak of the 1939-45 War he was loaned to the Air Ministry for special duties connected with Radar and later he was appointed Chief Inspector of Engineer and Signal Stores, and from 1942 until the end of the war he was Chief Inspector Electrical and Mechanical Equipment, being promoted Major-General in June 1944. From 1946 to 1947 he was Director of Armament Production at the Ministry of Supply. He retired in August 1947 but he was retained for a further year in a special appointment at the Ministry of Supply.

After his retirement he became a director of many companies, including the British Photographic Industries Ltd, Ross Ltd, Phoenix Telephone and Electric Holdings Ltd, Sewell and Hulton Ltd, and John Oakey and Sons Ltd. He was also for a time President of the Institute of Engineering Inspection and President of the Junior Institution of Engineers.

His recreations were golf, tennis and rifle shooting, being in the Army XX from 1939 to 1946.

He married in 1918 Adeline Frances, daughter of Brigadier-General Charles Godby who survives him.



Brigadier CJE Greenwood, CBE MC

BRIGADIER C. J. E. GREENWOOD, CBE, MC

Charles Joseph Edward Greenwood, who died suddenly on 23 February 1961, was the son of Captain T. Greenwood. He was born on 14 April 1892 and educated at Wellington College and at the Shop. He was commissioned into the Corps on 23 December 1911.

After his courses of instruction at the School of Military Engineering, Chatham he attended a Defence Electric Light Course at Plymouth before being posted to India in July 1914. From India he went in 1915 to Mesopotamia as a Subaltern in the Wireless Telegraph Section with the Sixth Indian Division. During the investment of Kut by the Turks the wires of the Wireless Section's aerial were often cut by rifle bullets and Lieutenant Greenwood and his Sappers had constantly to repair them although exposed to the accurate fire of Turkish snipers shooting from across the River Tigris. On one of these occassions Greenwood was wounded in the shoulder. He was made a prisoner of war at the surrender of Kut. For his services during the siege he was awarded the Military Cross and he was mentioned in despatches.

After the 1914/18 War, Greenwood attended a further Electrical and Mechanical Course before returning once again to India in 1921. He served in Military Works for a year and he was then posted to a junior staff appointment at Army Headquarters, Delhi. He passed into the Staff College, Quetta in 1924 and on graduating he spent a year in Military Works before being appointed DAQMG at Meerut. This appointment was followed by another staff post as Brigade Major of the Landi Kotal Brigade engaged at the time in operations on the North West Frontier.

On returning home in 1931 he spent three years as DCRE Dorset and in April 1934 he was back again in India where he spent one year as officiating Chief Engineer RAF, Delhi before being sent once again to the North West Frontier as CRE Peshawar District where he was mentioned in despatches for his work in support of the 1935 operations. He completed his overseas tour as CRE Rawalpindi.

On returning to the home establishment he was placed for a time on the Unemployed List, but in July 1939 he was recalled as AQMG Western Command. On 2 September 1939 he became AA & QMG British Expeditionary Force, his post being upgraded almost immediately to DQMG. After the evacuation from Dunkirk he was awarded the CBE. He then served in A/Q appointments in Home Forces before being posted to India in 1942 where he was made Chief Engineer IV Corps which had moved to Imphal to take charge of the forces then in the neighbourhood and to reorganize the formations of the Burma Corps on their arrival. IV Corps had some 500 miles of frontier to guard with little except the tired, ill-fed and hard pressed remnants of the Army of Burma. The engineer tasks were enormous. They had to be completed before the monsoon broke; there was a great shortage of engineer stores equipment and plant; the field companies and other RE units were under strength, short of tradesmen and decimated by malaria; but the task undertaken by Greenwood and his able assistants were completed before the rains came.

In March 1943 he was recalled to an AQ Staff appointment in India which he held for a year before being posted home where he became a Chief Engineer in Northern Command. He retired on 30 December 1946.

In 1919 he married Hannah, daughter of Doctor Purcell of Silsden, Keighley, Yorkshire. They had two sons and two daughters.

Colonel BS Rait Kerr CBE DSO MC

COLONEL R. S. RAIT KERR, CBE, DSO, MC

Rowan Scrope Rait Kerr, who died on 2 April 1961, was born at Bray, Co Wicklow on 13 April 1891, the son of Sylvester Rait Kerr of Rathmoyle, Edenberry, Kings County. He was educated at Rugby and at the Royal Military Academy, Woolwich.

