THE ROYAL ENGINEERS JOURNAL—JUNE 1958

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THE ROYAL ENGINEERS JOURNAL

Vol. LXXII JUNE 1958 No. 2

CONTENTS

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Financial Security

(During and after an Officer's Regular Service in the Army)

By COLONEL HAROLD B. FINCH (Retd.)

The Problem

During one's career, it is usual to find that one's pay is barely sufficient to meet one's requirements, and although pay is increased with promotion, expenses usually grow more rapidly and exceed that increase as time goes on. Financial hardship (which is certain to happen some time during thirty or thirty-five years of service) without a private income is likely to put one into such debt, that recovery is almost impossible, unless some special provision has previously been made.

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COLONEL HAROLD B. FINCH (Retd.)

(M.C., F.A.I.B., A.M.I.Mech.E., F.R.H.S., F.Z.S.)

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VOL. LXXII

CONTENTS

JUNE, 1958

The Royal Engineers and British Columbia

By MAJOR D. VEITCH, R.C.E.

INTRODUCTION

IN January of this year a series of commemorative events began in Canada's most westerly province, British Columbia, which stretches north along the Pacific Coast and astride the Rockies to the snow-bound vastness of Alaska and the Yukon Territory. These celebrations commemorate British Columbia's centenary and will cover every season of the year and every section of the province. Many of them will have a strong connexion with British Columbia's lifeline, the Fraser River, taking place both along its length and at its estuary. And principally because of this connexion with the Fraser of a hundred years ago, this article has been written for *The Royal Engineers Journal.*

For, as in so many other fields, the Corps of Royal Engineers, true to their motto "Ubique" were there, and as in so many other instances were there in the beginning. It was they who assisted in bringing law and order to the infant Colony of British Columbia. It was they who first surveyed and laid out many of the cities and towns of today. And it was they who prepared, amongst other things, the first maps, designed the first churches, the first postage stamps and established the first observatory.

It is in keeping then that in this centennial year we should review their achievements and be proud of their work—the foundations on which the Province of British Columbia was able to grow into such vigorous maturity.

HISTORICAL BACKGROUND

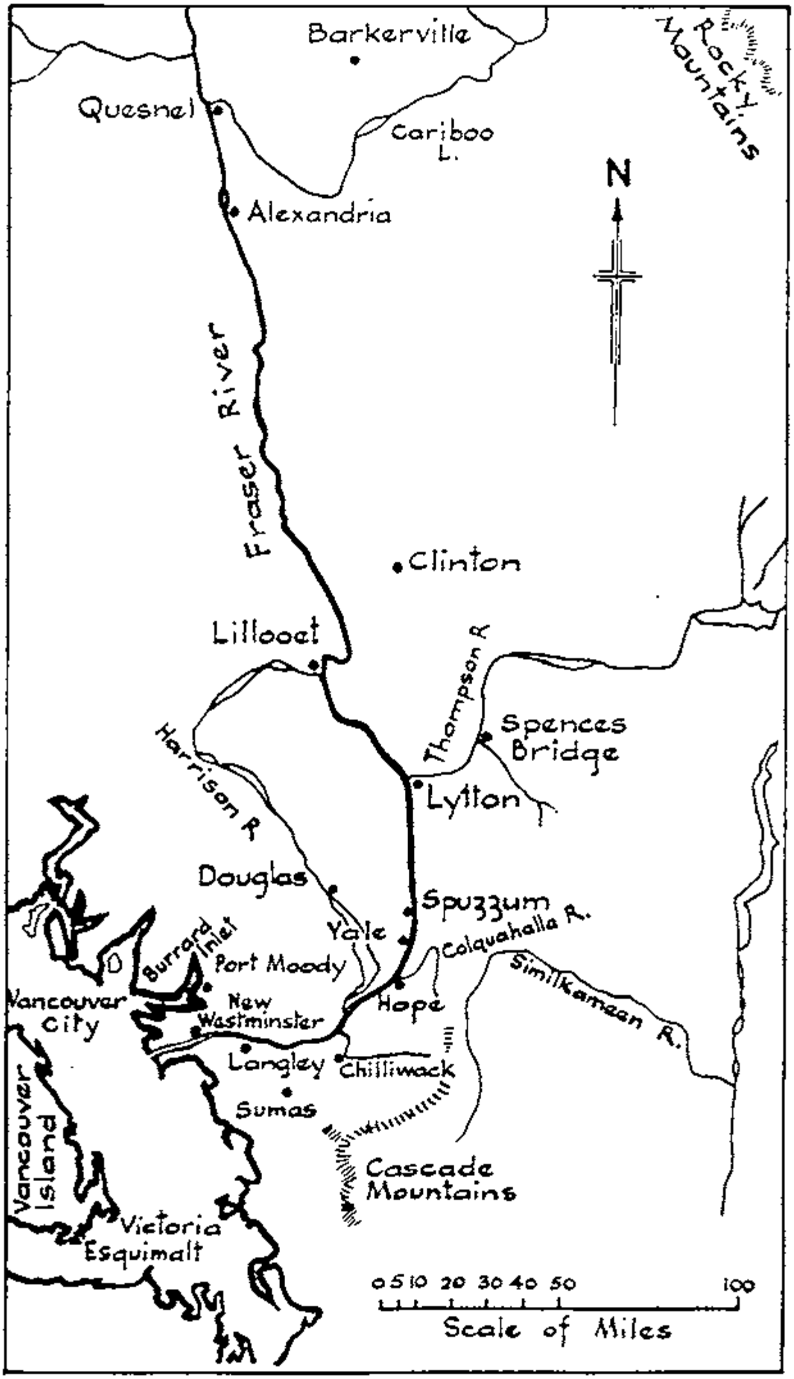
The area that is now the Province of British Columbia was once two separate colonies, that of Vancouver Island formed in 1849 and the mainland, originally known as New Caledonia and later proclaimed in 1858 as the Colony of British Columbia. In August, 1866, the two colonies were united under the name of British Columbia and eventually joined the Dominion of Canada on the 20th July, 1871.

It is the intention here to examine particularly the work of the Corps which was carried out on the mainland by Lieut.-Colonel Richard Clement Moody, R.E., and his special detachment from 1858 to 1863 with brief reference where possible to the others who followed or went before. No mention, other than this, will be made of the Royal Engineers who formed part of the Esquimalt garrison on Vancouver Island up to the turn of this century and only passing reference will be made to the achievements of the other Royal Engineers on the mainland, who did not form part of Colonel Moody's detachment.

By late autumn of 1857 the world was aware of the existence of gold along the Fraser river. Before the following summer was over, an estimated 25,000 people had flocked to New Caledonia, as it then was, from as far away as Hawaii, Central and South America. This horde of adventurers knew nothing of the land to which they were going, nor did many of them know much of law.

Leiut-Colonel Richard Clement Moody RE

PART OF BRITISH COLUMBIA



This land to which they were going, the mainland of British Columbia, was at that time merely a vast fur preserve of the Hudson's Bay Company. Inhabited by less than a score of white men scattered among a dozen or so widely separated trading posts of the company, it was a complete wilderness without government, towns, roads, or means of transportation. In brief, save for the few forts and what little agriculture was carried out adjacent to them, the mainland was in a natural state.

Fortunately the Colony of Vancouver Island was near by, and even more fortunately its Governor, James Douglas, head of the Hudson's Bay Company on the Pacific coast, was a man not afraid to assume authority or to accept responsibility. Although he had no jurisdiction over the mainland, he took it upon himself, as the nearest Government official, to issue regulations regarding the mining of gold and the terms under which people might enter the country. This action was subsequently approved by Sir Edward Bulwer Lytton, then Secretary of State for the Colonies, and pending action by Parliament, Douglas was offered and accepted, the governorship of the mainland. Simultaneously he was requested to continue the maintenance of order in the gold mines.

Knowing of the unsavoury reputation of many of the incoming adventurers, and with his recollection of recent events in California where Vigilance Committees had been formed to combat lawlessness, Douglas was determined that such would not take place under the British flag. Accordingly, he wrote to Sir Edward Bulwer Lytton asking for soldiers to assist in keeping order in the country. Sir Edward had already anticipated this request and had written to Douglas (the letters crossing), to say that he intended "sending to British Columbia by the earliest opportunity an officer of the Royal Engineers (probably a field officer, with two or three subalterns) and a Company of Sappers and Miners(sic)[1] made up of 150 non-commissioned officers and men". In setting out their duties, the Colonial Secretary used a very broad brush indeed, for he said, in part: "It will devolve upon them to survey those parts of the country which may be considered most suitable for settlement, to mark out allotments of land for public purposes, to suggest a site for the seat of Government, to point out where roads should be made and to render you such assistance as may be in their power . . . This force is sent for scientific and practical purposes and not solely for military object."

In a later letter, the Secretary of State indicated why he had chosen the Royal Engineers. Describing the quality of the men he was sending out, he said "The superior discipline and intelligence of this Force, which afford ground for expecting that they will be far less likely than ordinary soldiers of the line, to yield to the temptation of desertion offered by the goldfields, and their capacity at once to provide for themselves in a country without habitation, appear to me to render them especially suited for this duty; whilst by their services as pioneers in the work of civilization, in opening the resources of the country, by the construction of roads and bridges, in laying the foundation of a future city or seaport, and in carrying out the numerous engineering works which in the earlier stages of colonization are so essential to the progress and welfare of the community they will probably not only be preserved from the idleness which may corrupt the discipline of ordinary

[1]The Royal Sappers and Miners were incorporated into the Corps of Royal Engineers under a warrant dated 17th October, 1856.

soldiers, but establish themselves in the popular goodwill of the emigrants by the civil benefits it will be in the regular nature of their occupation to bestow."

The Arrival of Colonel Moody's Detachment

From the large number of volunteers who came forward, attracted, no doubt, in part by the opportunity of obtaining thirty acres (later increased to 150) after six years' service in British Columbia, a picked body of men was chosen. These men were selected with a view to having in their ranks and among their number every trade and calling that might be useful in setting up the framework of the new colony. The detachment was under the command of Lieut.-Colonel Richard Clement Moody, R.E. and was dispatched in three parties. The first section of twenty men under Captain R. M. Parsons, R.E. were mostly surveyors, whilst the second group of twelve under Captain J. M. Grant, R.E. were mostly carpenters. The main body consisted of two subalterns, Lieutenants Lempriere and Palmer, Staff Assistant Surgeon J. V. Seddall, 118 non-commissioned officers and men, thirty-one women and thirty-four children under the command of Captain H. R. Luard, R.E.

The first two groups left England on the 2nd and 17th September, 1858. They travelled via the Isthmus of Panama and arrived in time to take part in the formal launching of the colony; for during their voyage Parliament had passed an Act creating the Colony of British Columbia, to come into force on the Act being promulgated in the country; and that promulgation was made at Fort Langley on the 19th November, 1858. Governor Douglas after being received by a guard of honour commanded by Captain Grant, was that day sworn in as the Governor of the Colony of British Columbia; so that now two separate colonies, Vancouver Island and British Columbia were in existence, both with the same Governor.

The main body left Gravesend on the clipper ship, *Thames City* on the 10th October, 1858. They came by way of Cape Horn and in mid-April of the following year, arrived at New Westminster where they were to establish their permanent camp. An account of this voyage, in the form of a weekly news sheet called *The Emigrant Soldiers, Gazette and Cape Horn Chronicle*, has survived, and for those who wish to read it, a reprinted copy can be found in the R.E. Corps Library. This weekly paper edited by Corporal Sinnett, from "the editor's office, Starboard Front Cabin, Thames City" was written on large sheets of cardboard and read to the assembled company by Captain Luard, every Saturday evening.

The officer in command of the detachment, Colonel Moody, who was also to become British Columbia's first Lieut.-Governor, its first Chief Commissioner of Lands and Works and member of the Governor's Executive Council, arrived in Victoria on Christmas Day, 1858, having travelled separately from his parties via the Panama route.

Royal Engineers in British Columbia Prior to 1858

In dealing with the gold rush and the subsequent arrival of the Engineers, we are concerned with the best known group of Royal Engineers. But it should not be forgotten that even prior to the coming of this group, other Royal Engineers had been sent to this territory and a quick digression to examine their activities seems appropriate here.

In 1845, because of the heightening tension in the dispute between Great Britain and the United States over the Oregon question, two Engineer officers, Lieutenants Vavasour and Warre arrived overland from Canada. They were on a special secret mission to examine and report upon the defence of the Columbia River (claimed by Britain as the boundary) and the possibility of conveying troops overland to Oregon. They submitted detailed reports to the Secretary of State for the Colonies, but as negotiations with the United States had reached their final stage by the time the reports arrived in England, it is doubtful whether they had any effect.

Consequent upon the settlement of the boundary dispute it was, of course, necessary to survey the boundary line. The R.E. officers appointed to the Boundary Commission were Colonel Hawkins, Lieutenants Wilson, Darrah and Anderson and with them, under command of Lieutenant Wilson, was a group of fifty-six specially selected non-commissioned officers and men. In addition to their survey work through swamp, the densest forest, and across the grain of the Cascade Mountains, they were also called upon to preserve peace in the Fraser River mines. As a result of trouble between the miners and the Indians, Governor Douglas late in August, 1858 (before even the first of Colonel Moody's special detachment had left England) supported by Colonel Hawkins and fifteen of his men, together with twenty men of the Royal Marine Light Infantry arrived at Fort Hope. Fortunately, the disorder had ended, but Douglas' swift action was successful in cementing the peace with the Indians, and showing the miners that lawlessness would not be tolerated. To return to the original purpose of the Boundary Commission, the final line, run under their auspices, stretched along the 49th parallel of latitude, from the Pacific coast to the Rocky Mountains, terminating in longitude 114° West.

The Work of Colonel Moody's Detachment

In considering the work of this group, year by year from 1858 to 1863, one fact must be kept in mind or a false impression of haphazard planning will be gained. As gold petered out in one area new finds were made in other parts of the province, and the population would then rapidly gravitate to this new centre. Since the task of the Engineers was to provide for these changing centres of population, it was inevitable that a certain amount of vacillation should occur. With this reservation in mind let us then look at the achievements of Colonel Moody and his party.

1858

No sooner had Captain Grant dismissed the inaugural guard of honour than they, turning to their respective trades, began to prepare a permanent camp against the arrival of the main body. The site selected by the Governor for the seaport town, or capital, as others regarded it, was old Fort Langley, or Derby about two miles below the existing fort. However, when Colonel Moody arrived, he condemned Derby as being unsuited for defence as well as situated on the wrong side of the Fraser River and recommended New Westminster in its place. All the work done at Derby was thus lost and, in consequence, when the main body of the special detachment arrived in April, 1859, little had been accomplished.

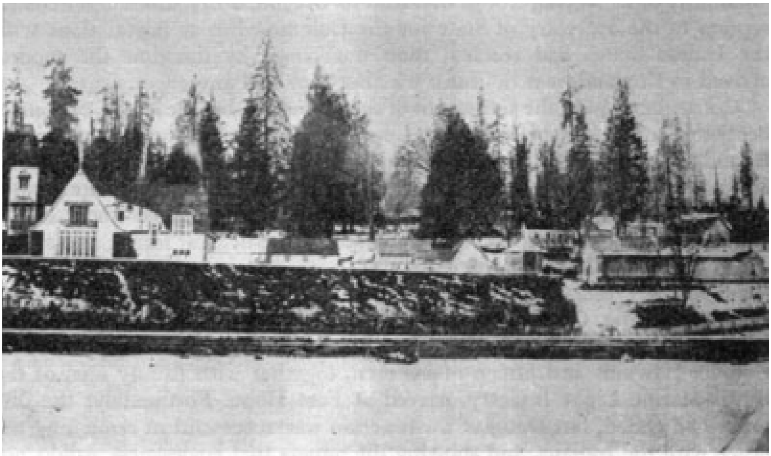


Photo 1.—Royal Engineer Camp.

Photo 2.—New Westminster, late in 1859.

The Work Of Colonel Moody's Detachment 1 , 2

1859

While the Sappers were still at Derby their work was interrupted by a bloodless "war", a trivial incident which occurred in the Yale area and is sometimes referred to as "Ned McGowan's War". A petty squabble between two magistrates, each with their adherents, exaggerated out of all proportions, sent Colonel Moody, Captain Grant and twenty men of the Royal Engineers post haste to the troubled area, closely followed by one hundred sailors and marines from H.M.S. *Satellite*. The nearer the party came to the "war zone" the less excitement there was, and at Yale everything was peaceful. In fact, the day following Colonel Moody's arrival being Sunday, he made use of the court house to hold Yale's first public divine service. Although the Engineers did not fire a shot in this "war" they were again the instruments whereby the Government showed its determination that lawlessness such as had transpired in California would not be countenanced in British Columbia.

After the arrival of the main body in April, all hands turned to the task of clearing the camp site, building the barracks and married quarters, storehouses, offices, a theatre, an observatory and other necessary structures. The chosen site, Sapperton, was near the new capital of the Colony selected by Colonel Moody, first known as Queensborough, but afterwards named by Queen Victoria, New Westminster.

Coincidental with this, the town sites of New Westminster, Hope, Yale, and Douglas were surveyed and laid out, the plans being lithographed and published; also books were printed in Sapperton by the Royal Engineers' press.

Road construction by the Engineers, which over the following years is almost beyond detailing, began with a trail from their camp out to Port Moody on Burrard Inlet. Next, to avoid the Fraser canyons, Lieutenant. H. Spencer Palmer and one hundred men of the detachment surveyed, relocated and improved the miners' primitive trail from Douglas to Lillooet until it was reasonably passable. In order to reach the Fraser in the canyon Lieutenant A. R. Lemprière and a small party, built a trail from Hope up the Coquahalla, along the south branch of the Anderson River through to Boston Bar, and up to Lytton keeping to the easterly side of the Fraser. In that year, also, Lieutenant Palmer with another detachment of Engineers made a complete exploratory survey of the whole country between Hope and the Columbia River.

During the summer of 1859 trouble occurred, between Great Britain and the United States over possession of an island of the Haro Archipelago, San Juan. Again Colonel Moody and his detachment were called upon to assist in the preservation of order, but this time he could only take forty-four Marines and fifteen Engineers with him—the remainder of the Sappers being engaged, as we have seen, in the peaceful and more useful occupation of building roads.

1860

In January, 1860, Governor Douglas made a proclamation permitting pre-emption of land. Accordingly, the surveyors of the detachment went to work over the district between Sapperton and Vancouver Harbour on Burrard Inlet and on the south side of the Fraser River establishing a draughting and record office as a natural concomitant of the process. In addition, the town plans of Lillooet and Lytton were completed and printed.

Captain Grant, with eighty men, began a project to control the level of the Harrison River so that freight could be sent from New Westminster to Douglas by steamer direct, without being off-loaded and portaged across the river shallows. Driven from this by a rise in the river, the party then began converting the first twenty-eight miles of the 1859 trail from Douglas to Lillooet into a road. Later, a party of Engineers under Sergeant-Major Cann, relocated the trail from Yale to Spuzzum blasting a pathway suitable for mules through the tremendous shoulders of rock along the Fraser.

It was in this year that gold was discovered in the Similkameen country to the east across the Cascade Mountains. To enable the miners to get from the Fraser to this new find, Sergeant McColl and his party located and laid out a trail, which started at Hope and climbed 4,000ft. over the Cascades with never a greater single gradient than one in twelve. This trail, built by Edgar Dewdney, later took his name.

Faced with the possibility that the Fraser might freeze in winter, Governor Douglas then set the Engineers the task of investigating the practicability of a road from Hope down to tidewater. During the summer of 1860, Captain Parsons and a small party explored the entire region between Hope and the tidewater areas as well as doing a reconnaissance survey of the Sumas and Chilliwack country (the present location of the Royal Canadian School of Military Engineering) with a view to protecting it from flooding and subsequently utilizing it as farmland.

1861

Although the Sappers had spent time during the two previous years improving the land portion of the Douglas-Lillooet road and, indeed further improved it in this year, transportation along the route would never be completely satisfactory. The total journey involved four separate trips by land interspersed with three voyages by lake steamer, with a consequent unloading and reloading of freight and usually a delay whilst waiting for the steamers to make the connexion at each point. Now it was the task of the Sappers to find a way through the Fraser canyons, through that terrifying and awesome country between Yale and Lytton. The reconnaissance survey made it clear that the river had to be crossed somewhere and Sergeant McColl and his party were dispatched to find the best site for a bridge. As mute evidence of the worth of his work, one of the piers of today's modern suspension bridge rests exactly on the spot chosen by McColl, and the other is only a few feet away.

In 1861 also, the Engineers transformed the 1859 trail they had constructed from their camp to Port Moody into a road which is still in use, the North Road. Captain Grant with eighty men, built a road much along the line of McColl's location of 1860, from Hope as far as Skagit Flats, about twenty-five miles, on the way to the Similkameen. The remainder of the trail was merely widened as a temporary expedient, and before it could be made into a real road, the miners' attention was diverted northwards by the new-found wealth of the Cariboo.

1862

1862 was the year the famed Cariboo wagon road was built. The Royal Engineers have frequently been credited with building this road but they did not. They built only two short pieces. One, the first six miles out of Yale, was built by Captain Grant and fifty-three Sappers between May and November, 1862, with Lieutenant Palmer and his party constructing nine miles from Spence's Bridge, eastward along the Thompson River, the following year. What the Royal Engineers did do, however, at the risk of their lives, was to find where the road could go. They surveyed and laid out the road and superintended its construction by contractors and as mentioned above they, themselves, built the most dangerous and difficult parts along the Fraser and Thompson Rivers.

Lieutenant Palmer was again sent out on reconnaissance, this time to find a shorter route to the Cariboo. He explored the whole country between Bentinck Arm on the coast and Cariboo, and concluded that the road then under construction through the canyons was in the best possible location. This region was later explored in connexion with the surveys for the Canadian Pacific Railway but nothing was found to alter the recommendations of Palmer's report.

1863

The last year of the Royal Engineers' work was 1863. Carrying forward the work on the Cariboo road, Captain Grant and his party located it from Clinton to Alexandria, the actual construction being done by a contractor. Since the existing trail from Quesnel to Barkerville, the current gold town, was at too high an elevation for winter travel it did not suit Governor Douglas. Accordingly, Captain Grant located a new route, and built a trail along it by September, the whole fifty-nine miles being so passable that Grant rode the full distance in one day. Also in this year, as previously mentioned, Lieutenant Palmer built nine miles of the Cariboo road eastwards out of Spence's Bridge. Lieutenant Palmer was also responsible for testing the new Alexandra suspension bridge built by J. W. Trutch across the Fraser at Spuzzum. The Engineers had drawn the plans for this bridge, supervised its construction and now after careful examination, tested it in a most practical manner by driving across it a four-horse freight wagon loaded with 3 tons of goods. The bridge stood, and the deflection was less than one quarter of an inch.

During 1863, the surveyors were also at work. A party under Lance-Corporal George Turner surveyed the original lots that marked the City of Vancouver and made a complete traverse of its shoreline from Hastings Townsite around Stanley Park into English Bay and False Creek. It is due to the Royal Engineers that the people of Vancouver are today blessed with Stanley Park, the largest and most beautiful natural park contiguous to any city in Canada, for the land was reserved by Colonel Moody originally for military purposes. A survey of the suburban lots adjoining the City of New Westminster was also carried out, and at the direction of the City Council of the day, a space of not less than twenty acres was reserved, to be called "Moody Square" in commemoration of the city's founder.

When one realizes the amount of work accomplished by the Royal Engineers in their four and a half years in British Columbia, one wonders how so few could accomplish so much. Yet it was not a case of all work and no play for the detachment gathered each winter, from November until

March, in its camp at Sapperton, and their camp was then the centre of the social life and activity of the community. They had a social club. Their theatre was the scene of all kinds of dances and parties and balls, and all that social life which tends, if properly guarded and looked after, to the betterment of a community. The Engineers had a theatrical troupe, and the men of the detachment played comedies, farces and all sorts of dramatic pieces.

Summarizing the work of the Engineers it may be said that they made all the important explorations of the country from the time they came there. They surveyed practically all the towns and the country land; they located and superintended all the trails. They built the North Road, which was originally a trail. They built the Douglas-Lillooet road. They built the Hope-Similkameen road for 25 miles; and portions of the Cariboo road. All the maps of that time they drew, lithographed and printed in Sapperton. They formed the Lands and Works Department; they established the Government Printing Office and printed the first British Columbia Gazette. They inaugurated the first building society on the mainland; the first social club on the mainland, the first theatre and theatrical society on the mainland. They designed the first schoolhouse. They designed and built the first Protestant church on the mainland—the church of St. John the Divine—originally at Langley and now at Maple Ridge and they designed other churches—the original Holy Trinity, New Westminster, St. Mary's, Sapperton and probably those at Yale, Hope and Douglas. They designed the first coat of arms of the Colony. They designed the first postage stamp. They established the first observatory where they kept continuous scientific meteorological observations. Of course, Captain Cook and Captain Vancouver had earlier temporary observatories, but the first permanent one was built by the Engineers with its position fixed as 49° 12′ 47″ North latitude and 122° 53′ 19″ West longitude. They had the first private hospital and the first private library, both of which were later to benefit the citizens of New Westminster. And indirectly they built the first Parliament buildings, for on 21st January, 1864, the first session of the first Legislative Council of the Colony of British Columbia opened in the then vacant barracks of the Royal Engineers at Sapperton, New Westminster.

These are the material things. But, apart from that, from the Colonel down, these were selected men. They were not an ordinary detachment of the Royal Engineers; they were selected men and always took their share in every good work. In everything that went to the building of the community, as well as in performing their regular duty, Colonel Moody at the head, followed by his officers and men, fully lived up to the mottoes of the Corps "Ubique" and "Quo fas et gloria ducunt".

The Detachment Disbands

In the summer of 1863 orders were received from England that the detachment of Royal Engineers should be disbanded, and that officers and men should be given the choice of remaining in the Colony as settlers or of returning to England. Colonel Moody[1] and the other officers, along with twenty of the men, left for England in October, but the remainder settled down in British Columbia, in civil life as plasterers, plumbers, gardeners,

[1]Coloncy Moody, later Major-General, died at Bournemouth on the 31st March, 1887, and now lies buried in St. Peter's churchyard there. He was born 18th February, 1813, the second son of Colonel Thomas Moody, R.E.

masons, bricklayers, tanners, grocers, blacksmiths, architects, carpenters, photographers, tailors, shoemakers, undertakers, surveyors, book-keepers, hotel proprietors, in fact as men who were active in every walk of life. In 1863 there were 130 of them. Thirty-five years later there were thirty-four. In 1903 there were twenty-five and in 1909 (forty-six years after they were disbanded) there were fourteen. The last survivor, Philip Jackman, died in 1927.

The Colonial Treasurer

Captain W. Driscoll Gossett, R.E., also referred to by Governor Douglas as "W. D. Gossett, Major on Seconded List of Royal Engineers" served in British Columbia at the same time as Colonel Moody, although not as a member of the latter's detachment. Gossett was the first treasurer of the Colony of British Columbia, and as was the case with many other officials of that time served as acting Treasurer for the Colony of Vancouver Island, whilst residing at Victoria.

Later he became a permanent resident of New Westminster, establishing the colonial treasury at that place. As treasurer his foremost duties lay with the assay office, the mint and the gold escort, all points on which he differed with the Governor. Under his supervision an assay office operated in New Westminster from August, 1860, until November, 1861, which establishment he was pleased to designate in his correspondence and documents as the "Royal Mint". For this he was officially rebuked by Douglas.

Early in 1862, consequent upon the gold discoveries in Cariboo and the resulting increase of gold dust in circulation, Douglas saw fit to import a coining machine. Gossett at once set to work to establish a mint, despite the fact that the Governor had by now changed his mind on the subject. Seeking permission to style himself "Deputy Master of the Mint" or failing that "Acting Deputy Master of the Mint" he coined £100 worth of $10 and $20 gold pieces. Unfortunately, Douglas would neither allow the titles nor the coins to be put into circulation and shortly thereafter in failing health Gossett applied for, and was granted leave of absence.

In 1861 the year previous to his retirement, he assisted Governor Douglas in establishing a gold escort. One of the greatest difficulties the miners in the Cariboo had to face was that of getting their gold dust out of the country. To this end, with a guard of Royal Engineers, an escort was formed, each member well mounted and thoroughly armed. Unfortunately, the Government would not guarantee safe delivery of the dust, and as a result the escort of 1861 was a failure, financially and otherwise.

The Royal Engineers Participation in the Centennial Celebrations

To mark the pioneer work done by the Royal Engineers during those days which the province is now commemorating, the Corps Committee have arranged, at the request of the British Columbia authorities, that one officer and five O.Rs., uniformed and armed as for 1858, will participate in the various centennial celebrations, in conjunction with a similar party in modern dress from the Corps of Royal Canadian Engineers.

In addition, the Corps is to present to the City of New Westminster, an enlarged replica of the Corps badge of 1858. This plaque will be hung at the entrance to the City Hall and will serve to remind all who pass of the long-standing association between the "Royal City" and the Royal Engineers.

Photo 3

The R.E. detachment to attend the British Columbia centenary celebrations in 1858 pattern uniforms. Names from left to right: Captain G. R. Gathercole (in uniform of a lieutenant); W.O.II W. A. Foster (25 Fd. Engr. Regt.); Sgt. D. G. Tucker (12 S.M.E. Regt.); Cpl. N. E. Millar (17 Port Trg. Regt.); L/Cpl. M. G. King (Sch. Mil. Svy.); Sapper K. G. Thomas (Wks. Services).

Since the main events take place during the summer months, the party are due to arrive in British Columbia early in May. They will be stationed at the Royal Canadian School of Military Engineering, located in the same Chilliwack country surveyed almost one hundred years ago by Captain Parsons and his small party. From there, joined by a similar detachment from the Corps of Royal Canadian Engineers, but uniformed and armed as for 1958 to emphasize the continuing Sapper tradition, and accompanied by the band of the Royal Canadian Engineers in pre-war scarlet, they will sally forth to take their part in the Province of British Columbia's Centennial.

By this joint effort it is intended not only to reflect the work of the Royal Engineers in the early days, but to illustrate the fact that although the Corps left the Province some fifty years ago, its work has, and is being perpetuated and carried forward by its offspring, the Corps of Royal Canadian Engineers.

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The Work Of Colonel Moody's Detachment 3

Future Trends for Field Engineers

By Lieut.-Colonel D. J. Willison, M.C., R.E.

Many articles have appeared in recent years discussing the impact of nuclear weapons upon the functions, organization and equipment of Field Engineer units. It is difficult, however, to produce reasoned proposals for organization and equipment until the probable functions of Field Engineers in future warfare have been analysed. This analysis in turn must stem from certain broad assumptions on all the forms of warfare which British forces may find themselves called upon to engage in at any future date.

The aim of this article is therefore to discuss current strategic problems as a background to suggesting some lines of policy which might guide the future development of Field Engineer units.

Field, or as the Americans call them, Combat Engineers exist fundamentally to develop and maintain the means of mobility needed by the fighting and administrative elements of the Army, while denying wherever possible such means to the enemy. The theme of this paper is therefore mobility in the various forms of warfare which British forces may encounter in the future.

The spectrum of warfare now runs from internal security operations through the somewhat nebulous field of limited wars to global war involving the use of hydrogen bombs. The scope of the mobility problem differs with each of the possible gradations of military effort. Each gradation will therefore be examined in turn with a view to suggesting the pattern of the engineer tasks involved. In conclusion, a synthesis of these tasks will be attempted to show what common factors exist as a basis for designing Field Engineer units in the future.

General Strategic Background

For some years now, the annual Defence White Paper has laid down that the priorities for British Defence policy are forces for the strategic deterrent in first place followed by those for Cold War, Limited War and the waging of global war, in that order. The possibility of tactical nuclear weapons being used in Limited War has not been excluded in the 1957 White Paper.

A recent book called *Nuclear Weapons and Foreign Policy* by Mr. Kissinger includes the following definition of a policy of graduated deterrence. "Deterrence is the attempt to keep an opponent from adopting a certain course of action by posing risks which will seem to him out of proportion to any gains to be achieved. The higher the stakes, the more absolute must be the threat of destruction which faces him. But the reverse is also true, the smaller the objective, the less should be the sanction."

This paper is no place to discuss the theory of graduated deterrence. The above extracts, do, however, show that on both sides of the Atlantic the concept of forms of warfare other than all out global are increasingly coming to the fore. The advent of the sputnik has brought the age of "nuclear parity" between the Communist bloc and the West much nearer to general acceptance. The strategic message contained in the phrase "nuclear parity" is clear. It is that both sides are then capable of destroying the main centres of population of their adversary in a matter of days. Faced with consequences of such catastrophic proportions, neither side is likely to unleash hydrogen bomb warfare unless vital interests are thought to be at stake.

The first major strategic conclusion therefore is that in future full weight must be given to the demands of Cold and Limited Wars when designing land force units. It is not enough to use the possible global war battlefield in Europe as a testing ground for new organizations and equipment, for this form of warfare is the most unlikely contingency to arise. Furthermore, it is by no means certain that limited war will inevitably involve the use of tactical nuclear missiles. A balance must therefore be struck between the requirements of Cold and Limited War using conventional weapons on the one hand and limited nuclear and global nuclear war on the other. These requirements will now be discussed in more detail.

The Cold War

The Cold War is a loose term which covers a wide field of potential action for British Forces in the future. In practice many of the internal security problems in British protected or colonial territories arise from nascent nationalism rather than direct communist inspired subversion. Local patterns differ, but in principle it is fair to assume that the "enemy" will be armed only with small arms and various explosive devices.

In his fourth lecture in the Reith series for 1957, Mr. George Kennan suggested that it was on the front of police realities, not on regular military battlefields, that the threat of Russian Communism must primarily be met. This definition of the methods needed to combat Communist subversion dovetails neatly into current British practice on maintaining law and order in overseas territories. Wherever the British rule of law is endangered in these territories, it is now customary for operations to be mounted by a triumvirate consisting of representatives of the Civil Government, the Police and the Army. The latter take the field in support of the Police in the first instance. Only when the situation is beyond the capacity of the Police to control does the Army take direct charge. Even then the Army functions under emergency powers; martial law is not declared.

A common feature of such operations has therefore been the continued functioning of the civil administration including the public works department. Ports, roads, railways and airfields have been able to continue operating under civilian aegis. Calls upon military engineer effort to improve Army mobility during internal security operations have accordingly been limited in scope. Analysis of Cold War campaigns in the last ten years shows that new road and track construction in mountainous, jungle or forest country, including bridging with standard or improvized materials, has been one of the largest demands. Of almost equal importance has been the request for landing strips for light fixed wing aircraft and helicopters. Clearance of mines and booby traps on the other hand has needed little effort.

Looking to the future, it is a fair assumption that the pattern of Cold War operations in British protected and colonial territories will remain largely unchanged. Field Engineer tasks are likely to remain limited in scope. Existing organizations and equipment will suffice, apart from such improvements in earth moving machinery and surfacing materials as may be introduced into service as the years go by.

Limited War Using Conventional Weapons

Past centuries record many instances of limited wars, that is wars in which the political aim was limited to forcing an opponent to change his policy rather than to deliver himself bound hand and foot into the hands of his enemy. The logic of history therefore surely points to a return to this form of warfare in an age when mutual suicide is the end product of total war.

It is important to identify the probable enemy in such wars of the future. Korea and Suez both provide useful pointers. In neither case were the forces of Russia herself involved. In both cases arms and equipment had been provided from Russian or Satellite sources. Organization and training had been carried out to a greater or lesser degree on Russian lines. In Korea "volunteers" from the Communist bloc took part; at Suez intervention by "volunteers" was threatened but failed to materialize during the few days of conflict.

The most likely form of enemy is therefore a state beyond the confines of the Communist bloc proper which has received armaments up to and including heavy tanks and artillery from Communist sources. Equivalent weapons will have been received by the other two Services. All three Services will be organized on Russian lines. Should the West be forced to intervene militarily against such a state, support from the Communist bloc would be forthcoming in the shape of "volunteer" units, given sufficient time for deployment.

Along the periphery of the Arabian peninsula and in South-East Asia it is easy to see signs of such states being built up as bridgeheads for the further extension of the area of Communist domination. Mr. Kissinger in his book already quoted devotes a chapter to what he terms the strategy of ambiguity. The threat posed by aggressive states trading on nationalism and anti-colonialism as the moral support for their acquisitive activities is surely the most dangerous and at the same time the most ambiguous threat to Western interests which Moscow can produce. With the threat of a preventative war against Russia launched by the West now held in check by the advent of nuclear parity, surely recent events in Syria are the portent of the new phase beginning to open in relations between East and West?

The term "West" has been used deliberately. It now seems most unlikely that the United Kingdom alone will have to wage a limited war against the type of threat outlined above. The network of alliances provided in NATO, the Baghdad Pact and SEATO coupled with the recent Eisenhower doctrine for the Middle East make it reasonable to assume that the days of "going it alone" are past. Nevertheless this in no way absolves the United Kingdom from the duty of being prepared to contribute effectively and quickly to the suppression of any military threat to the stability of Middle or Far East.

The nature of the enemy described above precludes, in the view of the writer, the use of nuclear weapons. No one has ever seriously sustained the idea that nuclear missiles should have been employed at Suez. Much has been written of American intentions to use such weapons rather than wage another Korean type war by conventional means. Yet even Mr. Kissinger admits that limited nuclear war is the riposte against a mass excursion by large Communist bloc forces. Nowhere does he maintain that such sanctions could be applied to aggressive nationalist states aided and abetted by the Communist bloc. Should the West intervene militarily against such a state, then the political object could be no more than to maintain the geographic *status quo* in the area concerned and thus prevent the further spread of Communist controlled areas. Public opinion both at home and in the world at large would surely insist that minimum force should be used to achieve this aim. Equally, any friendly state asking for assistance would certainly insist that her territory was not to be devastated by even tactical nuclear missiles.

All these arguments point one way. The West must retain the capability of intervening with conventional forces to prevent further erosion of the non-Communist half of the world. Intervention must be mounted so rapidly that resistance ceases before any large numbers of volunteers can arrive from behind the Iron Curtain.

The mounting of such a force brings the engineers at once to the centre of the stage. In general, port facilities, airfields, roads and railways are few and far between throughout the area from the Eastern Mediterranean east and south to the borders of the Indian subcontinent. The same applies to the South-East Asia area. The greatest difficulty facing the Western forces will therefore be the rapid deployment of sufficient strength to achieve the political aim. Helicopters and aircraft can only lift lightly equipped forces. To cope with Russian heavy equipment it will be essential to land and maintain adequate numbers of tanks and artillery. Port or beach working, improvements to road, rail and inland water transport resources and above all else airfields with their associated fuel storage tanks are bound to be in the forefront of demands upon engineers.

Direct engineer support for fighting formations will exhibit all those features which are familiar to us from World War II and subsequent campaigns such as Korea. These tasks require the conjunction of field, plant and engineer stores units in sufficient numbers to support the future planned size of the United Kingdom strategic reserve. If any one of these three elements is cut back too far in peace, then it will be at the expense of rapid development of the mobility of the strategic reserve on arrival in the operational theatre.

The administrative support of a force which must of necessity go into action the moment it is deployed raises formidable problems from the engineer aspect. The transportation agencies will be the key factor in the ability of the force to move far and fast in undeveloped countries. Ideally the solution is to do the necessary construction work in peace under some form of infrastructure programme as is the practice within NATO. Failing this, transportation units will have to be regarded in future as of equal importance with Field Engineers in achieving full operational mobility for the strategic reserve. The call up of transportation reservists for a number of post-war emergencies in addition to Suez illustrates the importance which such units have played and must continue to play.