He was commissioned into the Corps on 23 December 1910, his younger brother E. Rait Kerr being commissioned into the Corps four years later. After his SME courses he was posted to India. Here he served in Garrison Engineer appointments until being posted as a Company Officer in "F" Company 3rd Sappers and Miners at Kirkee thus commencing a most distinguished connexion with the Royal Bombay Sappers and Miners with whom he served throughout the First World War.

The Lahore Division, which contained 20 and 21 Company of the Royal Bombay Sappers and Miners, left India within a fortnight of the declaration of war. The two Sapper and Miner Companies had a most arduous and adventurous journey in the SS *Taiyibeh*, a ship that had been condemned as unfit to take pilgrims to Mecca and was about to be broken up. Nevertheless 20 Company Royal Bombay Sappers and Miners in which RK was serving was the first formed body of Indian troops to land in France. Both 20 and 21 Company were engaged in the desperate battle of Neuve Chapelle. On the day after the battle only two British officers of the two companies remained, namely Lieutenants Noseworthy and Rait Kerr, and both were wounded and had later to be evacuated to hospital. On leaving hospital RK was posted to 1 (Indian) Field Squadron and then in December 1915 with 2 Field Troop he embarked at Marseilles in the last transport of the convoy taking the Lahore Division to Iraq. For his gallant services during the war he was awarded both the DSO and MC and three times mentioned in despatches. He returned to India with the Indian Expeditionary Force after the war and became Adjutant of the Royal Bombay Sappers and Miners at Kirkee and shortly afterwards he was given command of F (Depot) Company.

On returning home in 1921 he was posted for a three-year tour of duty as Adjutant 54 (East Anglian) Divisional Engineers (TA). He then became an Assistant Instructor in the Field Works and Bridging School at the SME and in 1927 he took up duties at Cambridge University where he acted as a liaison officer between the Corps and the University and watched over the Sapper officers up there *in statu pupillaris* striving for degrees and blues. Those who were fortunate enough to be at Cambridge during RK's time will remember the great kindnesses and hospitality received from him and his wife, including the famous breakfast party, given on the morning after the day of a Shop–Sandhurst rugger match which many of us had gone up to London to see. Such were the subsequent celebrations of the Shop's glorious victory that certain RE undergraduates arrived back at Cambridge almost late for the breakfast date.

In 1932 RK was posted to Gibraltar to command the 1st (Fortress) Company RE. During his two years on The Rock the Corps Cricket XI which he captained, and which contained two other Corps cricketers, Teddy de Brett and Dan Grose, was invincible. He was also a member of the highly successful RE Gibraltar polo team and he was a great supporter of the Royal Calpé Hunt.

In 1934 he was posted home to become Vice-President of the RE Board which appointment he held until he retired in May 1936 to become Secretary of the MCC, a post for which he was eminently fitted having been a Corps and Army cricketer and a writer on cricket. Apart from the time when he was recalled for military service during the last war he remained as Secretary at Lords until 1952. He was largely responsible for the codification of the Laws of Cricket, issued in 1939 and 1947, and for the formation of the MCC Youth Cricket Association and even after his retirement as Secretary he continued to serve on the MCC Committee and also at the Imperial Cricket Conference.

On the outbreak of the 1939/45 War, RK was recalled for service and given command of No 1, later renumbered 141, OCTU raised at Shorncliffe in September 1939. He was the ideal Commanding Officer for a unit which was to produce hundreds of war-time Sapper officers. When the War Office Selection Boards were established in 1942 RK was appointed President of the Board concerned with the selection of officers for the technical arms, and a year later he was made President of the Research and Training Centre for the Selection Board. Among his many duties were those dealing with the finding of appropriate posts for officers who had got into difficulties or who had had psychiatric breakdowns. Immediately after the war the Tavistock Institute of Human Relationships was established with similar aims and for several years RK served as Chairman of the Council of that Institute.

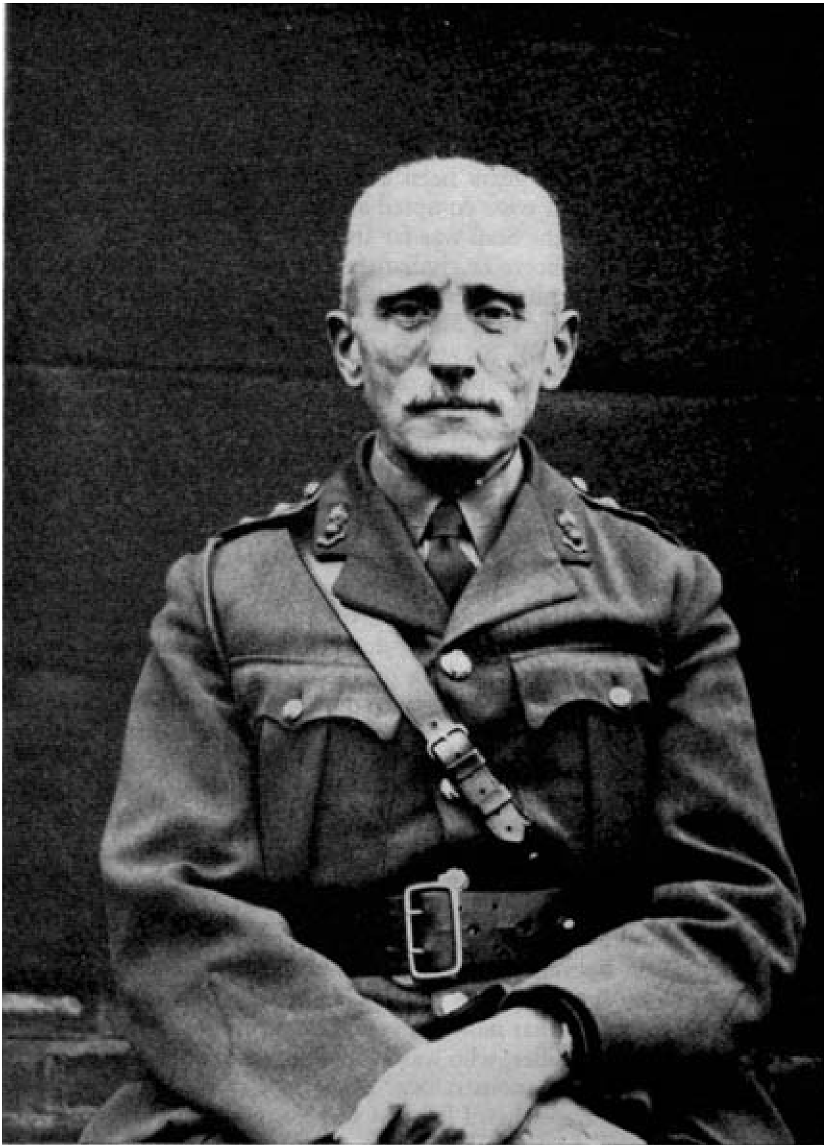
He married in 1916 Helena, daughter of Francis Metcalfe of Co Kildare and had one daughter, Diana whose meticulous work as Curator at Lords has done much to preserve the history and memorials of cricket. A memorial service was held for him on 4 May at St John's Wood Church close to the spiritual home of cricket.

CAPTAIN GEORGE DANN

George Dann, well known to a very large number of Sapper and Gunner officers who passed through the Shop, died on 25 February 1961 aged 80 years.

He was born on 13 May 1880 the eldest son of Captain and Riding Master George Dann RHA. From 1896 until 1910 he was employed as an engineers' pattern maker in the Royal Laboratory, Royal Arsenal, Woolwich. In November 1910 he was appointed Assistant Instructor in the Workshops of the Royal Military Academy, Woolwich and he remained at the Shop until it closed down on the outbreak of World War II. He must have instructed over 3,000 Gentlemen Cadets in his time and very many will remember this kindly and efficient instructor.

He was commissioned into the Corps in November 1939 and posted to the RE Apprentice Boys' School at Darland. On 23 July 1941 he joined the Staff of the Boys' Army Technical School at Chepstow as Works Manager and he remained there until his retirement in April 1945 having completed almost fifty years in the service of the Crown.



Captain George Dann

He married Georgina Fanny Webster, eldest daughter of Lieut-Colonel George Webster RGA (retired) on 29 April 1909, by whom he had two sons. His wife predeceased him in January 1945.

"T" writes the following tribute:—

"When I first met George Dann a few years after the 1914-18 War, he was in charge of the woodwork shop while Evan Arthur was in charge of the metal work. It was a time of change—firstly the new workshops were built in the centre road—later Arthur retired and Dann took over both sections—later still, with the beginnings of mechanization, workshops returned to the syllabus—they had for some years been a spare time pursuit—and Royal Engineer officers on the staff were co-opted as Instructors in workshops. But the workshop contact with the Staff was far from purely instructional. There was always a number of officers or civilian Instructors—sometimes six and more strong—who were turning out woodwork of some type. Amongst them were numbered, to name only two, Major C. J. S. King (now Lieut-General Sir Charles King), and Dr J. W. Stevenson (later Professor of Science at the Shop), and amongst the productions were two very successful sixteen foot sailing vessels. All the less skilled of the party owed everything to Dann for the work they produced. And the way in which the party kept up its strength as officers came and went was a measure of the popularity of his instruction.