Nuclear War

Strategic assumptions for nuclear war are of necessity the most nebulous to formulate. Such a war may start in a number of ways. A massed onslaught by conventional Communist bloc forces on a neighbouring country is one danger. In the present state of conventional forces in the West, such an onrush could only be stopped by initiating nuclear war in the limited area of the aggression. A limited war of this type might quickly spread beyond the confines of the original battlefield, thus leading to a global nuclear conflict. On the other hand global nuclear war might occur through a major miscalculation by either side of their opponents' intentions. Least likely of all is the current popular assumption of a sudden "Pearl Harbour" type assault by the Communist bloc using hydrogen bombs.

On the tactical battlefield there is unlikely to be any major difference between a limited and a global nuclear war. The days of nuclear plenty are already at hand. In consequence both sides are likely to start such a conflict with missiles and means of delivery adequate to support their tactical designs. The main difference may well lie in the ability of the contestants to sustain the conflict for any length of time. In limited war, by definition, at least the home territories of the main Western and Communist bloc countries would remain inviolate. The capability of sustaining the conflict in the limited war area from safe sea, land and air bases would therefore remain until a compromise political solution was reached. In global war the battle for thermo-nuclear supremacy would within a matter of days decide the main issue. Where the land forces were physically in contact, the side retaining some degree of nuclear capability should thereafter be able to mop up the opposing force now bereft of adequate nuclear support. Both sides could expect little if any re-supply or reinforcement as their home territories would have been devastated by thermo-nuclear attack.

The theme of this article is mobility; the engineer effort needed to give our own forces the maximum capability for movement while denying mobility to the enemy. In this context certain generalization on the effects of nuclear weapons on the tactical battlefield can be put forward. First and foremost comes dispersion of troops, vehicles and installations. Fighting formations will occupy frontages and depths up to three times or more greater than was customary in war with conventional weapons in order to avoid serious losses from enemy nuclear strikes. Furthermore, the battlefield is likely to be far more fluid. This is because both sides must be prepared at any time to accept large voids developing in their dispositions from a close pattern of nuclear bursts put down by their opponent. Exploitation by armour through such patterns, coupled with the possibilities for vertical envelopment using helicopter borne forces, make it seem certain that static defence positions will have little potentiality in nuclear war. Much greater reliance will therefore need to be placed on strong, well dispersed reserves moving rapidly to create and then exploit the effects of nuclear strikes.

A battlefield design of this type will raise enormous problems for field engineer units. At any level, the organic engineer units will have to develop and keep open routes over an area of "real estate" three or more times larger than before. Worse still, a fluid battle will force the abandonment of those old faithfuls Red Route and Blue Route. Lateral movement of armour, armoured personnel carriers and supporting artillery will be vital for rapid counter penetration and exploitation tasks. Route requirements for all vehicles up to and including tanks are therefore likely to multiply throughout the length and breadth of a formation area. It should be remembered that in future all brigade groups will contain armour.

More horsepower per field engineer deployed on the battlefield is the obvious answer to this problem. Road building, road maintenance and obstacle crossing must all be done by more machines and less men. In order to keep pace with fluid battle situations, field engineers must be organized and equipped to operate across country at the pace of the tanks. The numbers of engineers required, together with their associated plant, cannot be assessed until the pattern of the forces they are to support is clear. The introduction of amphibians on a large scale, for example, could reduce considerably the load on the engineers for crossing of water obstacles. A substantial reduction in the size and weight of tanks in service would have an even greater effect on the total demands placed on field engineers. Supply by helicopters, light fixed wing or vertical take-off aircraft would cut the route construction and maintenance requirement in rear areas very considerably.

The second great impact of nuclear war upon engineers is the heat flash effect of a nuclear explosion. Virtually all field engineer tasks must be executed by men in the open. Their work is often in progress at times and in places where they are particularly susceptible to enemy counter nuclear strikes. In principle there are perhaps three relatively safe places on a nuclear battlefield; the best of all is locked in combat with the enemy; second is inside an armoured vehicle; thirdly comes a hole in the ground. The sapper cannot make use of any of these while working. Logically, therefore, he must develop machines and equipment which need few men to operate and provide at least flash cover for these few. This conclusion reinforces most powerfully the requirements arising from the dispersed and fluid nature of the nuclear battlefield.

The third generalization on the effects of nuclear war upon demands for engineer work concerns denial of mobility to the enemy. Widespread dispersion of fighting troops on the battlefield must lead to big gaps between units. There are bound to be incessant demands for some form of obstacle to slow up the enemy in these gaps until he can be pinned and destroyed by nuclear attack. Defensive positions may well best be sited to gain maximum attrition of the attacking enemy forces through nuclear bursts over a primary obstacle belt. The rapid preparation of demolitions and minefields over frontages and depths much greater than in conventional war is therefore bound to be required. Once again more horsepower per sapper appears to offer the only hope of doing much more work with the same number of men.

Finally, mention must be made of the engineer problems likely to arise in rear areas. In his initial nuclear fire programme the enemy is bound to strike at communication centres, supply dumps and forward airfields serving the fighting troops and their associated air forces. The geographic spread of the rear areas must of necessity be geared to the frontages of formations in contact with the enemy. Corps and Army engineer resources will therefore be faced with tasks many times the scale of those envisaged in conventional warfare. It is therefore most unlikely that any spare engineer effort will be available for deployment in support of divisions or brigades. On the contrary, the need for numerous landing strips for transport aircraft to maintain a minimum flow of essential supplies will greatly increase the burden on the engineers. Air may well be the only reliable transport agency for a considerable time after the main ports and communication centres have been destroyed by nuclear attack.

In the Communications Zone the transportation agencies will be faced with even greater problems. In limited nuclear war these problems may be at their most acute. Supplies and reinforcements must be got forward by every available means to keep the forces in contact with the enemy in being until a political settlement can be reached. These means will include the working of small ports and beaches, the use of local barges and craft and the rapid repair of rail communications. In global war, the task of sustaining the forces in addition to the dense populations of Western Europe staggers the imagination.

Policy for the Future

The first principle which emerges from this review of strategic problems is that organizations and equipments must be designed in future to give full weight to the varying requirements of cold, limited conventional and nuclear wars.

Cold war campaigns lead primarily to urgent demands on the Royal Engineers for the development of new routes and airstrips in difficult country.

In limited war using conventional weapons the first demand may well fall on the Transportation Branch of the Corps to enable the United Kingdom component of an Allied Force to deploy through inadequate port, beach and railway facilities. Field Engineers will find themselves engaged on the familiar tasks of opening up road communications forward, supporting the fighting arms in battle and providing airstrips for all types of light and transport aircraft.

Nuclear war, either limited or global, will increase the size and scope of engineer tasks enormously. On the tactical battlefield the need is for more horsepower per sapper in field units. This need arises from the effects of dispersed tactical dispositions and of the vulnerability of sappers working in the open to heat flash effects from a nuclear explosion. Numerous additional airstrips for transport aircraft will also be needed in the Corps or Army area.

In limited nuclear war the demands on the Transportation Branch will be higher even than in limited conventional war. This is because the deployment and maintenance of the force will be even more difficult than in war using conventional weapons only. In addition, limited nuclear war might last longer than global nuclear war as the respective main bases would remain intact.

From this review of the varying requirements for possible future wars comes a second principle. It is that in the all regular Army of the future there must be an adequate Transportation Branch of the Corps of Royal Engineers. In limited war, conventional or nuclear, the initial deployment of adequate forces will depend on the speed with which formed Transportation units can start operating in the overseas area. Such units can therefore no longer be regarded as Lines of Communications Troops on a lower priority and state of readiness than field units.

Thirdly, demands for road making including bridging, for road maintenance and for the rapid provision of airstrips for light and transport aircraft are common to all the types of war discussed in this paper. Improvements in the plant and stores needed for these tasks should therefore constantly be sought.

Lastly, nuclear war demands a radical re-assessment of the ability of engineer field units with their existing equipment and plant to meet the probable scale of demands upon them. Each sapper in existing units must be organized and equipped in future to carry out three or more times as much work in the same amount of time. Any equipment or technique which relies upon large numbers of men working in the open for long periods in the same place must go.

The Non-Destructive Military Application of Nuclear Energy

By Captain P. F. Aylwin-Foster, R.E.

Introduction

Much has appeared in this journal on the general subject of nuclear warfare, but little as yet, with the exception of Lieut.-Colonel J. E. L. Carter's noteworthy article in the March, 1957, issue, on those uses of nuclear energy commonly termed peaceful. The aim of this paper is to review very broadly the present state of developments in this field and to summarize and assess the possible non-destructive military applications. The word military is taken in its widest sense as covering all three services, and non-destructive as anything not directly involved with nuclear weapons. Thus while atomic missiles are excluded from consideration, the ships, aircraft or land vehicles which fire them and which may be nuclear power propelled are not.

The subject is considered under three main headings: power supply, propulsion, and the use of radioisotopes. There is here neither the space nor the need to get involved in the nuclear physics side of the subject, and no attempt is made to do so. The basic principles and present major limitations of a nuclear reactor are now fairly well known, and when considering possible applications it is no more necessary to delve into the realm of the nuclear physicist than it is to be a petroleum expert when considering applications of I.C. engines.

The Background

Nuclear Power Programmes

"It is a feature of the design of atomic plants that the most daring progress must be made under conditions of the most stringent conservatism". So said Sir Christopher Hinton in March last year. The truth of it makes all the more astonishing the progress made in the nuclear energy field in the past decade, and particularly the past two or three years. Since the general relaxation of security regulations, when it became obvious that Russia was as far advanced as the West, it has been common knowledge that many types of nuclear reactors are now actually functioning, building or well advanced in the planning stage. From literature now accessible to the public two things are very clear. Firstly the initial popular expectations of what nuclear energy had in store for us at an early date were wildly optimistic. Secondly, and conversely, the actual technical advance has been considerably faster than the average scientist would forecast a few years ago.

The rate of advance of more recent progress is well shown by comparing the programme of the 1955 White Paper on nuclear power with the revised nuclear programme announced by Lord Mills in April last year, only two years later. The comparison is shown in Table I.

Table I. U.K. Nuclear Power Programmes

By 1965, U.K. will have	Old: White Paper Plan (Feb. 1955)	New: Revised Plan (April 1957)
Nuclear stations	12	19
Generating capacity	1,500–2,000 MW	5,000–6,000 MW
Coal equivalent (million tons)	4–5	16–20

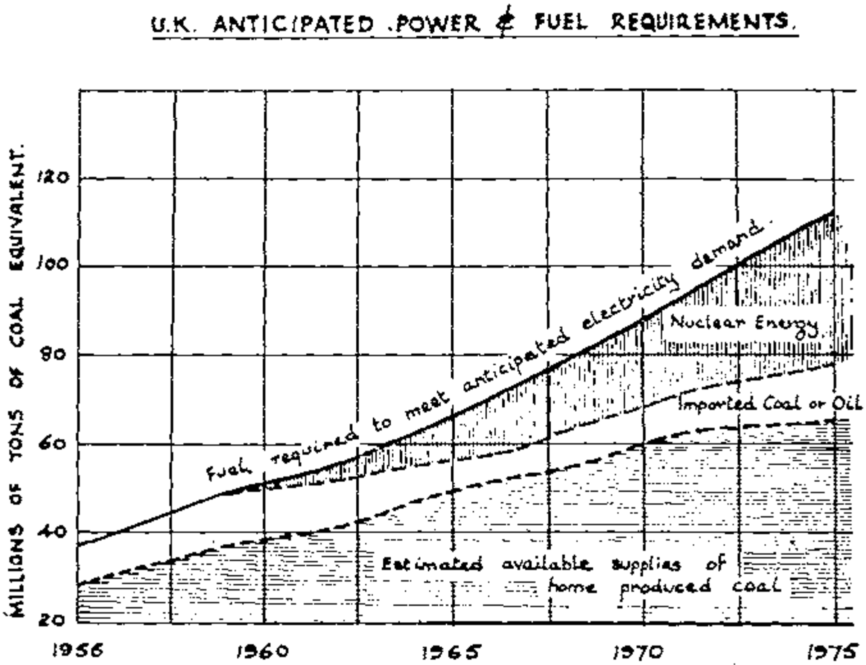
U.K. ANTICIPATED POWER & FUEL REQUIREMENTS.
MILLIONS OF TONS OF COAL EQUIVALENT.
120
100
80
60
40
20
Fuel required to meet anticipated electricity demand.
Nuclear Energy
Imported Coal or Oil
Estimated available supplies of home produced coal
1956
1960
1965
1970
1975

Fig. 1

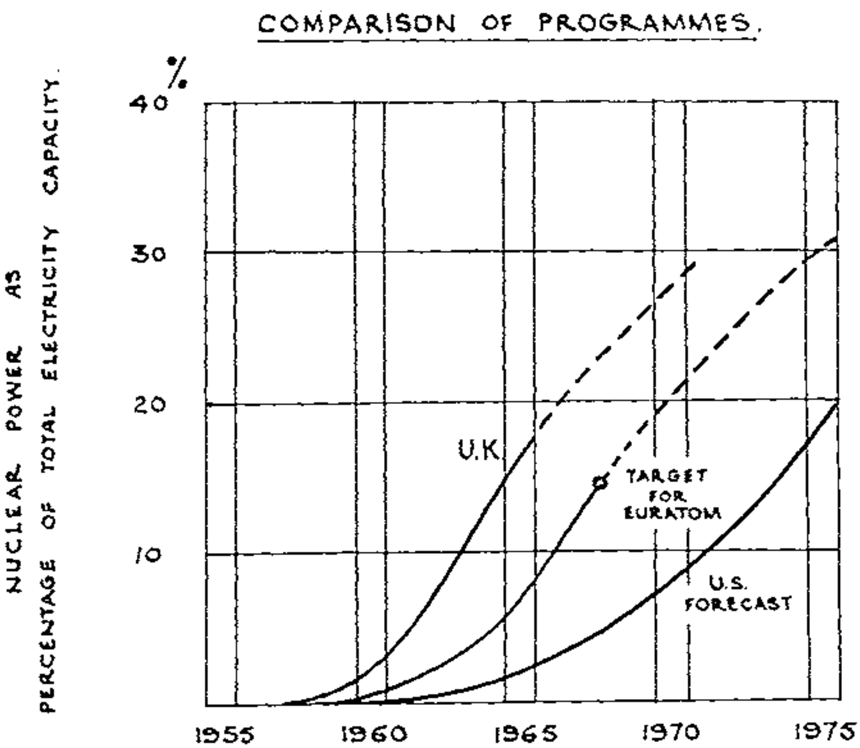
COMPARISON OF PROGRAMMES.
NUCLEAR POWER AS PERCENTAGE OF TOTAL ELECTRICITY CAPACITY.
%
40
30
20
10
U.K
TARGET FOR EURATOM
U.S. FORECAST
1955
1960
1965
1970
1975

Fig. 2

Perhaps even more significant than this rapid increase is the estimate that by 1975 rather more than 33 per cent of the total generating capacity in this country will be coming from nuclear stations. There can be little doubt that by that date the nuclear station will be more conventional than the coal. Fig. 1 shows what is required from nuclear energy over the next twenty years, and Fig. 2 compares the U.K. nuclear programme with those of Euratom and the U.S.A., and shows that when set out in this form the U.K. has a substantial lead.

The Military Lead

This rapid development of reactor technology is due in great measure to military requirements. In fact until about three years ago when industrial concerns were sufficiently versed in nuclear techniques to start their own investigations and research programmes, development was entirely due to military demands. In this country, for instance, Windscale and Calder Hall were built in the first place solely for the production of military plutonium, the grid supply from Calder Hall being an important but only secondary consideration. In America the power reactors designed to Navy and Army requirements were prototypes for many of the civilian reactors built or building today. There is nothing new in this, for of course many developments of value to the civilian world have had their roots in military research, where cost is subordinate to the results. But military research in the U.K. and U.S.A. has followed very different lines, with the result that although we are now acknowledged by many to be comfortably ahead in the economical production of commercial power, there is no doubt we are behind in the matter of power for purely military purposes, be it for either static or mobile plants. Britain's military effort has been almost entirely devoted to the weapons side of nuclear energy while the U.S.A. has progressed both along this line and the production of military power and propulsion units. The primary reason for this difference is, as usual, cost. This has affected not only the comparative scope of our nuclear energy programmes but the general line of reactor development.

Power Reactor Development

The U.S.A., like Russia, is basing her immediate large-scale programme mainly on the water-moderated water-cooled type reactor, normally known as the pressurized water reactor (P.W.R.). For economic reasons the U.K. is basing hers on the graphite-moderated gas-cooled reactor, as already built and operating at Calder Hall. It is a much argued point, witness the recent wrangles in the efforts to obtain reactor orders from Japan, as to which of the two lines of development will pay the best dividends in the long run, but so far as the U.K. is concerned there was little choice. The P.W.R. system needs enriched fuel, whilst the Calder Hall type functions on natural uranium. The process of enrichment involving the separation of the two isotopes, U 235 and U 238, in natural uranium is prohibitively expensive, and although we have our own separation plant at Capenhurst this does not produce sufficient pure fissile material in excess of present nuclear weapon requirements to allow its burning in power plants. This is not to say that the U.K. Atomic Energy Authority is not actively investigating other types of power reactor, several of which are operating or building at Harwell, and notably the fast breeder reactor at Dounreay. But it does mean that all commercial stations in what may be called the first reactor phase, and possibly for many years to come judging by the unexpectedly successful first results of the Calder Hall reactors, will be natural—or possibly slightly enriched—uranium burners. Consequently the major part of industrial research is undoubtedly concentrated on that type.

Now as far as a military power plant is concerned this is an all-important fact, because one great difference between the natural and the enriched uranium burning reactors is size and weight. Fundamentally there is a minimum size, known as the critical size, of fuel, or core, required before the heat-producing chain reaction will start, and the greater the degree of enrichment the smaller the core, and therefore the reactor, may be. Compare the 8 cu. ft. "dustbin" core of the Dounreay fast reactor at one end of the scale with the 13,500 cu. ft. core of a Calder Hall thermal reactor at the other, and even allowing that the heat output of the latter is three times as great, the difference is not difficult to see. Nor is it difficult to realize that any small plant, either static or mobile, must be one which uses fairly highly enriched fuel.

This then is the broad background on which it is possible to see why the Americans already have small nuclear power and propulsion plants operating and we as yet have neither. One school of thought says the reason is simply that we do not need them, or can do as well without them, but that seems a most short-sighted attitude. In any case, we have had a naval team working at Harwell for more than three years on the first British nuclear propulsion plant, and it can only be hoped that if there is not already an equivalent team working on small military type power plants there soon will be. However, that blandly stated hope must be supported by reasoning so let us examine in some detail the need, or otherwise, for the small military nuclear power plant.

The Military Power Plant

General

The one outstanding advantage of the nuclear power plant over conventional types is its virtual independence of a fuel supply system. This factor must ultimately decide its worth in the military sphere. Against it there must be set, at present, the disadvantages of high capital cost, weight, complexity and, for some military plants, immobility. It is at once apparent that the applications for which a military reactor would now be most suitable are those in which:—

(*a*) conventional fuel for power and heat makes up the largest part of the total supply effort;

(*b*) the nature of the terrain, the climate, or the distance from a supply base, or a combination of these, makes access by cargo ship or aircraft difficult or impossible;

(*c*) the need for a reliable source of power, not dependent on long vulnerable supply lines, is great.

Application at Remote Bases

To fit all these criteria the most obvious military application for the nuclear plant is the generation of power and heat at isolated bases, for instance radar stations and strategic air bases in the Arctic regions. In the Arctic aircraft control and warning network, which extends from Alaska across Canada into Greenland, there are stations with garrisons of around

200 men, and because of their remoteness these bases must be self sufficient. American study has established that the diesel or fuel oil for the power and heating plants at such a base constitutes 75 per cent of the total annual re-supply tonnage.[1] At present this may be taken in by truck or tractor-train overland, by sea during the ice-free season or sometimes entirely by air. Now if a nuclear plant were installed to supply all the power and heating requirements, one aircraft every twelve or possibly eighteen months would be all that was necessary to carry in fuel replenishment. During the same period the conventional system would require some 6,000 tons of fuel.[2] Periodic maintenance of the reactors, possibly annual, and the refuelling could be done by travelling maintenance teams. There would of course have to be stand-by plant, either diesel or gas turbine, to cover emergency and any maintenance periods, but the fuel requirement for this would be negligible.