"George Dann was one of those individuals who are lucky in themselves and in whom his friends and pupils—if one may ever differentiate between them—are lucky. Quiet, calm, unassuming, unobtrusive, out of mind and liable to be forgotten until one wanted his advice or assistance. Then he was always to be found in his office downstairs, or about his workshops, never flurried, always courteous, never too busy to break off what he was about if he could answer a query or advise in a problem. Woodwork, metal work, motor cars even (one highly placed officer required a complete overhaul for his car and this, though privately considered a complete foul, was—if memory is correct—carried out), or on a personal matter, for he was a shrewd and sympathetic counsellor with an inner strength—all such problems came his way. And withal, he could react strongly to inconsiderate treatment, whether to himself or to another. He was a member of Staff House, but to the constant regret of many of its members could rarely be prevailed on to come in; once a year perhaps if as often.

"No word of Dann would be complete if it did not mention his two loyal assistants, Reddy and Dwyer. The first, cautious and careful with 'The job must be a good one' attitude; the second, light-hearted and a cheerful whistler, with 'If it works what more do you want' attitude. And his neighbours Mr Hopkins the Modeller, who was such a dear and an artist in wood, and Mr Turner and Science demonstrator.

"He was still at the Shop when I left but was posted so I heard to Chepstow at the beginning of the 1939 War, and it was to there I wrote in 1942 to tell him that Bill Roberts had finally severed his connexion with the Army. In his reply he said that he was shortly retiring as well, and that was our last contact."

Book Reviews

WAR IN THE DESERT; AN RAF FRONTIER CAMPAIGN

By Lieut-General Sir John Bagot Glubb, KCB, CMG, DSO, MC

(Published by Hodder and Stoughton. Price 25*s*)

Deserts are the same today as in the days of Cain and Abel. If you have health and food, water and a means of locomotion—whether it be the camel of old or the motor car or aeroplane of today—you have little to fear from the wastes of sand and rock. But if things go wrong; if you are sick or have lost your way, or even think you have lost your way; if the camel can go no farther, or the petrol tank is dry; if these things happen, only the stoutest heart will retain hope; and man, for all his modern knowledge and skill, is forced back upon his native courage and resource. Man may learn many things in the desert; the greatness of God, the blessings of primitive virtue and the scourge of original sin. Good and evil are sharply defined; and life in the desert may be something of a liberal education where the fees are paid in physical endurance.

General Glubb has probably lived with deserts as much as any Englishman alive today. He has had unique experiences; he has pondered deeply upon them, and now he writes from a vast well of Arab lore. He writes too, with a charm, a simplicity and a humility that will win the hearts of his readers. Your reviewer believes that anyone who reads for pleasure will enjoy his latest book, *War in the Desert.* It tells of an era that has gone for ever, when British imperial power sought to manage the affairs of Iraq through the exercise of influence by air power. The underlying theory was simple: where roads do not exist and where the maintenance of garrisons is impossibly costly, it should be simple to control the area with an air force operating from a central base. In practice there were difficulties. Although the airmen might only be a few hundred feet from the tribesmen below, and were incomparably better armed, they might have been in another continent for all the human touch they could have with them. The RAF quickly perceived that force is not the only argument, and devised a system whereby a number of selected officers on the ground played the role of military attaché, with political officers and governors in charge of districts. Glubb, a Sapper Officer back from World War I, was seconded for one of these posts, and arrived in Nasiriya on the Lower Euphrates in 1922. The *RE List* shows that he was then 25 years old; and the narrative of this book covers the period of his youth and service from 1922 to 1931.

The Author begins by introducing the "Dramatis Personae" of Iraq, Nejed, the Hejaz and of Arabia generally. We see Ibn Saud before the days of his wealth as a shrewd desert ruler. We meet his neighbour Husain of the Hejaz and the young King Feisal (his third son). We are introduced not only to the main streams of Middle Eastern politics in which the British Government played its part in seeking to maintain stability in an area of the greatest strategic importance; but also to the eddies and cross currents of local feuds and intrigues that often actuated sheiks and rulers in the shifting sands of Arabian affairs. Many of these affairs will not remain with the reader after he has put down the book, unless he is already steeped in them; but what will remain is a picture of the bedouins, their character, the lands where they live and the form of their nomad lives. It is all skilfully and vividly portrayed. We fly with the Author in what now seem elementary RAF aeroplanes, or ride with him in the company of tribesmen or the Camel Corps on their camels, or in his Ford trucks with their new-found desert mobility. It is a splendid story in its own right. It tells of a continuous series of operations that saved "a poor, simple and hardy community from the terror of constant massacre and established a peace which has never since been broken".

It would be impertinent to try and condense into a few sentences how this was done; and it would be impossible to follow the trends without the historical and biographical background that General Glubb gives us. The reader must learn these things himself by reading this excellent book. He will be caught up in a good story and will read happily to the end. Perhaps he will gain a juster appreciation of the benevolent intentions of British imperialism at that time. The good far outweighed the bad. The British officers of the day knew and loved the bedouins; they shared their joys and their hardships; and in many ways identified themselves with them.

The reader should note that the title of this book is not *The War in the Desert*; but more simply *War in the Desert*. A casual glance at the title in a library list might lead the unwary to suppose that it was one of these fashionable books debating who beat Rommel in another desert at another time. The subtitle "An RAF Frontier Campaign" will guide the intending reader, who wants a few hours' leisure in the company of some of the most fascinating nomads on the surface of the globe. M.C.A.H.

HISTORY OF SECOND WORLD WAR: CIVIL AFFAIRS AND MILITARY GOVERNMENT NORTH-WEST EUROPE 1944–46

By F. S. V. Donnison

(Published by Her Majesty's Stationery Office 1961. Price 42*s*)

The potential reader might well decide that an official history with this title would be extremely dull and would therefore pass it by. This volume, however, belies its prosaic title. The author in his concluding paragraphs says: "Few recruits came happily to Civil Affairs in the first instance, for there was a certain lack of glamour about a service which was clearly going to be largely concerned with the operation of public utilities, of banks, of criminal courts and of what looked as if it might become a nightmare grocery business . . . little by little their attitude changed. They found themselves engaged in work of great value and absorbing interest, work above all that was constructive in a world temporarily given over to destruction." Anyone who is prepared to read this volume cannot fail in the end to feel that his efforts had been well rewarded.

Although he tends to give too much space to the tactical handling of civil affairs (military government) detachments in the field, Mr Donnison has succeeded in making a subject live, which could very well have been boring. He relates how the British and American governments, profiting from their experiences at the end of the 1914–18 war, began as early as October 1942 to make their plans for the civil affairs activities which would inevitably arise in the closing stages of the war in north-west Europe. He has distinguished clearly the differences between civil affairs applied to liberated countries, where the aim was to assist the indigenous government at all levels to re-establish its authority, and civil affairs applied to occupied countries, where the aim was control of a conquered country by a military government. The volume is so arranged that the reader can select which of these two quite different functions he wishes to study and in the case of civil affairs in what part of north-west Europe from the Channel Isles through France, Belgium, Holland and Denmark to Norway.

The author has brought out in the chapters devoted to the preparatory period how planning was bedevilled by the struggle between the protagonists of the methods employed by AMGOT in the Mediterranean and those who advocated integrated military/civil affairs control, by the intransigence of General De Gaulle, and by the impact of the completely unrealistic Morgenthau plan for the political and economic treatment of Germany on President Roosevelt which prevented an Anglo-American agreement being reached on the policy to be adopted towards her after the war ended. As a result there were delays, overlapping and duplication in the preparation of plans, there was no agreement with the French authorities on the relations between civil affairs and the local government authorities when the second front was launched, and by the time hostilities had ended the Supreme Commander had received no directive on the policy he was to adopt towards Germany during the post-surrender period.

Although one chapter is devoted to the establishment of military government in Austria, the latter half of the volume deals almost exclusively with the application of military government in occupied Germany. It is probably not generally appreciated that the stark necessity of saving Germany from starvation and complete collapse caused the British Army to discard its weapons the moment Germany surrendered and set to work to rescue its late enemy from the disastrous results of Hitler's policies. Major-General (now Field-Marshal Sir Gerald) Templer (Director of Military Government 21st Army Group) and his small civil affairs staff quickly realized that they were engaged in a new but equally dour struggle to win the battle of the winter of 1945/46. They saw there was no time to lose and that to win it they would have to depart from many of the accepted principles of military government in Germany. Mr Donnison shows how, thanks to Templer's foresight, energy and administrative capabilities (and he virtually became the Prime Minister of the British Zone), and the fact that the Army placed engineers and transport at his disposal, the plans for the new battle were quickly drawn up and put into execution. There were many moments of crisis during the winter but little by little the battle was won; won by the joint efforts of the Allies and Germany for, without the resilience and industry of the German people and their co-operation with their conquerors, it would have been lost. Had it been lost the Iron Curtain might well have come down on the Rhine or indeed even on the Atlantic coast. The chapters on food, displaced persons, coal and transportation make fascinating reading and show the touch-and-go nature of the struggle during the first post-war winter in Europe.