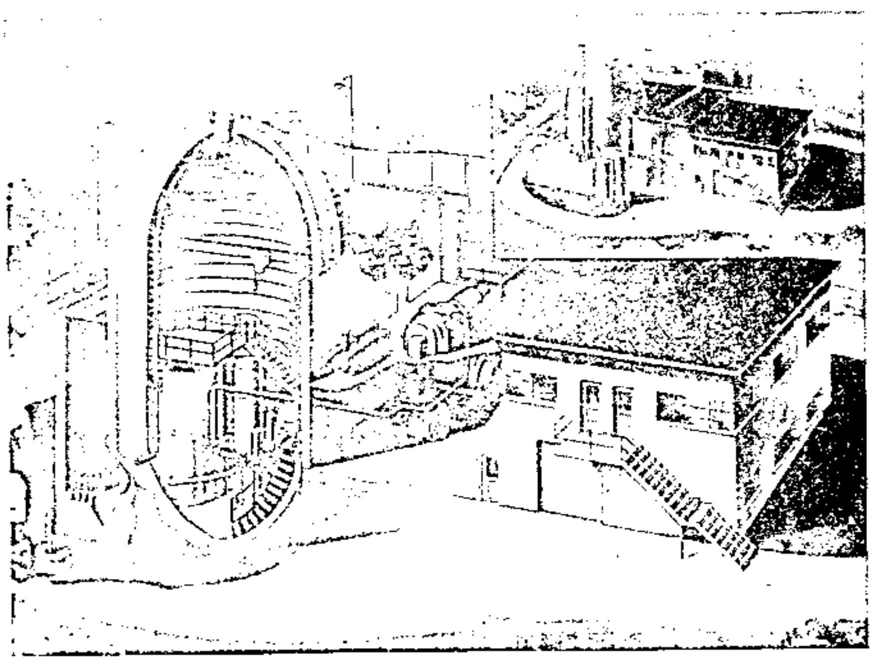

Fig. 3.—U.S. Army Package Power Plant, APPR-1. Some details of this plant are included at Appendix A.
(By kind permission of "The Military Engineer")

The U.S. Corps of Engineers, after investigations commenced as far back as 1952, long since decided that here was a case for the small nuclear plant. The result is that their first Army Package Power Reactor (APPR-1) is now in existence. It was officially opened in April, 1957, and successfully completed a 700-hr. test run in July. A picture of the plant is at Fig. 3, and some facts and figures at Appendix A. Also in April that year, the Alaskan District Corps of Engineers awarded a design contract for a power-and-heat reactor, expected to be a 1.5 MW. modified APPR, for the Big Delta in interior Alaska.

[1] "Military Nuclear Power", by William B. Taylor, *The Military Engineer*, March–April, 1955.
[2] "Nuclear Power for Military Uses", by Colonel James B. Lampert, *The Military Engineer*, May–June, 1957.

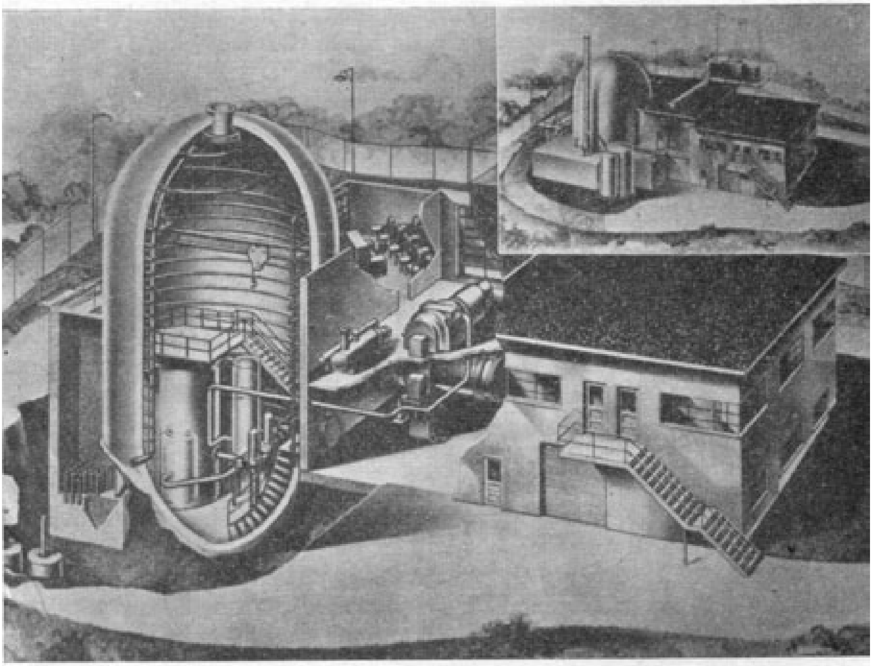

Fig. 3.—U.S. Army Package Power Plant, APPR-1. Some details of this plant are included at Appendix A.
(By kind permission of "The Military Engineer")

The Military Power Plant

These remote Arctic bases are at present primarily the responsibility of the American or Canadian forces, whose needs cannot be used to justify changes in British equipment; but it is worth considering that in the event of global war, or earlier as part of N.A.T.O. policy, we might well be required to establish remote bases. The present British undertakings in the Antarctic expedition bases and at Christmas Island in the mid-Pacific may be taken as examples of a kind. Moreover in these days of far-reaching air and submarine warfare one does not need to go so far to find an isolated base. Consider the virtual isolation of Malta in World War II, astride one of the world's main ocean supply routes, remembering the fact that Russia is now reputed to have upwards of 700 sea-going submarines and undoubtedly many more building. There is no heating requirement here, admittedly, but certainly a power requirement which would increase fast in the event of war over that area.

Permanent Overseas Bases

This leads naturally to consideration of other British overseas bases, subject in wartime to the same isolation; indeed to Britain herself when it is a question of fuel supply by tankers. Singapore, Hong Kong and Gibraltar are all perfect examples of bases which need reliable sources of power and whose dependence on long vulnerable supply lines is great. It cannot be said that the fuel for power generation at these bases constitutes a large percentage of the necessary imported supplies, certainly nothing like the figure applicable to the small Arctic base mentioned above. Nevertheless every tanker saved on this score would be one more available to carry conventional fuel where its need is essential, and tankers, as proved in the last war, are priority targets for the enemy. Furthermore there is the real possibility that much of our conventional fuel supply might be cut off at source, as recent events in the Middle East have shown only too clearly.

The power requirement at these large bases, including all three services and essential civil requirements, is of the order of 20–30 MW. This is at present supplied either by small stations placed centrally in the various military cantonments or load centres, or by local civil supply. The replacement of these by nuclear stations of 2–5 MW. capacity, still sited at the load centres but linked on a grid, would be the ideal solution. Moreover this should be controlled by one authority and not four as in some cases at present. For instance at Gibraltar, where the entire population, military and civil, exists to maintain the military base, there are at present an army power station, a naval power station, and a civil power station, independently controlled and operated and not even on a common grid. There is also the independently run diesel-operated distillation plant. Two or three small nuclear stations, grid-connected and under single control would be a much sounder system. A single larger nuclear station should be ruled out as too concentrated for possible war damage.

Replacement of perfectly sound existing conventional plants before they are due for extensive maintenance or routine replacement would of course be very extravagant, however desirable, and would never get past the Treasury. An existing station housing, say, six diesel sets will have only one or two sets replaced by new machines at any one time, certainly never a 100 per cent replacement in one operation. However, redistribution of sets between neighbouring stations would avoid wastage of good sets as any one station was replaced by nuclear plant. Alternatively the diesel sets could be relegated to the role of peak load and standby supply, the latter being needed in any case. Certainly for any new stations planned, of 2-MW. or over, perhaps in Kenya, there is justification for considering the installation of nuclear reactors.

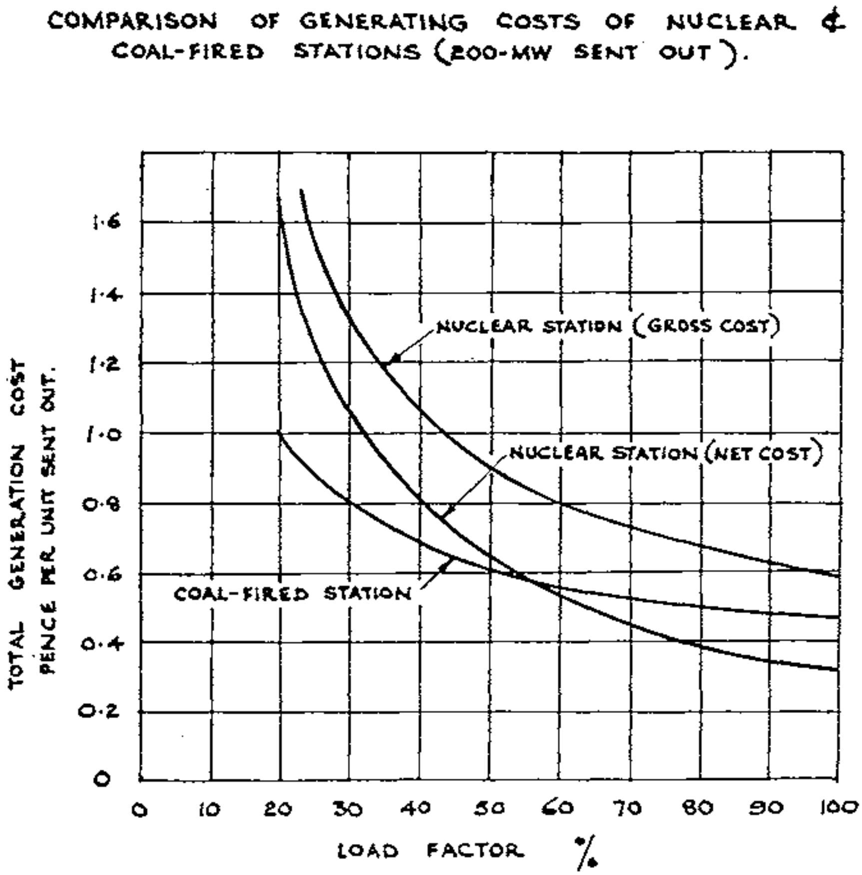

Fig. 4

(Reproduced by kind permission of the British Nuclear Energy Conference, from the Journal of the B.N.E.C., Vol. 1, Number 1, January, 1956, p. 20.)

Note

(i) The net cost line is derived by allowing credit for the plutonium produced (at £10,000/kg.).

(ii) These figures were estimates for the graphite-moderated natural-uranium reactors. Pressurized water reactors needing enriched-uranium have a much higher initial fuel cost but a lower capital cost, and according to recent comparisons between the British Calder Hall plant and the American Shippingport P.W.R. plant the net cost per unit sent out should only be a little greater for the latter than for the former. It must be remembered however that at present the U.S.A. produces enriched-uranium more cheaply and on a much greater scale than does Britain.

(iii) Sir Christopher Hinton has forecast that by 1970 nuclear power will be appreciably cheaper than conventional; and that by 1990 if present trends are followed the total costs per unit sent out (for a 75 per cent load factor on stations similar to the above) will be 0.84d/kWh. for coal and 0.32d/kWh. for nuclear.

The Present Position on Small Power Reactors

There are already nuclear plants in the 2–10 MW. range, commonly known as "Tennis Court" reactors, on the British market, albeit they are still only of U.S. origin based on the APPR design; and there may be British designs available within the next few years. At least one well-known British concern, Ruston and Hornsby Ltd., are greatly interested and doing research in the small reactor field, which of course materially affects their gas turbine industry. Dr. M. D. Wood of their nuclear section has written an interesting article entitled "Nuclear Energy and the Export Market", which was published in the November, 1956, issue of *Nuclear Engineering*. From this it is clear that the present overseas demand for nuclear plants of as low as 2 MW. capacity is substantial, although Ruston and Hornsby consider that 5 MW. units will be about the lowest in reasonable civil demand in ten years time. The immediate hold-up, as mentioned earlier, is the present lack of British produced enriched fuel necessary for small reactors. However, the U.S.A.E.A. announced some eighteen months ago that this would be made available for export if small nuclear units showed promise.

The present ruling British attitude (though not an Army one) towards a military nuclear plant seems to be that we should wait for a suitably cheap model to appear on the commercial market. It would be more logical to realize the obvious military (certainly wartime) advantage inherent in the nuclear plant and treat this as an important reason for, rather than result of, early small reactor development. In his article Dr. Wood stresses the fact that should the U.K. fail to develop a small reactor, the demand will almost certainly be satisfied by the Americans. This would not only permit them to move into export markets which are now regarded as predominantly British, but would in all probability mean that "our" military reactor, which is bound to come sooner or later, would be an "all-American" equipment.

Nuclear Plant Disadvantages

Returning to the present disadvantages of a nuclear plant, stated earlier, the only one of any consequence in the case of a static type at a permanent base is capital cost. Weight and immobility are unimportant; and complexity is a label frequently given to any revolutionary design, and invariably overemphasized in the early stages of development. This is no attempt to belittle the many highly technical problems with which our nuclear experts are faced, but it has recently been emphasized on more than one occasion that it is now the economic problems which are the obstacles more often than those of nuclear engineering. For trained operators the operation of a nuclear station will in all probability be easier than that of a conventional station, and certainly the staff will be no greater, probably less. Cost, then, is the operative factor. This again is overemphasized by many people, and unfortunately only too frequently when it comes to Army equipment. The author has been unable to obtain any detailed comparison of costs between an existing small static military power station and a nuclear equivalent, but a comparison for larger stations, nuclear and coal-fired, is shown at Fig. 4 and gives at any rate a rough idea. It may be noted that the nuclear unit is more suitable economically for a base-load station than for one with low load factor. This may be a disadvantage for its peacetime usage at military bases, but since the bases exist to serve a wartime purpose, and in wartime there is inevitably an increase in power demand usually met by shift work, it can only be considered a minor one. Costs for smaller stations will be appreciably higher in both cases, but diesel plants will invariably be more so than coal-fired. As an example, a reliable source recently gave the overall cost of our electricity at Gibraltar as 3½d. per unit sent out. Now even today Humphreys and Glasgow Ltd., the British firm marketing the "Tennis Court" reactor, claim that the cost of their 10-MW. plant at an average site will not exceed £150/kW. installed, and net operating costs will be less than 1½d. per unit. They claim, it seems with reason, that this is an offer generally competitive with conventional plants of equivalent size. While this may be slightly exaggerated salesmanship, there is not the difference in cost that the pessimists attempt to show, and the difference will decrease fast as nuclear fuel becomes more plentiful.

In any case it is not realistic to argue that merely because initial and generating costs may be greater at present, the nuclear plant is not yet a sound military proposition. Independence of a fuel supply system in wartime could mean an immeasurable saving in cost in terms of tankers at the bottom of the ocean, to say nothing of the value of having a really assured source of power. It might be expressed mathematically as "£(Nuclear stations + assured power) $\leqslant$ £(Conventional stations + D + x tankers)", where D is the present difference in capital cost, certain to decrease in time, and x is an unknown, dependent on enemy sea-power. The latest equipments of any kind are invariably more expensive than current types, but it would be a sad thing if that had a ruling effect on, for example, the modernization of our weapons. Power consumption everywhere is increasing at a tremendous rate, and there is every indication that the same will apply in the services. All the more important will it be for the source of power to be reliable in every aspect.

The Safety Problem

An immediate criticism nowadays of any nuclear plant is the safety problem or radiation hazard, recently emphasized in an unfortunate manner by the Windscale mishap. Although, in the author's opinion, this was grossly overplayed by certain sections of the press and public, it is impossible to avoid the question of what is to happen if a nuclear plant is destroyed, even by conventional bombs, and fission products from the reactors make the area uninhabitable. The only real answer to this at present is that the reactor must be bomb-proof, and that means even H-bomb proof. This is no insuperable problem. Biological shielding usually comprising several feet of reinforced concrete is necessary in any case, and this can be made to stand up to any blast yet produced. In addition the whole plant could be constructed underground, as are already some power stations and other important military nerve-centres. The latter precaution applies equally to conventional plants, so there is no question of additional cost in this.

Before leaving this point it should be stressed that a release of radiation as happened at Windscale is most unlikely to happen with any power reactor. The Windscale reactors, which are not power producers, are cooled by air on an open circuit, this air normally being filtered at the top of the 400 ft. high exhaust stacks before discharge to the atmosphere with negligible, if any, radioactive content. In a power reactor, with closed cooling circuit, radiation could only escape from the circuit in the most unlikely event of a serious fracture, and only then if the coolant itself was contaminated.

Conclusions

The whole matter can be boiled down to one question: does the advantage of a reliable source of power independent of any vulnerable fuel supply tail outweigh the present (underlined), disadvantage of higher cost? With the reduction in manpower and vehicles to be effected in Mr. Duncan Sandys' new defence force, meaning less need for conventional fuel and a parallel saving in cost, and with the increasing need for generated power that will almost certainly follow the current trend everywhere, the answer, in the author's opinion, is unquestionably yes. Planning for any new military base, unless fuel oil is plentiful and close at hand, should be based on nuclear power supply, at any rate for the main load. At existing stations where the same condition applies, and allowing for the economical run-down of existing equipment as suggested, replacement power source as it becomes necessary should be the nuclear type. The early establishment of nuclear stations at some of our overseas bases could not but help to sell British atomic energy abroad. This should be current policy and not an idea to be considered periodically as techniques improve.

In the Field

General

Before considering the possible substitution of nuclear plants for some of the conventional types in current use in the field it would help to be clear on what the exact power requirements in a future war will be. Unfortunately, with the present state of uncertainty in the three services, all awaiting firm decisions on the form of our forces and planning policies of the future, it is quite impossible to get any authoritative planning figures. No one can decide how the next war is to be fought, though current teaching allows two basic possibilities: the limited and the global. The first will be fought with conventional and certain nuclear weapons, though what "limit" will be agreed is a matter for conjecture. The second will be "all-out" and include the use of the "ultimate" weapon, whatever that may be when the war starts. Today it might be either the H-bomb or the I.C.B.M. Whatever the case, there are two aspects which affect consideration of likely power requirements. Firstly, the proportion of the P.O.L. load required for power generation, if using conventional power plants, will be considerably greater than it has been in the past and is likely to go on increasing as modern weapons develop. Secondly, in the early stages of any major war there will be urgent need of emergency power supply for disaster relief or rehabilitation.

The P.O.L. Load

A brief reference to the latest R.E.S.P.B. publication on petroleum installations will suffice to show what a large organization in personnel and stores is taken up in the construction, supply and distribution of P.O.L. requirements. If this could be appreciably reduced it would be a big advantage to any commander in the field. Unfortunately, using current figures for conventional warfare, only a small percentage of the load is taken up in power generation. Power requirements in divisional, corps and forward army areas are negligible by comparison with transport and aircraft requirements, and in any case the need for small, highly portable generator sets, widely dispersed over the forward areas, could never be met by nuclear plants of any type envisaged today.

In the communications zone and base area, or its modern dispersed equivalent, the picture is different. Here, assuming an army of three divisions, the total power requirement according to one source of information will be of the order of 8,000-kW., dispersed in say four group areas of 2,000-kW. each. Another source of information, emphasizing that a R.E.M.E. base workshop alone carries a total installed load of 7,000-kW. under current organization, thought that 15–20,000-kW. would be a more reasonable "guesstimate". Certainly the change over from concentrated base area to the several smaller dispersed rear depot areas of current teaching is more likely to increase power demands than decrease them for any force of a given size, unless it is decided that many of the power using equipments erstwhile considered necessary can now be dispensed with. Taking a middle course of 12,000-kW. and using diesel sets, and also assuming poor operating conditions and high load factors, this would require possibly 30–35 tons of fuel per day. The comparable figure of total P.O.L. requirement for an army covering three divisional slices, and including forward R.A.F. units, is given as 1,170 tons per day. The power generating proportion is thus only about 3 per cent. If supply was all by gas turbine the figure would rise to about 8 per cent. In either case the figure by itself is hardly large enough to be considered a vital saving when a complicated P.O.L. system has to be established in any case, even converting it to shipping terminology as one tanker in twelve.

These figures, however, are for present-day requirements and based largely on World War II experience. In the future the workshops, hospitals, stores units, guided weapons units and essential civil services will have ever increasing power demands. At the same time the fuel requirement for propulsion will decrease with both the disappearance of the obsolescent heavy tank and the intended reduction in the number of vehicles in the administrative tail. It is probable also that the R.A.F. fuel requirements, although showing a gross increase, will actually decrease so far as they affect R.A.S.C. and R.E. supply. In line with improvements in aircraft range, air operations of the future will tend to be conducted more from distant bases, in the case of bombers, or from fast-moving aircraft carriers in the case of fighters, than from the much more vulnerable airfields close to the scene of operations. If in the light of these changes the power generating proportion of the total P.O.L. load rises to 10 per cent or above, and this seems more than likely, then the possible saving in the use of nuclear plants will surely become worthwhile.

Field Power Plant Requirements

Such plants must of course satisfy several important requirements in addition to that of fuel economy. They must be air-transportable; easy and quick to assemble if not carried as a complete unit; and of such design that they can be brought quickly into operation. Ideally we should have mobile sets, in the 500–2,000 kW. range, which could be flown in as complete units and then trailer-mounted. For a nuclear reactor these are exacting requirements, and there is nothing yet designed which could meet them all. The 2-MW. APPR, mentioned earlier, is certainly air-transportable in packages, but its disassembled fuselage-size components will make 75 to 100 Globemaster loads, and would take from three to six months to assemble in the field. This is not too bad when compared with the figure of four months currently taught as the assembly time for a 900-kW. station made up of conventional static diesel sets; but six of the latest planned 300-kW. air-transportable gas turbines sets with, it is hoped, a total weight of not more than thirty tons, would give the same output as the APPR and could be installed in a matter of days. Leaving out fuel considerations, this gives some idea of the competition the nuclear plant is up against.

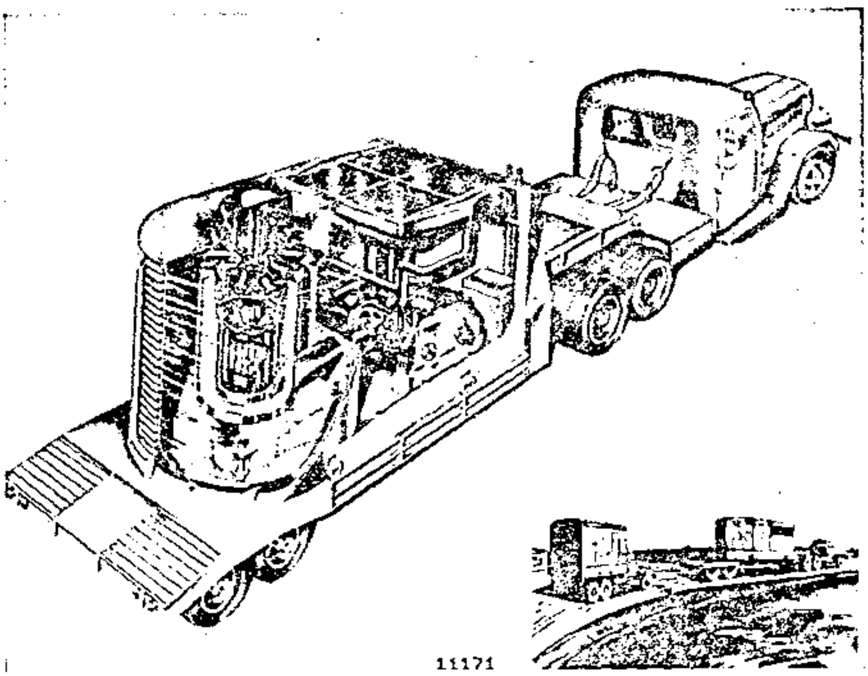

Fig. 5.—U.S. Army "Mobile Nuclear Power Plant".
(*By permission of "The Military Engineer"*)

Nevertheless the Americans obviously consider the odds are good, and their current military power reactor development programme is aimed at providing them with a family of nuclear power plants.[1] In addition to the APPR-1, already in operation at Fort Belvoir, they have nearing design completion a 300-kW. boiling-water type reactor (ALPR) with air-transportable components, and "under active development" a small gas-cooled reactor for use with a closed cycle gas turbine and generator set. The last mentioned would be the ideal basis for their small mobile reactor, for which they consider the outlook favourable even though it may be hidden beyond several years of research. In fact it was only recently reported that the U.S. Atomic Energy Commission has already got as far as inviting qualified industrial firms to submit proposals for preliminary studies on this compact mobile military plant. An impression of how the final product might appear is shown at Fig. 5. As contemplated it would have a capacity of "several hundred kW.", would be mounted on a standard 25-ton trailer and be transportable complete in a Globemaster.[2] Such a piece of power generating

[1] "Nuclear Power for Military Uses", by Colonel James P. Lampert, *The Military Engineer*, May–June, 1957.
[2] "Army Working on Mobile A-Power", *Nucleonics*, September, 1957.

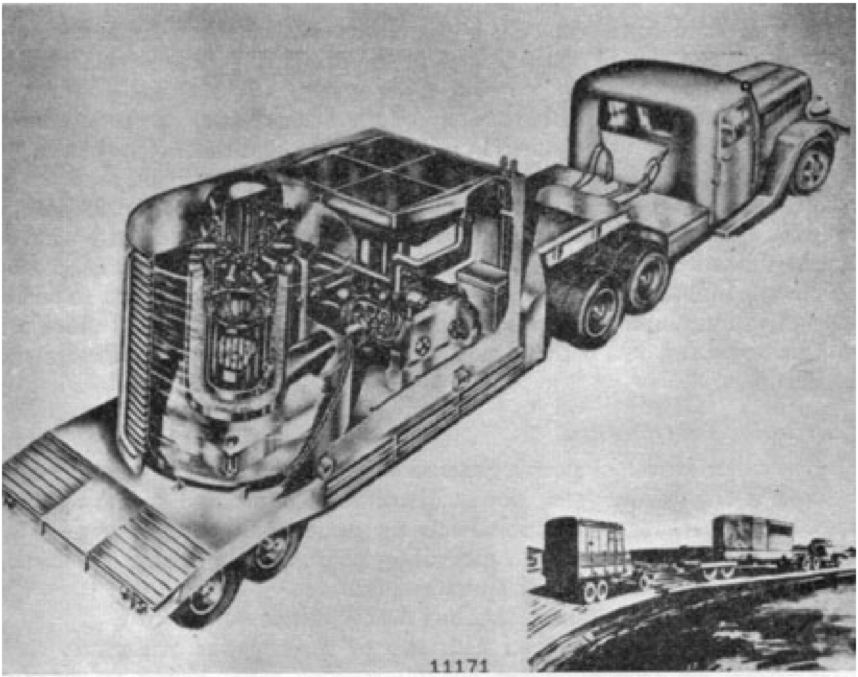

Fig. 5.—U.S. Army "Mobile Nuclear Power Plant".
(By permission of "The Military Engineer")

equipment, completely self-contained and needing not a drum of fuel or water except for the propulsion of its carrier, would obviously have great advantages over anything we have today. The problem of the shielding for such a plant might be simplified initially by "digging in", which would be a necessary precaution against enemy action in any case, and by putting the operators into protective clothing. But shielding during any subsequent movement would then have to depend on a combination of allowing the reactor to "cool" and enforcing a "safe-distance route", neither of these being practicable in wartime. It is therefore essential that a suitable shield be built-in, and this of course is one of the principal problems confronting the designers at present.

It has been suggested that mobile plants of this type, for use on land, will eventually find various uses in the civil world, and that again the proper course for the military is to await the development of these and then try to adapt them. In the author's opinion this reasoning is totally false. It is most unlikely that any commercial concern will be seriously interested until it can be shown that the small mobile nuclear plant is in proven fact an economic proposition, and plainly this is not likely to be so for some time to come. It is an entirely different case from that of the larger static plants, which are now materializing on a national scale and as a result of the work of industrial consortiums.

Distribution and Operation

One other aspect of power generation in the field which must be considered is the balancing of power distribution effort and operating staff requirements. Using conventional sets the extreme alternatives are:—

(*a*) every unit with its own generating plant, entailing minimum distribution line work and maximum operator demand;

(*b*) a central power station, entailing the opposite.

Current teaching compromises with two or three power stations to each 2,000–2,500 kW. group in the communications zone, giving an average station capacity of 700–1,000 kW., which at present would normally be provided by several small sets. If therefore nuclear plants in the 500–2,000 kW. range were introduced there would be little or no difference in the distribution and operation problems.

Emergency Supply

Turning to the need for emergency power supplies in the early stages of a war, the advent of the so-called "clean" bomb, "free" from radioactive fallout, does much to destroy the argument of those who say a nuclear war will be the end of everything. "What is the use of worrying", they say, "because if the blast doesn't get you the radiation will!" There will undoubtedly be appalling damage on what we used to call the home front, with chaos in industrial centres, communications and port facilities, but it will not necessarily be irreparable and the area may remain uncontaminated and inhabitable. Such may be the situation in the opening stages of a major war. Assuming that our own forces are able to administer similar punishment to the enemy and check his offensive, and this after all is a fundamental objective of N.A.T.O., a major task will be the urgent re-establishment of power supplies where the existing plant has been obliterated or the fuel supplies fired. Nuclear power plants, trailer- or barge-mounted, would be invaluable in these circumstances. Some might consider this a Civil Defence rather than military matter when applied to the U.K., but for any overseas theatre where the same conditions could apply it would certainly be a military, and as such, R.E. responsibility.

Conclusions

A mobile reactor such as the Americans visualize and are working towards would be quite as valuable on our own inventory; and research on it should already be in hand, either jointly with the Americans or within our own resources. It is a purely military requirement, with no civil counterpart such as has the larger static reactor, and little headway will be made by awaiting developments in industrial reactor technology. It is far more probable that if the mobile military plant is seriously followed up it will also assist in civil reactor development. It will of course ultimately become purely engineer equipment, but its importance is such that it deserves a much larger allocation of development funds than would be available from the apparently meagre amount allocated to engineer equipment at present.

Nuclear Propulsion

General

Propulsion by nuclear energy is already a well established fact, principally on account of the U.S. submarine *Nautilus* which was launched two years ago and has since covered many thousands of miles. There is no longer any doubt about either the feasibility or the practicability of using nuclear powered sea vessels. On land and in the air the situation is different. Although nuclear land- and air-craft are undoubtedly feasible, leaving out cost consideration, their practicability and desirability are both much in question. In the following paragraphs the pros and cons of conversion to nuclear propulsion are considered in descending order of likelihood: at sea, in the air and on land.

At Sea

Advantages

The advantages of nuclear propulsion at sea are:—

(*a*) The possibility of considerable increase in speed by the use of much more powerful machinery, consuming very little fuel. High speed makes severe demands on fuel supply, and to double the speed of a ship requires an expenditure of eight times as much power. Nuclear fuel with its million-fold greater concentration of energy than conventional fuels could meet this demand.

(*b*) Fuel tanks will be eliminated, leaving more room for the carriage of extra weapons, extra fuel for aircraft, or extra stores in naval ships, and for the carriage of cargo in merchant ships.

(*c*) Range will be virtually unlimited. This, together with the greater carrying capacity through lack of fuel tanks, will mean, for naval vessels, less dependence on logistic support and more time on the fighting front, and for cargo vessels a shorter turn-round time in ports.

(*d*) Experts have predicted that it will be easier to operate a nuclear ship because there will be no drain on fuel tanks resulting in changes in the vessel's weight.

(*e*) Maintenance problems caused by the use of tanks for ballast of sea-water part of the time and for fuel at other times will be eliminated.

(*f*) Although the initial investment in a reactor may be high, running costs should be low.

(*g*) Nuclear fuel does not require combustion with air to liberate its energy. This is the characteristic so important for the submarine, enabling it to remain submerged for long periods.

Disadvantages

The present disadvantages of nuclear ship propulsion are:—

(*a*) The weight and size of the reactor, or reactors, and the necessary shielding. This offsets the advantage gained through lack of fuel tanks, and at once means that this advantage only holds good for ships above a certain size.

(*b*) High capital cost and higher fuel cost. It is fairly certain however that both of these will be substantially reduced in the coming years.

(*c*) Possibly the greatest disadvantage, certainly for merchant shipping, is the safety problem. A conventional ship sunk in a large port can at worst block the port for a limited period until it is salvaged and is more likely to constitute only a navigational hazard in a particular area. A reactor-powered ship sunk in a port might under certain circumstances render most of the port uninhabitable and cause widespread damage. The risk is obviously worth taking in the case of some naval vessels, which need never enter large civil ports, but for merchant shipping the problem is real. However, it is worthy of note that the *Nautilus* has been operating in harbours such as New York, and was recently welcomed in ports in this country.

The Present Position

Assuming that the many advantages outweight the cost, and the accident risk is acceptable, it is the shielding weight which becomes the ruling factor. Relating this to current types of warship it appears that aircraft carriers gain considerably by nuclear propulsion, cruisers break even and will certainly do better as reactor technology improves; destroyers and smaller ships will gain nothing until the reactor power/weight ratio is greatly increased.

Britain has not yet declared any intention of proceeding with the construction of nuclear-powered naval surface ships, but the intention to build a 65,000 ton nuclear tanker has been announced and marine reactors have certainly been under serious investigation for several years. The Americans, however, are already designing or building at least one nuclear cruiser and one nuclear aircraft-carrier, and have made it clear that they intend their naval task forces of the 1960s to be entirely nuclear powered. There is talk of six nuclear carriers afloat by 1966.[1]

The Russians have a nuclear-powered 25,000-ton ice-breaker at present under construction, and to be launched this year, but no details of any other nuclear vessels are known.

Submarines

The special requirements of submarines include the following:—

(*a*) Complete submersibility, i.e. unlimited submerged range.

(*b*) Small hull.

(*c*) High silent speed, limited by propeller noise.

(*d*) High underwater speed.

[1] "Nuclear Navy Paces U.S. Atomic Industry", *Nucleonics*, July, 1957.

All these can be satisfied by nuclear power except for the small hull, and the nuclear submarines already operating prove that the hull size difficulty is surmountable. In fact the success of the U.S.S. *Nautilus* has been such that the U.S. Navy now officially considers nuclear power to be conventional for all new submarines. Today America has fifteen nuclear submarines of various types built, building, or authorized and another four projected for the 1958 programme. As is well known, the U.K. is now building her first, the *Dreadnought*, at Dounreay and Barrow.

It is most interesting to compare the capabilities of the nuclear and conventionally-powered vessels. *Nautilus* has recently had a new core put in her reactor, but on her original fuelling she steamed 69,000 miles. In doing this she consumed little over 8 lb. of nuclear fuel, compared with the 10–11,000 tons of oil fuel which would have been necessary to achieve the same result. Of 5,300 hours under way she spent 60 per cent of the time submerged. Amongst other spectacular performances she recently completed a voyage of 1,200 miles, entirely submerged, at a speed of "well over twenty knots". The most modern conventionally powered submarine can at best make twenty knots for only a few minutes; and full power propulsion completely submerged is limited to only a few hours with a range of 100–200 miles, and a top submerged speed of about eight knots.

"Perhaps the most significant aspect of the performance of *Nautilus* has been her reliability. In 50,000 miles her engineering plant has not had a single disabling casualty."[1] Her reactor is a pressurized-water thermal type, light-water moderated and cooled. The second U.S. nuclear-powered submarine, the *Seawolf* has a sodium-cooled intermediate reactor, and has apparently not proved so successful in her sea trials. It has now been officially stated that America does not intend to use sodium-cooled reactor systems in any other naval vessel. However, this is no detraction from the outstanding success of the *Nautilus* type design.

An even more revolutionary vessel is the U.S. high-speed attack submarine *Skipjack*, now building, which according to authoritative speculations may reach the fantastic submerged speed of 52 knots—60 m.p.h.[2] This will be not so much a new type of submarine as a completely new weapon.

In the Air

Advantages and Disadvantages

The advantages and disadvantages of nuclear-powered aircraft are basically the same as in the case for ships, but the odds are considerably heavier on the disadvantage side. Briefly they are:—

Advantages

(*a*) Very long range, especially for supersonic aircraft.

(*b*) Endurance, the ability to stay aloft for several days or weeks.

(*c*) Tremendous saving in the ground fuel supply system. (The latest figure for an average divisional slice of aviation fuel is 130 tons per day, and this for forward R.A.F. units only.)

[1] "A Nuclear Navy" by Charles S. Thomas, lately U.S. Secretary of the Navy, *Sunday Times*, 7th April, 1957.

[2] "Nuclear Navy Paces U.S. Atomic Industry", *Nucleonics*, July, 1957.

Disadvantages

(*d*) Weight of necessary shielding.
(*e*) Cost of initial fuel.
(*f*) Risk of radiation hazard from a crash.

The Present Position

The shielding is a major difficulty. Concrete and water are out of the question, and at present it seems that the most promising answer will be lead and alternate layers of boron, lithium and steel. Even this would produce a prohibitive weight for all round shielding, but this can be overcome by reducing the shielding in certain directions, for instance by having all crew forward of the reactor and little shielding to the rear. Various estimates of the minimum all-up weight of a nuclear aircraft have been put forward and the least of these is 150,000 lb. The largest conventional aircraft at present weighs around 400,000 lb., so it can be seen that a reactor-powered plane is well within the existing limit; but the other size limitations of an aircraft mean that only a fast reactor using highly enriched fuel will be feasible.

It is clear from these factors that the only practicable nuclear aircraft in the foreseeable future is a large bomber suitable for a global force such as the existing U.S. Strategic Air Command. The Americans are working on this line and the U.S. Air Force is concentrating research on two particular reactor projects, one being the more favoured air-cooled direct-cycle system, and the other a liquid-metal-cooled indirect-cycle. It has recently been stated that they have successfully operated a turbojet engine by reactor heat.[1] Little has been published on aircraft reactor work in this country apart from a recent press report that consideration was being given to the use of the giant "Princess" flying boats as flying test-beds for nuclear aero-engines, but it is certain that some of the manufacturers are doing their own nuclear research. In Russia the Tupolev aircraft construction team is working on a nuclear design, and a Russian journal reported recently that "certain parts and elements of the projected nuclear aircraft have exceeded the stage of projecting and blueprinting, constructing and testing".

Possible Applications

The idea of nuclear seaplanes or flying boats seems an attractive one, once the reactor problems have been solved. A task force of these could be armed and fuelled at sea by submarines, and with the unlimited waters as runways would considerably reduce the safety problems associated with crashes in populated land areas.

Two other interesting, if revolutionary, ideas have been put forward, leaving aside the many which must still be considered "H. G. Wellsian". One is the use of a nuclear-powered tug aircraft which would tow conventional planes glider-fashion once they had taken off under their own power and hooked on. This has potentially attractive economy for civil airlines, in the replacement of fuel by cargo which would be possible, but there does not seem much in it from the military viewpoint except possibly for trooping or the towing of a glider force for a considerable distance. The other idea is to return to the all but forgotten field of airships. An airship could carry aloft the heavy shielding required much more easily than could an aeroplane, and the old danger of fire would be greatly reduced by the use of nuclear fuel.

[1] p. 21, *Nucleonics*, June, 1957.

Such a ship might one day be economical and useful as a commercial passenger-carrying proposition, but for the military it could at best be only a peacetime troopship. Its vulnerability to modern weapons would make it quite useless in any war.