Mr Donnison tells of the inception and build-up of the Control Commission for Germany, of its introduction to the British Zone and of the gradual handover from the military to the civilian authorities. Here, alas, the volume stops although the story is far from complete. There are hints that another volume is to follow. It is to be hoped that this will come about and that it will describe the way in which the Control Commission built on the foundations laid by military government. Should Mr Donnison be selected to write it, such a book should be full of interest for he would bring to it the clarity of style and lucid handling of complex material which distinguishes this volume.

S.W.K.

FOUNDATION FAILURES

By C. Szechy, D.Sc

(Published by Concrete Publications Ltd. Price 20*s*)

Because so much is to be learned from failures, the author, who is a Professor of Foundation Engineering at the University of Civil Engineering and Architecture, Budapest, has made a close study of foundation failures in Hungary. He originally published the results of a selection of these studies in a Hungarian book in 1957. This book was so well received by engineers in other countries that he has now had the work translated into English and added more case studies of failures in other countries.

The causes of failure are diverse, but the examples give direct attention to the more important causes in both design and construction, and to remedial measures where these were possible. The causes are classified into four groups (1) The absence of a proper investigation of the site or a wrong interpretation of the results of such an investigation. (2) Faulty design of the foundation or superstructure. (3) Defective temporary works or poor workmanship in the construction. (4) Insufficient provision for exceptional natural phenomena such as thermal and biological conditions, rainfall, and floods greater than those hitherto recorded at the site. Most forms of ordinary foundations are dealt with, and in particular the foundations of many types of buildings, bridges, industrial storage, marine and riverside structures are included.

The book appears to suffer none of the normal disadvantages of being a translation. The English grammar and use of technical terms can hardly be faulted; but what is even more important, the author has gone to considerable trouble in transforming all metric units into equivalent English units for dimensions, loads, pressures, etc., not only in the text but also on drawings and diagrams. The drawings themselves are models of clarity, drawn specifically for the book and containing only relevant information. There are twenty clear photographs most of which graphically illustrate the various engineering nightmares described in the text. There is, however, one minor but annoying editorial slip in that the text references to the first twelve photographs refer the reader to the wrong pages.

The book contains 139 pages of the usual "Concrete Series" size with 103 figures and twenty plates. There is a comprehensive bibliography giving twenty-nine references (nineteen in English) and a concise, though perfectly adequate, index.

To sum up—a most interesting and valuable book for any civil engineer. J.D.E.

REINFORCED CONCRETE

New Edition Rewritten and Extended

By John Faber *and* Frank Mead

(Published by E. & F. N. Spon Ltd. Price 75*s*)

This is a very comprehensive textbook running to 532 pages and covering a great variety of subjects. Simple reinforced concrete theory is covered in four chapters including a chapter of examples. Use is made of design graphs but it was surprising to find that the approximate method of design of doubly reinforced beams is not mentioned. Foundation design receives very thorough treatment and the chapter is introduced by a very useful forty-three page résumé on soil mechanics. Bunkers and silos, tanks, water towers, tall chimneys, roads and pavings, and shell roofs each have a chapter on their design.

The final chapter is devoted to prestressed concrete. In this one chapter the authors have covered most aspects of prestressed concrete in a simple and understandable way. They include a portion on stresses at the anchorage and go on to design anchorage reinforcement but I feel that on a subject such as this, when there is still considerable controversy on anchorage stresses, they should have emphasised that their solution is one of many and much work still remains to be done on anchorages. Current experiments seem to show that the treatment by Magnel, and used in this textbook, is wrong by a factor of between 1.6 and 2.

My only criticism, of what is a very excellent textbook, is that the design graphs and curves would be much better if enlarged to full page size and collected in one section at the end of the book where they could be found easily instead of being scattered through the text as they are. W.C.

THE DESIGN OF CYLINDRICAL SHELL ROOFS

By J. E. Gibson

(Published by E. & F. N. Spon Ltd. Price 52*s* 6*d*)

Analysing a shell roof requires a sound mathematical background and engineers have often been criticized for their reluctance to make use of higher mathematics. With this fact in mind Dr Gibson has revised and enlarged his book and although the theory is carefully developed, the reader does not necessarily need to be able to derive the equations obtained provided he is aware of the principles behind them. Worked examples are interspaced with every two or three chapters of theory and I found these very helpful when working through the theory.