On Land

General Considerations

This field of application carries the identical advantages and disadvantages given for nuclear aircraft, but the desirability for nuclear propulsion is considerably less, if indeed it exists at all. The main advantage would be the virtual abolition of the large and complicated fuel supply systems with all the logistic efforts which these at present demand. Against this must be set not only technical considerations of weight, complexity and maintenance but the dangerous possibilities which would result from accidents, which occur frequently enough in peacetime let alone war.

A major technical obstacle at present, apart from nuclear problems, is the lack of gas turbine engines sufficiently robust to put up with the treatment that a military vehicle must be able to withstand. The only alternative to the turbine as a means of translating reactor energy to mechanical rotation is the indirect one of using powerful electrical batteries which might be charged from a central nuclear plant. Such batteries would have to deliver considerably more power per pound of battery weight than does the best available today. The shielding problem is vastly greater than with sea or air vessels because of the unavoidable proximity of the crew or passengers, which makes selective shielding impossible. Even if this problem and all others of a technical nature are solved there remains the fact that a large number of vehicles are inevitably written-off through enemy action or accidents, and every one of these would be a potentially lethal hazard amongst our own ground troops. These factors must rule out any serious consideration of nuclear power for the ordinary soft-skinned vehicle, at any rate for a very long time to come.

Nuclear AFVs

Assuming that the turbine problem can some day be solved, it is worth paying a little more attention to the case of the vehicle in which weight is comparatively unimportant and fuel consumption all-important—the tank. Here is a vehicle of say 50 tons (for nothing bigger need be considered under present day policy) which already carries about 20 tons of armour, or shielding, and has the limited range on full tanks of about fifty miles. Nuclear propulsion, if practicable, would certainly be of greater benefit here than anywhere else. Since the shielding is already there to protect crew and instrumentation, why not use it as a two-way shield, anti-radiation from within and anti-enemy action from without? There would be of course an additional internal shield between crew and reactor. The immediate snags to such a scheme are several. Firstly the shielding weight would rise very much above its present figure, even if a more modern weapon is substituted for the heavy gun and the turret weight thereby appreciably reduced. The armour plating of a conventional tank is already selective, and would certainly have to be increased at the sides and rear, to say nothing of the additional shield to protect the crew. There would be no saving to offset this in the replacement of engine and fuel weight by a nuclear plant, for the present engine complete with auxiliaries weighs only about a ton, and full fuel tanks little more than half a ton. Secondly there is no indication that the same type of shielding would be suitable against both enemy fire and radiation, though doubtless a suitable compromise could be reached. Thirdly there is still the problem of armour-piercing shot, which would almost certainly make any "brewed up" tank a radiation hazard, even if the radiation was limited to a series of pencil beams.

Any suggestion of overcoming some of these difficulties by having an unmanned remotely-controlled tank is quickly shot down by the tank school. They point out, with some logic, that there is nothing to gain in making a tank radio-controlled, since with the best will in the world it cannot select targets which are probably out of sight of the controller. Moreover, four men already have considerable trouble in manipulating all the controls from within, and any form of remote control would be hopelessly complicated. The *coup de grace* to the whole idea is given by the comment that "the idea of a rogue tank, atomic-powered, roaming the battlefield beggars description!"

Conclusions

Nuclear power propulsion is an excellent proposition for submarines and certain types of large surface vessels, in particular the large fast aircraft carrier; but not for small vessels. It has attractive possibilities for long range or long endurance heavy aircraft, but little future for the light or close support type. For the army on the ground it is, in any form conceivable at present, neither practicable nor desirable. In short, the Navy needs it, the R.A.F. can use it and the Army, certainly for the moment, is better without it.

The Use of Radioisotopes

General

Radioisotopes and the uses of them are probably the least publicized but most important aspect of nuclear energy application today. Introduced into industry some ten years ago, it is estimated that their use now saves this country at least £100 million a year, while in medicine and agriculture they have been of even greater importance. New techniques of measurement and control have been evolved which are many times more accurate or sensitive than earlier methods. It is not unreasonable to suppose that some of these may have a military engineering application, and the purpose of the last section of this paper is to review present progress for any uses of military interest.

Definition and Origin

Isotopes are atoms of the same element which are identical in their chemical behaviour but have different atomic weights and different nuclear properties. Radio-active isotopes, or radioisotopes as they are called, are precisely what the name implies and may emit one or more of the four types of radiation: alpha particles, beta particles, gamma rays and neutrons. The subject is very much bound up with the various hazards to human life of these radiations, too involved to be discussed here, but it must be assumed that such hazards can be overcome by fairly simple and sound precautions, as indeed they are in industry all over the country. This is not to imply that they are always a simple problem, but nevertheless it is a fact that many useful radioactive sources can be carried by hand in small containers (see Fig. 6), and handled by simple tongs, and in many cases the necessary precautions

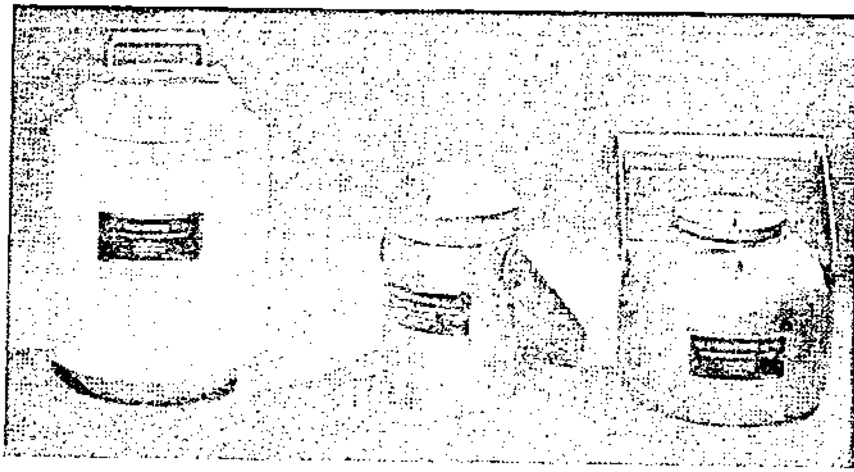

Fig. 6.—Standard containers for the storage and transportation of radioactive isotopes. (*By kind permission of E.R.D. Engineering Co. Ltd.*)

may be little more than keeping at a specified distance and watching the dose rate on a simple portable instrument when close to the source. In some cases even this is unnecessary, as will be apparent from the example of an ionizing application given in a later paragraph.

It should here be stressed that only neutrons can induce radioactivity in a normally non-active substance. Material exposed only to alpha, beta, or gamma radiations from a radio-active source does not itself become radio-active.

Radioisotopes appear in three ways; they may

(*a*) exist in a natural state,

(*b*) be formed in nuclear fission as fission products,

(*c*) be produced by the irradiation (or bombardment by neutrons) of non-active isotopes in atomic piles.

Types of Application

The many applications to which they may be put have been conveniently grouped into five main types. These are[1]:—

(i) *Tracer Applications* in which the radiations are used to detect the presence and usually also to measure the quantity of a radioisotope in any system. Any substance with which a small quantity of radio-, active material is mixed may be thought of as "marked" or "labelled" and its subsequent progress through any mechanical, chemical or biological system can be readily followed.

(ii) *Use as Ionizing Agents.* Here the physical effects of the radiations are used. In particular the ionization of the air or of other gases is used in many electrical applications, and the effects of ionization upon living tissue are applied to the treatment of disease.

(iii) *Absorption and Scattering.* The degree to which the radiations are absorbed or scattered gives a considerable amount of information

[1]*Radioactive Isotopes*, by W. J. Whitehouse and J. L. Putman, Oxford University Press, 1953.

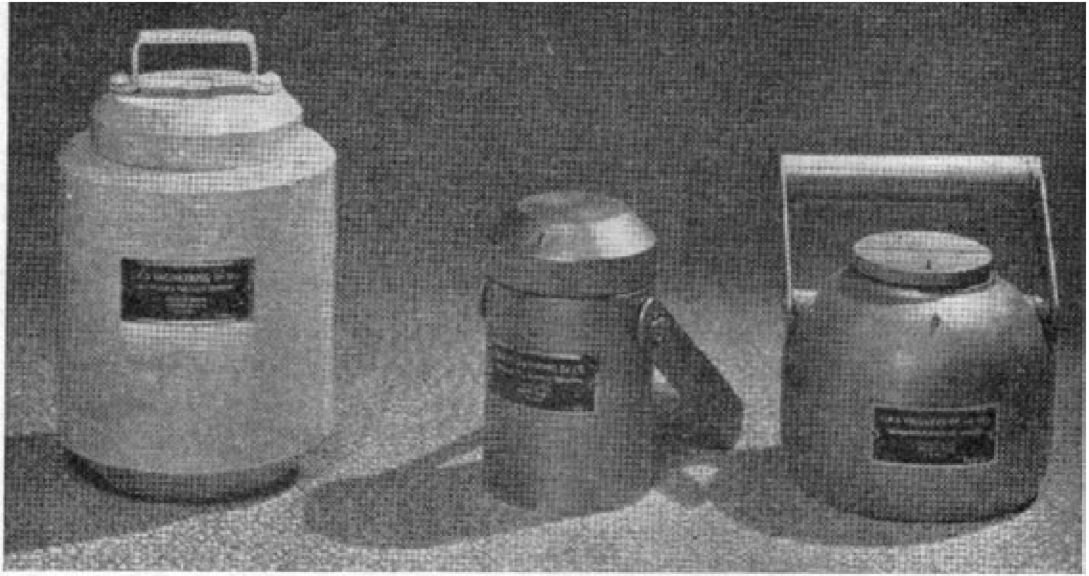

Fig. 6.—Standard containers for the storage and transportation of radioactive isotopes.
(By kind permission of E.R.D. Engineering Co. Ltd.)

about the materials through which they are passing. The internal structure of objects can be investigated using gamma rays instead of X-rays. The attenuation of the radiation or the amount of scattering can be used to measure the thickness of a sheet of material, or to give some indication of the composition of a medium.

(iv) *Use of Decay Rates.* The well-defined and unalterable rate of decay (normally expressed as half-life) of radioisotopes can be used as a measure of time.

(v) *Activation Analysis.* It is possible to detect very small quantities of certain elements by exposing the material containing them to a neutron flux and measuring the activity of the radioisotope which is produced.

Of these it is fairly certain that only (i) and (iii) are ever likely to have much military application, allowing that (ii) will be, or already is, used by service medical branches in the same way as in the civilian medical world.

Uses of Military Interest

Unlike nuclear power production and propulsion, where the specific advantages of fuel density, unlimited range, etc., justify the military being in the forefront of, and not lagging on, civil research, with radioistopes the only practical approach is to watch civil developments and utilize any which will improve existing methods. Their use will be justified either by a greater saving in time or material, or by a more accurate result than other methods will give. Generally speaking, accuracy in this context implies laboratory standards and is beyond the scope of normal military requirements. The present, or probable, applications with any military slant which the author could find are discussed below.

Tracer Applications

The basis of tracer applications is that materials can be detected at a distance from themselves, without removing them or interfering with them in any way. Applications which might in certain circumstances be of service value are the tracing of leaks in underground pipes, the tracing of partial blockages in underground and surface pipes, the marking of the interface in petroleum systems, and the locating of missiles after test-firing. The first-mentioned might be very much a sapper concern in conditions after a nuclear strike.

Tracing of Leaks

A radioactive solution is pumped through the pipe and permeates the soil in the vicinity of the leak. The pipe is emptied, and the leak is then detected either by a counter taken along the pipe-run at ground level, or for deep pipes by a more costly system in which a detector is floated through the pipe itself, in a non-active liquid at steady speed, and records the position of the leak. Either of these systems is of course quicker than the old solution of testing consecutive sections of pipeline until the leak is found.

Tracing of Partial Blockages

This application is already a recognized military one, being included in R.E.S.P.B. No. 6 B. "The simplest method of locating a partial block is by 'watching' the progress of a radioactive isotope along the pipe by means of a geiger counter. When the rate of progress changes for no apparent reason the pipe must be opened at that point and cleared."

Petroleum Interface Marking

In any petroleum system in which different fuels have to pass in succession along one pipe there is always some mixing at the interface resulting in wastage of fuel. R.E.S.P.B. No. 6 B states that this "calls for adequate arrangements for segregation at the delivery end" and leaves it at that. If a radioactive "slug" of liquid is introduced between successive consignments, it indicates accurately at the far end of the pipeline the end of the first consignment; and the extent of the mixing can be accurately determined, so reducing to a minimum the quantity to be discarded. A simpler system, merely to indicate the interface quickly, is the insertion of a go-devil carrying a radioactive source.

Location of Missiles

The missile carries a radioisotope, making it readily detectable by counter if "lost" to other devices.

Use as Ionizing Agents

A major application here is the dispersal of static-electricity to reduce fire risks. Beta-emitters, that is radioisotopes which emit beta particles, are used to ionize the surrounding air and so provide a leakage path for any electrical charge. For instance, an anti-static floor to prevent ether fires in the operating theatre of a hospital may have laid in it metal strips containing the beta-emitter. These would be laid in such positions that direct radiation on to personnel would be reduced to negligible proportions. There is also on the market a gadget known as an ion blower, which consists basically of a strong radioisotope source enclosed in a fairly small container, through which air is blown and ionized as it passes. The ionized air is then blown in whatever direction desired and provides the necessary leakage path for static without being at all radioactive. This may be ideal for use in the operating theatre of a field hospital, if indeed it is not already standard equipment for that purpose.

A reported problem at present is to devise a means of producing sufficient ionization not merely to reduce the risk of fire or explosion but to guarantee prevention, without at the same time making the air too "hot" radioactively. If this is solved there may in due course be useful military application in safeguarding the handling of propellants and inflammable liquids in arid climates.

Absorption and Scattering

Of the many applications under this heading at least five are of possible service value. These are the determination of soil moisture content for water supply or compaction purposes; the determination of concrete or soil density for structural purposes; the measurement of thickness of material when only one face is accessible; another method of petroleum interface marking; and gamma radiography.

Determination of Soil Moisture Content

This method is based on the facts that hydrogen is the most effective element in slowing neutrons (i.e. moderating) from fast to thermal energies, and particularly more so than most common soil elements, and that practically all the hydrogen in mineral soils is in the form of water. If a fast neutron source is placed in the soil and a slow neutron counter placed close to it the counting rate will be almost entirely a function of the amount of hydrogen present, and hence of the moisture content. A possible disadvantage of the method for sapper use is that the total moisture content measured includes water present in crystal form as well as liquid and vapour, and opinions vary as to whether or not this unusable content will often be appreciable. Against it there is the distinct advantage that the calibration curve is independent of soil type if represented on a weight by volume basis. The ideal apparatus is a probe unit containing neutron source and slow neutron counter, connected to a robust portable meter. One such equipment designed three years ago had a total weight of 20 lb. Counter and source were lowered together into an auger hole in the soil and a reading taken on the ratemeter at the surface after 2 min[1]. Doubtless better equipments are now in being, but the author has been unable to obtain any details.

Density Testing of Concrete or Soil

Radioactive techniques have already been successfully used in determining the density of soil or concrete *in situ*, where non-destructive methods are required. Basically there are two methods, one depending on absorption and the other on back-scattering. The first entails the measurement of the absorption of gamma radiation during propagation through a fixed thickness of material. With a concrete structure this would entail having the gamma source at one face and the counter at the opposite face, while for soil it means merely having two auger holes a certain distance apart, with the source in one and the counter in the other. The second method depends on the fact that a proportion of gamma (or beta) radiation is scattered-back (or to oversimplify it—"reflected") by any medium through which it is passing, and the amount of back-scattering depends to an extent on the nature or density of the medium. This method is obviously useful where only one face of the material under test is accessible, for instance a concrete road or floor slab, so that both source and counter must be placed on the same face. A concrete density indicator on these lines has been developed in France and is already being advertised by a French firm. Similar work is proceeding in this country, where neutron-scattering by hydrogen as used in the soil moisture content determination has also been studied with reference to concrete.

Measurement of Material Thickness

Back-scatter gamma ray instruments are also widely in use to detect differences in density or thickness when measurement can only be made from one side of a vessel or pipe. They are used for keeping a check on the internal corrosion of tanks and pipes, and for detecting the level of liquid in closed vessels.

Petroleum Interface Marking

In addition to the two methods mentioned on page 146 there is a third method of detecting petroleum interfaces which is probably the simplest and the most used in the oil industry. This is to use gamma source and detector on opposite sides of the pipe and rely on the difference in density in successive fuel consignments to spot the interface. Different densities will give different absorption readings on the detector, which will detect changes of as little as 0.002 specific gravity. The advantage of this method is that nothing need be put inside the pipe.

[1]*Proceedings of the Second Radioisotope Conference, Oxford,* 1954, Vol. 2, p. 111.

Gamma Radiography

One of the most important radioisotope applications is the use of a gamma source instead of an X-ray tube. This has great attractions because of its independence of power supplies and of any kind of maintenance, the great thicknesses of steel which can be penetrated and the convenience of dealing with tubes (e.g. gun barrels) and with structures (e.g. parts of a building or a bridge) *in situ*. This last point may be very useful in assessing damage to a structure subjected to heavy loading. It may also be useful in deliberate demolition work, as it has already been used successfully to locate the reinforcement in R.C. slabs, and also to locate in concrete any areas of dubious strength due to poor compaction. Gamma radiography offers considerable advances over any alternatives, and will probably be the first radioisotope application to come the way of the Corps.

Mine Detection

To a sapper the idea of detecting hidden material at a distance from itself will immediately suggest mine detection, and there are in fact at least four ways in which radioactivity might if necessary be used for this. All these should be suitable to detect any type of mine, metallic or otherwise.

(*a*) *Tracer method.* This would entail a radioactive source fitted in the mine, say the fuze assembly, and a counter in the detector. As so much effort has been spent in making mines undetectable, it may seem at first sight ludicrous to label them thus. But in the case, for instance, of beach mines around our own shores, particularly any which are buried in constantly shifting sands and probably cause more casualties to our own troops lifting them than to anyone else, the idea is not unjustifiable.

(*b*) *Activation method.* Again for use on our own mines only, but this time more suitable for field use as well, there could be a neutron emitting source and a counter both fitted on the detector, and in the mine itself a small quantity of some non-active material which when irradiated would instantaneously become radioactive and signal its presence. In this case the enemy would need a similar neutron emitter as well as a counter in order to detect the mines.

(*c*) *Back-scattering method.* Both gamma source and counter, screened from each other, would be carried on the detector. In principle the counter would measure the radiation scattered-back or "reflected" off the soil, and the intensity of this would vary appreciably over a shallow buried mine. This could be used for our own and enemy mines alike, but unfortunately, whereas the conventional detector will pick up any metal object be it mine or otherwise, this radioisotope version would react on rocks and any other buried denseness as well.

(*d*) *Neutron-scattering method.* This would work on the same principle as the soil moisture content indicator. Neutron source and counter would again both be on the detector, and readings would vary according to the hydrogen content of the material being investigated. This might be particularly suitable against plastic mines if the plastic represented a significant increase in the hydrogen concentration per unit volume.

There may well be other possibilities in this field, but of course it is unlikely that any reports will be published as the subject is hedged with security restrictions. Whether any of these methods would show significant improvement on existing methods of detection remains to be seen, but it seems quite possible that they might.

Food Preservation

This really comes under the medical side, but is briefly mentioned here as it may one day affect the refrigeration commitments of the Corps. Work on the radiation preservation of food has been going ahead for a long time, and in America the military are showing considerable interest, the Army Quartermaster Corps playing a large part in current research with a food-irradiation reactor.

Conclusions

The use of radioisotopes, although well established, is still in its early stages. There are few military field jobs which at present are not better or equally well done by conventional methods, though it can be argued that this is only so because no suitable organization exists for the handling of the radioisotopes. In a few years time however the situation may be different and the subject should be kept under constant review. If and when radioisotopes can be of general and varied military use, there will have to be formed some specialist unit such as an Isotope Troop, R.E., which must be skilled in the use of these things and capable of carrying out a multitude of various jobs over a large area.

Summary and Conclusions

The form of future war is full of uncertainties, but it is at least sure that preparedness, speed of action and self sufficiency will be vital factors. All the major powers are concentrating on submarine development, the object of which speaks for itself, and it needs no emphasizing that British and Commonwealth bases are more dependent on sea supply routes than any other powers.

Nuclear energy offers a source of power independent of logistic support, and though the rate of progress in nuclear developments is great there is a danger in always deferring action to await the next improvement. Small static nuclear plants are already on the open market and British designs in sight. These should be developed fast and installed in our important bases as early as possible. Planning and construction inevitably take time, and any decision now will probably take five or six years to reach fruition. Meanwhile the training of military reactor operators and engineers, as in America and no doubt Russia, should be started forthwith. For forces in the field, nuclear plants to provide the main power loads, always increasing, would be of great value if mobile and easy to operate. Small mobile plants are not yet in existence but their feasibility is no longer doubted. They are however a purely military requirement, and are unlikely to make rapid headway unless treated as a military urgency. This is being done in the United States, and should be so here.

The advantages of nuclear propulsion for sea vessels are already well acknowledged. There is a case for nuclear propelled aircraft, particularly for the global force type bomber and the military flying boat, but there is much research still to be done and the need is not so pressing. There is no case for the nuclear propelled military land vehicle unless a revolutionary solution to the radiation and weight problem is discovered.

The use of radioisotopes in the civil world is increasing daily as more applications are found. There will very soon be sufficient justification for their inclusion on the military inventory, and progress in this field should be constantly watched. In due course their use will be a specialist military engineer task.

The over-all conclusions of the author are three:—

1. Military nuclear energy applications of great consequence, other than destructive power, do exist;

2. The indications are that in this country these may be generally known but they are not fully appreciated;

3. Their development should be given much greater impetus, which in the case of the Army must originate from the Royal Engineers.

APPENDIX A

U.S. ARMY PACKAGE POWER REACTOR—APPR-1[1]

General

The APPR-1 is a prototype of a reactor designed to meet the requirements and site conditions of a remote military base. Since it is constructed at Fort Belvoir, near Washington, some of the design requirements were changed to meet the circumstances, in particular the substantial shielding and containment against worst possible accident. The reactor is to be used as a training facility for troops and specialists who may eventually be required to operate and service such plants. All components are designed to be transportable by air.

Design Details of Interest

Over-all Plant Performance

Thermal power developed in reactor	10,000-kW.
Electric power generated	2,005-kW.
Net electric power delivered	1,825-kW.
Thermal Efficiency of net electric power generation	18.25 per cent
Core life before refuelling	15 MW.-yrs.

Reactor Vessel

Dimensions	4 ft. dia. × 11 ft. 6 in. high
Wall thickness	2.5 in. steel
Total uranium content	approx. 8 lb. U. 235
Operating pressure	1,200 p.s.i.
Coolant outlet temperature	450°F.

Steam at Full Load

Pressure	200 p.s.i.
Temperature	407°F.

Shielding (approx. total thicknesses)

(*a*) Primary	
i Radial	21 in. steel 32 in. water
ii Vertical	5 in. steel 106 in. water
(*b*) Secondary	1 in. steel 60 in. concrete

Weight

Weight of complete plant	1,300 tons

(This figure includes 900 tons for concrete shielding, the materials for which might in some cases be at site. There is also an alternate shield of steel filled with water. It may seem a formidable figure, but must be

[1] "*Army Package Power Reactor. Description and Supplement*", by ALCO Products Inc., Schenectady, New York.

viewed against the very much heavier weight of conventional fuel needed to achieve the same result.)

Some Early Test Performance Results

"*APPR goes on line*

The APPR, first complete pressurized water reactor plant for electric power . . . was begun on 10th December, 1954, went critical 8th April, 1957 and first generated electricity on 13th April, 1957.

During these (early) tests the reactor exhibited a degree of stability under violent load changes that surprised even its builders: when a circuit-breaker connecting the generator to the outside electrical system opened and load dropped instantaneously from 2,000-kW. to 200-kW., the reactor followed within a minute and with no over-pressure or over-temperature. The experiment was repeated deliberately, with the same result. Then load on the turbine was increased from 200 to 2,000-kW. at a rate of 1,000-kW./minute and again the reactor followed smoothly. . . ."

Nucleonics, May, 1957.

"*APPR on the line.*

. . . Several measurements were made during the test, and the reactor demonstrated that it could be adequately cooled by thermal convection in the event of loss of primary coolant flow. Among the significant characteristics of APPR-1 to come out of the 700-hr. test was its response to load demand—the stability of the reactor exceeded all expectations. . . ."

Nucleonics, August, 1957.

"*APPR completes 700 hours*

. . . The power plant operated at a load designated by the A.E.C. for a period of 700 hours, during which shutdowns totalling only 8 hours were required for adjustment and repair of plant components. During more than 600 hours of the test, electricity was generated at a rate exceeding the design output of the plant. . . ."

Engineering, 30th August, 1957.

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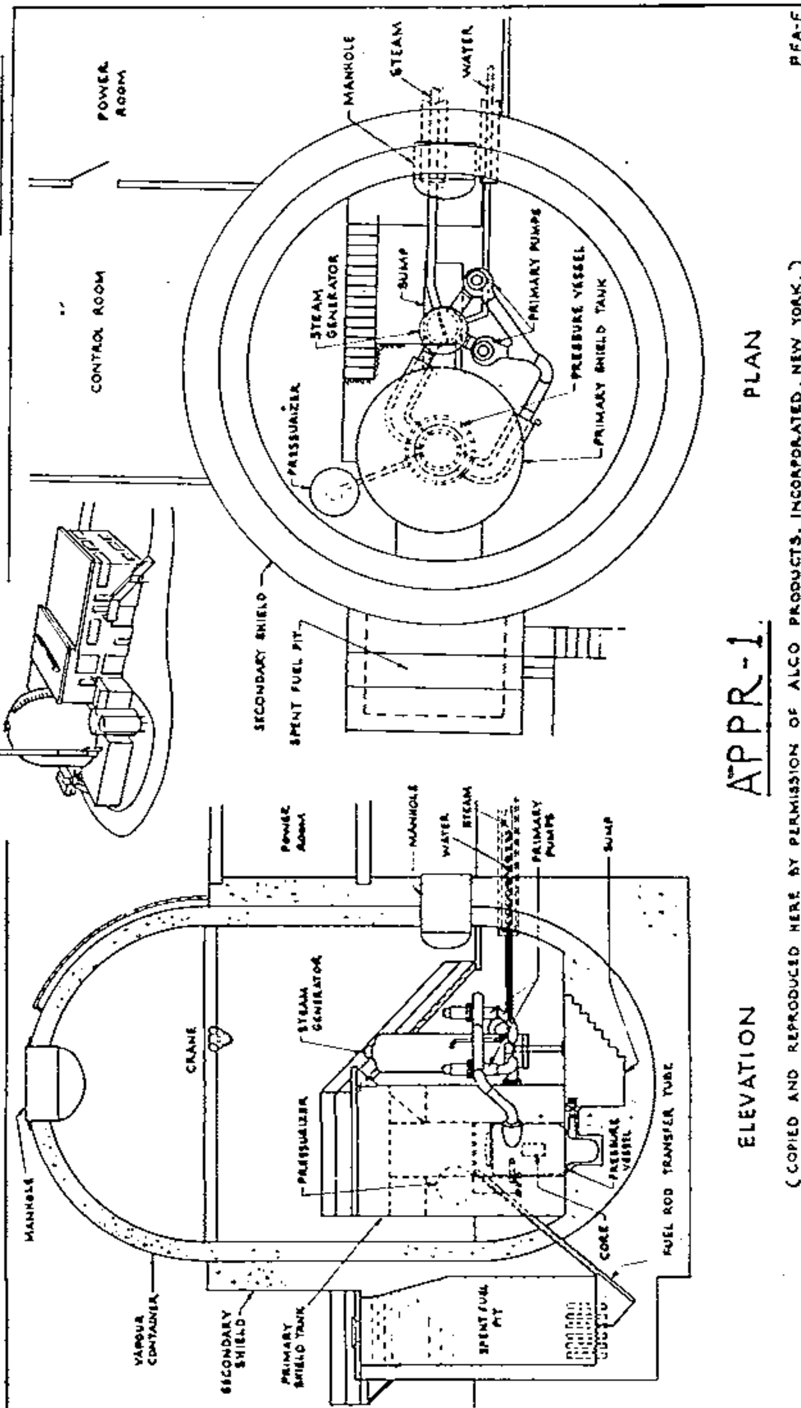

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Sputniks, Moon Rockets and Martians

By Major J. Ewart, B.Sc., A.M.I.E.E., R.E.

The successful launching of an Earth-orbiting satellite on 4th October, 1957, by the U.S.S.R. captured the public imagination throughout the civilized world, and the interest so aroused is still very much alive. *Sputnik I* (180 lb.) was followed within a few days by *Sputnik II* (1,118 lb.) with its living passenger. The U.S. Army's 30-lb. satellite *Explorer* was launched on 31st January, 1958. Just recently Russia has also announced her intention of launching more than 150 satellites in the summer of 1958 as part of the International Geophysical Year programme.

The interest provoked by these events is reflected in the large amount of space devoted to extra-terrestrial affairs in the daily press, magazines, and radio programmes. The information so freely poured out has covered a wide range: cartoons depicting the projection into space of payloads ranging from golf balls to ex-party bosses; the possibility of landing on the Moon; and even a radio programme on the academic aspects of existing International Law as it affects the extra-terrestrial rights of the nations; all these for the layman. However, cartoons no matter how amusing, artists' impressions of multi-stage rockets, and "Science for the Million" do not satisfy the engineer. We are left with a lack of precise definition which will relate these happenings to our everyday knowledge. The impression is given that the technical side of space flight is:—

(*a*) Secret.

(*b*) Too difficult.

Some few of those who may read this article will have attended courses on guided weapons and similar subjects and will presumably be well informed on these matters. The majority of readers, however, will, like the author, be merely run-of-the-mill officers with no such specialist knowledge, but we are not laymen. It is intriguing to find that the basic whys and wherefores of space flight are neither secret nor difficult; they fall quite easily into any Sapper's technical background.

So simple are they in fact that Sir Isaac Newton can fairly be said to have "invented" Earth satellites nearly three centuries ago. His Law of Gravitation and Laws of Motion established the basis for all the necessary calculations. Newton undoubtedly did these calculations himself, and we can do likewise with little difficulty.

As every schoolboy knows (and many adults have forgotten) Newton's Laws of Motion can be briefly stated as:—

1. Any body will continue in a state of rest or of uniform motion until acted upon by an outside force.

2. A body acted upon by a force will accelerate in the direction along which this force acts. For a given force (P) acceleration (f) is inversely proportional to the mass (m)

i.e., $P = mf$ ———————————————— (i)

3. Action and Reaction are equal and opposite.

The Law of Gravitation states that any two bodies in space attract each other with a force which is proportional to the product of their masses, and inversely proportional to the square of the distance between them.

Now let us apply these laws to Sputniks and the rest.

Escape Velocity

"What goes up must come down." At first sight it appears common sense that a body thrown upwards will eventually fall back to Earth; but if we remember that the force of gravity is decreasing inversely as the square of the distance, as the body moves away from the centre of gravity, the suspicion arises that perhaps a body *could* be given sufficient "muzzle velocity" upwards so as never to return. Escape velocity is that velocity with which any body must be projected from Earth never to return (that is, stated mathematically, it will travel to infinity). Conversely, it is the velocity with which a falling body will arrive on Earth if it starts from rest at infinity.* This velocity, for Earth, can be shown to be 7 miles per second, and the calculation is as follows:—

From Law of Gravitation:—

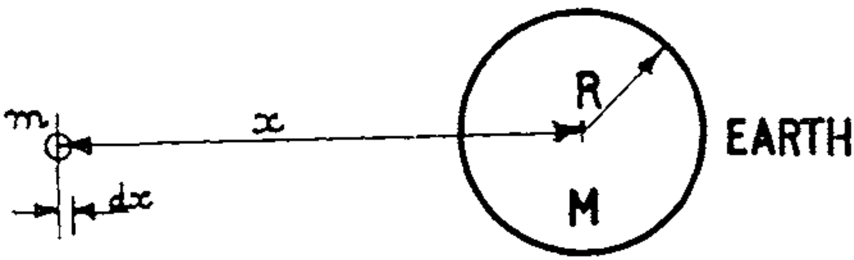


FIG I

Force between two bodies in space (Fig. 1) $= K\dfrac{Mm}{x^2}$ – – – – – – – – (ii)

Where M, m are masses and K is some constant

Now work = force x displacement

Let body m move distance dx

Work done $= \dfrac{KMm}{x^2}\,dx \; (= KMmx^{-2}dx)$

i.e. when body moves between $x = R$ and $x = \infty$ —

$$\text{Work done} = \int_R^\infty KMmx^{-2}\,dx \; \text{– – – – – – –} \; \int ax^n = \frac{ax^n + 1}{n+1}$$

$$= KMm \left[\frac{1}{x}\right]_R^\infty$$

$$= \frac{KMm}{R} \; \text{– –} \; \text{(iii)}$$

This work is the energy possessed by the body at R due to its velocity, i.e. it is Kinetic Energy ($\frac{1}{2}mv^2$) where V_e is the escape velocity.

$$\therefore \; \frac{KMm}{R} = \tfrac{1}{2}mV_e^2 \; \text{– –} \; \text{(iv)}$$

*Air resistance being ignored in each case.

We also know that at the earth's surface the body is experiencing a force P, where (from (i)):—

$P = mf = mg$—($f = g$ at earth's surface)

But P (from (ii)) can also be expressed as:—

$$P = \frac{KMm}{R^2} = mg$$

$$\therefore gR^2 = KM \qquad \text{(v)}$$

Substitute (v) in (iv)

$$\frac{gR^2m}{R} = \tfrac{1}{2}mV_e^2$$

$$\text{or } V_e = \sqrt{\frac{2gR^2}{R}} = \sqrt{2gR} \qquad \text{(vi)}$$

For earth, $R = 4{,}000$ miles and $g = \frac{32.2}{5{,}280}$ miles/sec.^{2}

$$\therefore V_e = \sqrt{\frac{2 \times 32.2}{5{,}280} \times 4000}$$

$= 7$ *miles/sec.* (25,000 m.p.h.)

Reaching an Orbit

(*a*) If the body is projected upward at *less* than escape velocity it will decelerate to rest and then fall back to Earth. The Earth's atmospheric density ceases to be significant at about 150 miles up, so to avoid air drag in orbit a satellite will be sent up initially to about 300 miles. The need for the safety factor of 2 will soon be clear. However, 300 miles is small compared to the diameter of the Earth, so it can be assumed that g is constant up to this height. What velocity of projection is necessary to reach 300 miles?

$$V^2 = U^2 + 2fs$$

$$\text{i.e. } 0 = U^2 - 2gh$$

$$\text{or } U = \sqrt{2gh} \qquad \text{(vii)}$$

$$= \sqrt{2 \times \frac{32.2}{5{,}280} \times 300}$$

$= 1.9$ miles/sec. (6,880 m.p.h.)

It is interesting to compare equations (vii) and (vi). The velocity required to move to infinity, with decreasing gravitational force as the body moves outward, is exactly the same as the velocity required to move upwards a distance equal to the planet's radius if gravity had remained constant.

(*b*) The body in (*a*) would now fall back to Earth, but *Sputnik* had an angle of projection and rocket power such that at 300 miles up, it had a velocity V_o parallel to the earth's surface. The centrifugal force acting outwards on the satellite due to V_o, exactly balanced gravitational force downwards.

The satellite is now weightless. We experience something of this sensation at the instant a lift starts to move downwards, or the garden swing starts to descend from its highest point; and in nightmares, most unpleasant.

Orbital mathematics start from the simple statement that centrifugal force outwards $\left(\frac{mv^2}{r}\right)$ equals gravitational force inwards

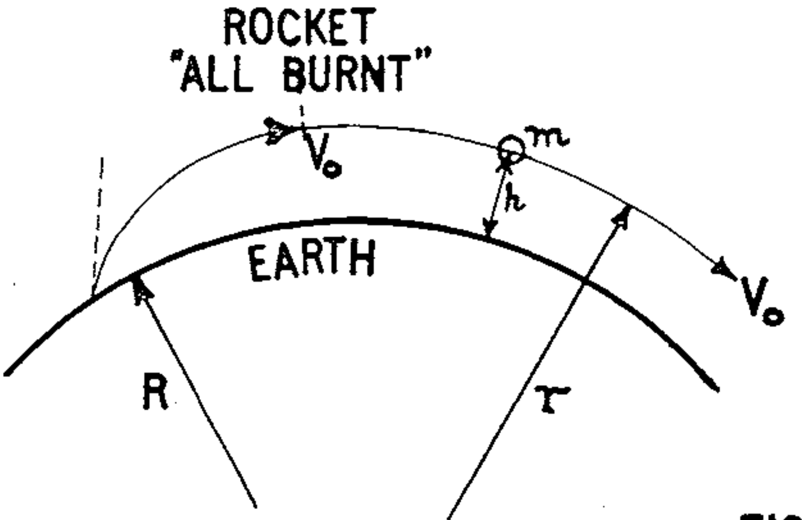


FIG II

From Fig. II:—

$$\frac{mV_o^2}{r} = \frac{gR^2m}{r^2} \text{ (from (ii and (v)) where } r = R + h$$

i.e. $V_o = \sqrt{\frac{gR^2}{r}}$ ——————————————————————— (viii)

In fact, since h at 300 miles is small compared to R at 4,000 miles, we can say as an approximation that $r \doteqdot R$

Equation (viii) then becomes

$V_o \doteqdot \sqrt{gR}$ ——————————————————————————— (ix)

This is again an interesting result, for comparing (ix) with (vi) we can see that for a "close-in" satellite where $r \doteqdot R$:—

$$V_o = \frac{V_e}{\sqrt{2}}$$

That is, for earth $V_o = \frac{7}{\sqrt{2}} = 5$ miles/sec. (18,000 m.p.h.) (*Sputnik* speed).

(*c*) Several other important facts can be deduced from equation (viii).

(i) This is a general equation applicable to any celestial body. Since astronomers can tell us the diameter of every major body in the solar system, and the gravitational constant at the *surface of each*, we can find the escape velocity and the circular velocity of a "close-in" satellite for each of them. These have been calculated and are shown in Table I.

(ii) For given planetary constants R and g, the value of V_o is entirely dependent upon h. There is only one possible circular velocity for a given height. The greater the height, the smaller the velocity.

(iii) The orbital Time (T) is a straightforward calculation:—

For *Sputniks*: $V_o = 18{,}000$ m.p.h.

$$T = \frac{2\pi r}{V_o} = \frac{2\ \pi\ 4{,}300}{18{,}000}$$

$$= 1\tfrac{1}{2} \text{ hours approx.}$$

For the Moon: $V_o = \sqrt{\frac{32.2 \times 4{,}000^2}{5{,}280 \times 244{,}000}}$

$= 0.63$ miles/sec. (2,280 m.p.h.)

and $T = \frac{2\pi \times 244{,}000}{2{,}280}$ hrs.

$= 28$ days.

(iv) A *Stay-Put* satellite. A body in orbit will appear to stand still relative to Earth if its orbital time T is 24 hrs. This occurs when the orbital height h is 22,000 miles above the Equator.

TABLE I CONSTANTS OF MAJOR SOLAR BODIES

Body	Approx. Radius "R" (miles)	Surface Gravity (times g)	Escape Velocity $V_e = \sqrt{2gR}$ (miles/sec.)	"Close-in" Satellite Orbital Velocity $V_o = \frac{V_e}{\sqrt{2}}$ (miles/sec.)
Mercury	1,500	0.27	2.4	1.85
Venus	3,800	0.85	6.3	4.45
Earth	4,000	1.0	7.0	5.0
Moon	1,100	0.16	1.46	1.03
Mars	2,100	0.38	3.1	2.2
Jupiter	44,000	2.64	37	26.0
Saturn	38,000	1.17	22	15.5
Uranus	16,000	0.92	13	9.2
Neptune	14,000	1.40	15	11.3
Pluto	2,000	?	?	?
Sun	430,000	28	383	272

Elliptical Orbits

By Newton's first Law of Motion a satellite, having been placed in circular orbit beyond atmosphere, is in a state of uniform motion and should continue so. Why then are the *Sputniks* travelling in elliptical, as opposed to circular, orbits? There are several good reasons, viz.:—

(i) The Earth is *not* itself a true sphere. It has flattened poles and an equatorial bulge.