Of the four new chapters in this edition, Chapter 11 deals with preparation of programmes for the Mercury Automatic Digital Computer and this is, I feel, a very useful addition. Any engineer faced with the design of a shell roof must expect to carry out a considerable amount of calculation before the final details of the design are reached, and use of computers in this field will save days, possibly weeks, of calculation.

A clear and concise book giving both theory and worked examples which will be invaluable to any engineer faced with the design of a cylindrical shell roof. W.C.

A GUIDE TO THE B.S. CODE OF PRACTICE FOR PRESTRESSED CONCRETE No 115 : 1959

By F. Walley and S. C. C. Bate

(Published by Concrete Publications Ltd. Price 12*s* 6*d*)

In November 1959, The British Standard Code of Practice No 115 was issued. This code deals, for the first time, with the design and construction of prestressed concrete.

Concrete Publications Ltd produce an explanatory handbook on the code for reinforced concrete and the new guide is identical in layout to the explanatory handbook which will be of assistance to engineers already familiar with the explanatory handbook.

In the guide the appropriate clause of the code is reproduced in full and sidelined with a thick black line, comment and explanation following.

As may be expected with a new code much is omitted—eg, shear resistance at ultimate load condition, end block stresses and design, statically indeterminate structures, and the guide in these cases makes little more than a reference to them in passing.

Elsewhere, however, the comments are clear and concise and are illustrated with sketches, tables and graphs. This is a very useful book and any designer dealing with prestressed concrete design would be well advised to have a copy in his library. W.C.

Technical Notes

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, January 1961.

A NEW CANADIAN STRUCTURAL TEST INSTALLATION: The November, 1960, issue of *The Engineering Journal of Canada* contained an interesting paper on "Structural behaviour of highway bridge decks" (see Technical Notes *RE Journal*, March 1961). This described practical tests carried out to determine the actual strength of certain bridge floors, for comparison with the designed strength based on conventional calculations. The growing interest of structural engineers in the effects of interaction between the components of a structure, and in the validity of design assumptions regarding elastic behaviour, has led to the establishment of structural testing laboratories in several countries.

The Canadian installation, based on a study of these, is suitable for full-scale loading tests on a wide variety of structural elements. The design of the installation and the main constructional features are clearly described, but no information is given about the results of tests, although they are stated to be entirely satisfactory.

RECENT ADVANCES IN EXPERIMENTAL STRESS ANALYSIS: The importance of experimental stress analysis has been greatly enhanced by the vital need for weight-saving in the design of missiles and space vehicles. This paper deals mainly with the advances made in three-dimensional photoelastic stress analysis, and with the use of light weight strain gauges. It is as well that the engineer should be able to appreciate what is involved in the laboratory work on which design depends.

FRAZIL ICE AND FLOW TEMPERATURE UNDER ICE COVER: Frazil ice particles are thin discs, which form in turbulent water when the surface is supercooled, and they can present a serious clogging problem at power station intakes. A general paper on this subject was summarized in Technical Notes in the *RE Journal*, March 1960. The present paper tends to disparage the effectiveness of a surface cover of ice as a preventive, and propounds some new aspects of the problem. The discussion is mainly theoretical, and by no means conclusive.

BRAKING OF HYDRO-ELECTRIC GENERATORS: The use of automatic and remote control of generating stations entails the adoption of automatic braking systems, and increases the number of braking operations carried out. This paper sets out the design considerations necessary to secure efficient braking, and to prevent damage.

TRANS-CANADA ELECTRICAL INTERCONNEXION: The development of power production and distribution in Canada has, in the main, been on a provincial basis. The interconnexion of "units" into an integrated system has obvious advantages, and is now common practice, but the economic aspects of a coast-to-coast project to serve the whole Dominion require extensive and detailed study. The author of this paper sets out to show that an *a priori* case for such a project can be made. He has provided some interesting reading matter.

MONTREAL'S JET AGE AIRPORT: This comprehensive general description of the rebuilding of Montreal's airport at Dorval, to meet the needs of modern commercial air traffic, provides a most valuable picture of a major engineering project, with an illuminating summary of the technical services required. The pavement provided for the existing three runways, with taxiways and aprons, covers an area of 359 acres, and projected extensions will nearly double this figure. Soil investigation and pavement design are briefly discussed, and interesting details are given about the terminal building, with a floor area exceeding 250,000 sq ft, and about power supply, heating, and refuelling systems.

Notes from *The Engineering Journal of Canada*, February 1961.

TEST BUILDINGS IN BUILDING RESEARCH: For research purposes full-scale buildings, whether existing or specially designed, rarely provide the most satisfactory data, owing to the great number of variables due to external environment and occupancy. Small test huts admit of simpler instrumentation and analytical techniques, and they are more readily adaptable to particular studies, as well as being far more economical. The authors of this paper are at pains to demolish the popular conception of the "research house", and they stress the value of laboratory methods in the investigation of most problems. Their suggestion of three stages, from laboratory to pilot scale to full scale, is tentative, and their paper reaches neither conclusion nor recommendation.

THE FORMATION OF CONTINUOUS CHIPS IN METAL CUTTING: This paper presents the results of experimental investigations, in which high-speed photography played an important part. Its interest is primarily academic.

GREATER WINNIPEG FLOODWAYS: Very serious flooding in 1950 led to an investigation of methods of flood protection for the whole Red River basin, since spring flooding is a recurring problem in Winnipeg. This account of the various projects considered, and of their economic evaluation, is remarkable for its practical approach to what might have become a complicated exercise in accountancy. It could have been written only by an engineer, and other engineers will appreciate, and perhaps profit from, his down-to-earth analysis and presentation.

SAULT STE MARIE BRIDGE DESIGN: The two cities of Sault Ste Marie, one in Michigan USA, the other in Ontario, Canada, are divided by the St Mary's River, which forms the international boundary. The construction of the foundations for a new international vehicular bridge, joining the two cities, started on 1 September 1960, and the opening is planned for 1 September 1962. The total length of the bridge structure is 9,280 ft; the length of approaches carried on fill is 1,044 ft; and the project also includes a toll "plaza" at either end, to accommodate toll booths, and Customs and Immigration buildings. The total length of the whole project is approximately 2¾ miles.

In general, the bridge roadway consists of a 7-in reinforced concrete slab, with a 1½-in bituminous wearing surface. The over-all width is 28 ft between kerbs. The structure includes main truss spans crossing the American and Canadian ship canals, with a minimum clearance of 124 ft above low water, and continuous girder spans over the US power canal and St Mary's rapids. The design of the superstructure has several points of interest.

After a very clear account of the background of the project, and of the site conditions, the author describes the salient features of the location and design of the bridge structure and its approaches, and outlines the construction schedule. The exclusion of technical details which are unnecessary for proper understanding of the project makes this paper easy to read.

EARLY OTTAWA AND ENGINEERING: Though not a technical paper, this historical sketch of the development of Ottawa (originally Bytown) is well worth the attention of RE readers, if only for its graceful references to that famous Sapper, John By, and his faithful assistants. Those were, indeed, the days for the military engineer, but the modern Sapper will, in his turn, find as great a need for foresight, and for skilled improvisation when specialist equipment gets lost or damaged.

The remaining three papers in this issue are not of particular interest to the military engineer. The titles are:—"Glacial lake clay deposits", "Economic aspects of industrial power plants", "Trends in electrical engineering education". R.P.A.D.L.

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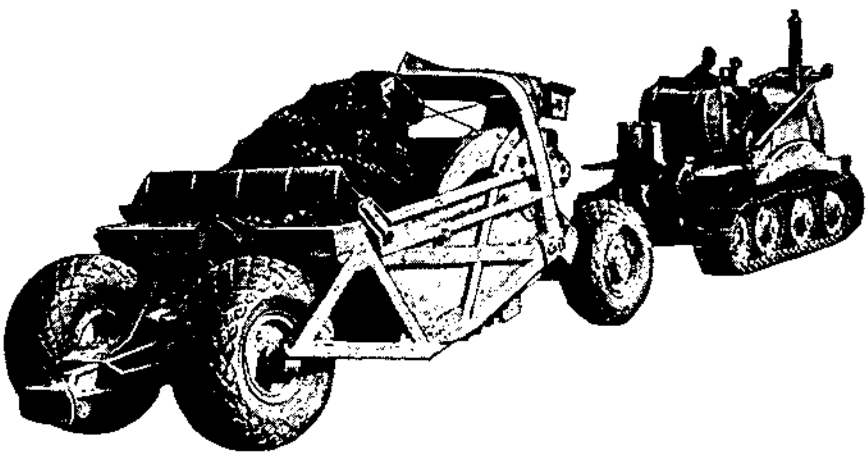

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