(ii) The *Sputnik* is of metallic construction mainly, and is cutting the Earth's magnetic flux, which is *not* constant around the globe. It will therefore experience a *varying* electro-magnetic drag.

(iii) The *Sputnik* is spinning, so will have a "crabwise" drift.

These effects cause decay of the circular orbit, and also cause the orbit to precess around the Earth. (*Sputnik I* precessed at about 3.2° per day.)

Paths of Heavenly Bodies

All bodies moving under the influence of gravitational forces only will follow paths which are conics.

General Equations of the Conics

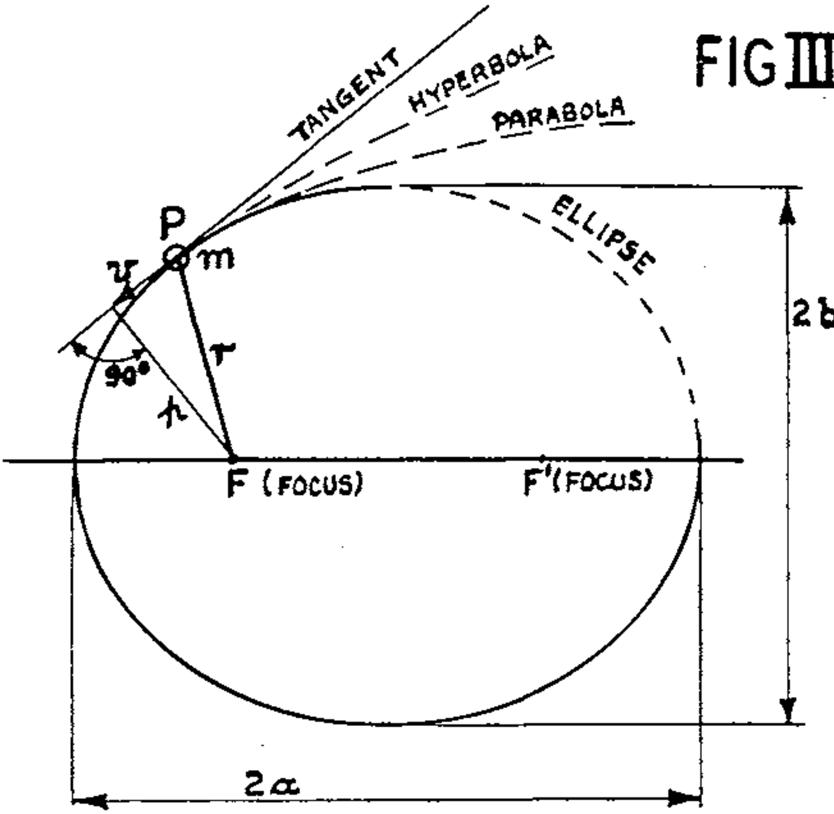
These are generally known to engineers in the form of either Cartesian co-ordinates (x, y) or polar co-ordinates (r, θ). For present purposes it is necessary to use tangential co-ordinates, which give us (Fig. III):—

$$\left.\begin{aligned} \frac{b^2}{P^2} &= \frac{2a}{r} - 1 \text{ for an ellipse} \\ &= \frac{2a}{r} + 0 \text{ for a parabola} \\ &= \frac{2a}{r} + 1 \text{ for an hyperbola} \end{aligned}\right\} \text{-------------- (x)*}$$

*Ramsey, *Dynamics*, Art 12.5.

EQUATIONS OF A SATELLITE

FIG III



Consider the small body of mass m (Fig. III) moving with velocity v and acted upon by the earth's centre of gravity at F, at a distance r.

Kinetic Energy at $r = \frac{1}{2}mv^2$

Potential Energy at r = work done in bringing m from ∞ to r against gravity g

$$= \int_{\infty}^{r} \frac{KMm}{x^2\,dx} \text{ — (from (ii))}$$

$$= \int_{\infty}^{r} \frac{gR^2m\,dx}{x^2} \quad \text{(from (v))}$$

$$= gR^2m \left[\frac{1}{x}\right]_{\infty}^{r}$$

$$= gR^2m\left(\frac{1}{\infty} - \frac{1}{r}\right)$$

$$= -\frac{gR^2m}{r}$$

Total energy of body per unit mass is a constant.

i.e. $\dfrac{KE + PE}{m}$ = a constant

or $\frac{1}{2}v^2 - \dfrac{gR^2}{r}$ = a constant ——————————(xi)

o

Now angular momentum vp is a constant (say k)

$$\text{or } v = \frac{k}{p} \qquad \text{(xii)}$$

Substituting in (xi):—

$$\tfrac{1}{2}\frac{k^2}{p^2} - \frac{gR^2}{r} = \text{a constant}$$

$$\text{or } \frac{k^2}{p^2} = \frac{2gR^2}{r} + \text{a constant}$$

But this is the form of the general tangential equation of the conics about a focus (equation (x)) where the constant is:—

Negative; zero; positive: for an ellipse; parabola; hyperbola. Returning to equation (xi):—

$$\tfrac{1}{2}v^2 - \frac{gR^2}{r} = \text{a constant}$$

$$\text{or } v^2 - \frac{2gR^2}{r} = \text{a constant say } C$$

but $\sqrt{\dfrac{2gR^2}{r}}$ is the escape velocity v_e at r (from vi)

$\therefore C = v^2 - v_e^{\,2}$

Therefore the path of the body is:—

	ellipse;	parabola;	hyperbola
as C is	negative;	zero;	positive
i.e. as	$v^2 < v_e^2$;	$v^2 = v_e^2$;	$v^2 > v_e^2$
or as	$v < v_e$;	$v = v_e$;	$v > v_e$

Summing up therefore:—

(*a*) A body in space moving about a gravitational centre at less than escape velocity (i.e. a *Sputnik*) will describe an elliptical orbit about the gravitational centre at a focus.

(*b*) At exact escape velocity it will coast away from the gravitational centre along a parabolic path and come to rest at infinity.

(*c*) At more than escape velocity it will coast away from the gravitational centre along a hyperbolic path, and at infinity will have a residual velocity.

Russian Accuracy

To place a satellite into orbit clearly requires precise calculation and engineering skill. When the rocket is "All Burnt" the payload must be travelling at the correct speed and correct height to achieve the initial circular orbit. This will decay into an ellipse and remain stable provided it does not enter atmosphere at its lowest point. A measure of the Russian accuracy is that *Sputnik I* in its earliest phase had an orbit where h was 600 miles at maximum and 155 miles at minimum, i.e. ratio of major axis to minor axis was 1.0001. This was indeed a remarkable achievement for the first ever.

Rockets

It is not intended here to repeat the familiar arguments proving that the rocket will work in a vacuum. The absence of air merely means that no energy is wasted in pushing aside the air in front and accelerating the air behind. The increase in thrust at 300 miles up over that at sea level is believed to be about 12 per cent.

Rocket Speed in Vacuum

Let R = Mass Ratio of rocket = $\dfrac{\text{Mass of rocket} + \text{fuel}}{\text{Mass of rocket}}$

v = velocity of exhaust gases

V = final "All Burnt" velocity of rocket

It is obvious that V will increase as:—

(i) v increases

(ii) Mass of fuel to be burnt increases

(iii) Mass of rocket decreases

But (ii) and (iii) are implicit in R. The actual *size* of rocket is not important. What *is* important is the unit mass of load to be raised by unit mass of fuel, i.e. V will be the same for a small and a large rocket, using the same fuel, if their mass ratios are the same.

Obviously V varies directly with v, but not so with R. For a rocket of given "take-off" weight, a small increase in R means not only a saving of x lb. of rocket structure to be propelled, but also x lb. of extra fuel to propel it. The variation of V with R is not linear therefore, but logarithmic.

To prove that $V = v \log_e R$

Let M = total "take-off" mass of rocket

M_o = Mass of rocket "All Burnt"

$$\left(R = \frac{M}{M_o}\right)$$

Now Momentum (mv) to rocket = momentum to exhaust (from Newton's Third)

$$MdV = vdM$$

$$\therefore dV = vM^{-1}\, dM$$

$$\therefore V = v \int_{M}^{M_o} M^{-1}\, dM$$

$$= v \log_e \frac{M}{M_o} \qquad \left(\int \frac{1}{x}\, dx = \log_e x\right)$$

$$V = v \log_e R \qquad \text{(xiii)}$$

e.g. if V is to equal v, $\log_e R$ must be 1

or $R = e = 2.718$

i.e. 1.718 tons of fuel per ton of structure. This figure can easily be bettered, for the 1944 German V2 had a mass ratio of 3. In other words, it travelled faster than its exhaust velocity.

Rocket Fuels

Some of the well-known liquid fuels are given in Table II. The exhaust velocities quoted are practical as opposed to theoretical figures, and make allowance for the losses which occur in rockets of post-war design.

TABLE II. LIQUID FUELS

Fuel	Exhaust Velocity (miles/sec.)
Oxygen and alcohol*	1.45
Oxygen and hydrogen	2.25
Nitric acid and petrol	1.5
Fluorine and hydrogen	2.4

*Used in German V2.

Example—For V2, ignoring air resistance

(*a*) $V = v \log_e R$ (from (xiii))

$= 1.45 \log_e 3$

$= 1.59$ miles/sec. (5,600 m.p.h.)

and

(*b*) to calculate h

$u = \sqrt{2\,gh}$ (from vii)

$$1.59 = \sqrt{\frac{2 \times 32.2 \times h}{5{,}280}}$$

$h = 210$ miles

Rocket Temperatures

The fuels used burn at temperatures around 2,800°C. Mild steel (used for V2 motors) melts at about 1,250°C. This unwelcome state of affairs can be largely overcome by using liquid fuel as a coolant in the jacketed combustion chamber (Fig. IV).

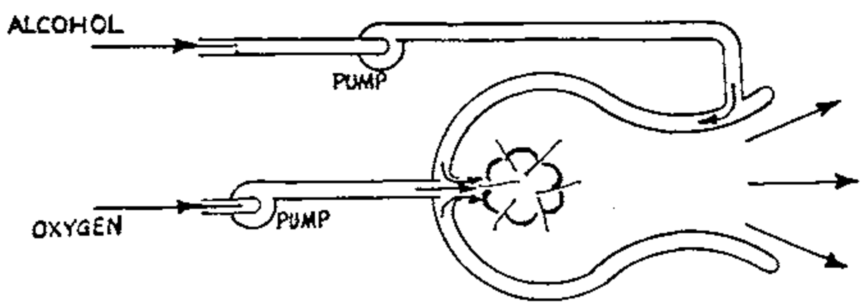


FIG IV

Even with this arrangement, the fuel used in V2 was also "watered down". It actually achieved a speed of 1 mile per sec. and an altitude of 115 miles due partly to the weakened fuel and partly to air drag.

Stepped (Multi-Stage) Rockets

Assume that a rocket can be built to withstand 2,800°C. operating temperature, using hydrogen and fluorine (which will even attack glass!). Assume also that air and gravity drag absorb 20 per cent of the initial velocity. To achieve orbital velocity (5 miles/sec.) such a single-stage rocket must have mass ratio R where:—

$V = v \log_e R$

i.e. $5 \times \frac{100}{80} = 2.4 \log_e R$

$R = 12.$

Therefore the rocket will carry 11 tons of fuel per ton of structure. This is not possible with the state of rocket technology today. Modern rockets may well have achieved a mass ratio of say 5 (an uninformed guess: the true figure will of course be secret). Let us assume a figure of 5, made up as follows:—

Payload	5 per cent	
Structure	15 per cent	
Fuel	80 per cent	$R = \dfrac{80 + 20}{20} = 5$
	100 per cent	

If the payload (5 per cent of take-off weight) is itself a smaller rocket of $R = 5$ which disengages and starts to fire when the carrier rocket is "All Burnt" then obviously the final velocity achieved by the smaller rocket will be twice the speed of the larger.

Any number of stages could be used, and for n stages the final velocity will be n times the velocity of one stage.

The difficulty with a large number of stages is that each is twenty times the weight of the next ahead.

e.g. A three-stage rocket to lift 112 lb. would require:—

Final payload	.05 ton (112 lb.)
Stage III rocket	1.0 ton
Stage II rocket	20.0 tons
Stage I rocket	400.0 tons
Total	421.05 tons at take-off.

A five-stage rocket based on these figures would have a take-off weight of 168,421 tons. Since this is the sum of a geometric progression, it will be appreciated that a small improvement in mass ratio, fuel velocity, or motor design will drastically reduce the total take-off weight required.

The U.S.A. satellite is to be placed in orbit by a three-stage rocket as were the *Sputniks.*

Moon Rockets

The Moon at 240,000 miles distance is practically at infinity. The velocity required to reach it is 6.95 miles/sec. (0.05 miles/sec. less than escape velocity). Undoubtedly the Moon can be and shortly will be reached, either by improved rocket design and fuels, or by adding a fourth stage to existing types.

Accelerations

We are all familiar with the "gs" so freely quoted by our fighter-pilot friends, and the distressing effects thereof. How is this related to rocketry? We have gaily considered the possibility of blasting a payload into space to unearthly velocities, and ignored the acceleration required to do this. A fit human body in a horizontal position can tolerate 10g for about three minutes without loss of consciousness; and 10g will give escape velocity in approximately two minutes. Smaller accelerations are possible, for a longer time, but the total energy requirements will increase.

The faster we can accelerate the rocket initially, the less time and energy will be wasted against "close-in" gravity and denser atmosphere.

The dog Little Lemon was the living proof that the rocket may be unpleasant for short bursts of acceleration, but is not necessarily fatal.

The Future

There are two very interesting possibilities for rocket development:—

(*a*) Atomic Energy. The nuclear processes eject the heavier sub-atomic particles at speeds of several thousands of miles per second. If this could be applied as a rocket exhaust jet, staggering speeds are possible. Just compare say 6,000 miles/sec. with the well-known liquid fuel figures in Table II. Of course the particles are radio-active; and the mass of "fuel" rejected from any fissile material is minute, so mass ratio R will be little better than 1.0. But outside Earth's atmosphere it could mean small rocket accelerations for long periods.

Or

These difficulties could be overcome by using a heat-exchanger system, where the jet would be, say, steam from a mass of water carried as the "fuel".

(*b*) The Ion Rocket. This device, the beloved of science-fiction writers for the past decade, is in fact a remote possibility. The cathode-ray gun, as used, for example, in a television tube, emits electrons in vacuum at speeds approaching the velocity of light (186,000 miles per sec.). This makes even the neutrons from a reactor appear to be in slow motion. Again, the mass of electrons is infinitely smaller than the mass of neutrons.

Interplanetary Flights

Referring back to Fig. III, the importance of this is that the path of any projected body can be calculated with a high degree of accuracy. To reach the Moon, for example, it *is* possible to travel in a straight line at escape velocity, fighting Earth's gravity practically all the way until the weaker Moon's gravity becomes significant. It is much more economical of energy to project the vehicle into an elliptical orbit about the Earth such that the path of flight intersects the Moon's orbit (when the Moon is at that point). That is the vehicle will be in *free fall* under Earth's gravity for the bulk of the journey.

The problem of reaching the planets is similar, if we remember that they, with Earth, are satellites of the Sun. The most economical paths for these journeys are again elliptical orbits around the Sun, such that the ellipse is tangential to both the Earth and the planet concerned.

Interstellar Flights

In our earlier calculations of escape velocity from Earth we ignored Sun's gravity. It should be clear now that 7 miles/sec. will provide escape from Earth but *not* from the solar system. In fact, a calculation similar to our first will show that 10.2 miles/sec. is necessary to achieve interstellar space.

The Martians

Most people will have heard the story recently circulated that a flying saucer crashed in the Arizona desert with the attendant decease of its crew. They were three little men averaging about two feet in height, were of human type, and were alleged to be Martians. Let us examine this story in the cold clear light of mathematical logic.

Let L_1 be the unit of length on any planet whose surface gravitation is g_1

Then mass (volume of matter) $\propto L_1^3$

and weight $\propto L_1^3 g_1$ (from equation (i) $P = mf$)

also area $\propto L_1^2$

$\therefore$ bearing pressure $= \frac{\text{Weight}}{\text{area}} \propto \frac{L_1^3 g_1}{L_1^2} \propto g_1 L_1$

If the average Homo Extra-Terrestrial of similar composition and construction to ourselves is to have a bone structure (e.g. the ankle bone) stressed to the same value as ours, then obviously:—

$g_1 L_1$ is a constant for all ——————————————————— (xiv)

Now L_1 on Earth, say average human height $= 70$ in.

$$\left.\begin{array}{l} g_1 \text{ on Earth } 1.0g \\ \text{and } g_1 \text{ on Mars} = 0.38g \end{array}\right\} \text{(from Table I)}$$

$\therefore$ height of average Homo Martian $= \frac{70 \times 1}{0.38}$ in. (from (xiv))

$\qquad\qquad\qquad\qquad \doteqdot 15\frac{1}{2}$ ft.

Equation (xiv) is the "Law of Extra-Terrestrial Equal Ankle Bone Bearing Pressures" herein proclaimed for the first time and now given freely to the world by the author. This law exposes the saucer story for what it is; a deliberate lie designed to confuse and deceive. Even to the most casual reader it must be perfectly obvious that the little men were *not* Martians from Mars. The discerning reader with one penetrating glance at Table I will discover the truth for himself. The little men were Jovians from Jupiter: or they were extra-Solarians.

Conclusion

This article is no substitute for a textbook on Astronautics.

It is hoped, however, that sufficient has been written in describing the basic facts of matters extra-terrestrial to reduce the happenings of today and tomorrow to a formula within the Sapper's own frame of reference. No secrets have been divulged; the facts are readily available in any library and the calculations involved have been elementary.

The author, resisting the almost overwhelming temptation to philosophize at this stage, will confine himself to one parting but happy thought. It is that the frontiers of Earth, the cause of so much friction and loss to our race, must begin to look rather silly and unimportant when viewed from the frontiers of an infinite and expanding universe, and we have already taken the first firm step in that direction.

Sappers in the Infantry Role

By Major D. L. G. Begbie, M.C., R.E.

Introduction

With the dispersal imposed on an army in conditions of nuclear warfare, it will not be difficult for a resolute enemy to infiltrate between the forward positions. Every unit will therefore have to make a very serious effort to prepare some sort of a defensive position around its harbour area; the infantry can no longer provide a solid front to the enemy behind which the other fighting arms and the services can lead a comparatively protected life. The field squadrons in the brigade groups will be even more intimately involved in the defensive battle. The use of Sappers as infantry is certainly undesirable, though it is not novel. The story of the Airborne Sappers at Arnhem has been written, but it may not be generally remembered that field squadrons were called upon to fight as infantry from time to time in North Africa, frequently at Anzio, and in Burma at Kohima and Imphal. It will be recalled too that all these occasions were in desperate days when gaps in the line were being plugged with whatever was available. This article is a brief study of the Sapper problem when in the infantry role, taking Anzio as an example from which to draw lessons.

Anzio 1944

On the 22nd January, 1944, 6 United States Corps consisting of a British and an American division landed virtually unopposed on the Anzio beaches between Rome and the Gustav Line about Cassino. The intention was to get astride the German communications, but the early surprise achieved was not followed up with sufficient speed. It was not until the 30th January that the Corps, now of four divisions, made its first attack in strength. The Germans had reacted with extraordinary swiftness considering their difficulties of movement under the hazard of almost complete air inferiority. The Allied attack was held by elements of eight enemy divisions which had concentrated around the beach head during the wasted eight days. The British First Division were in a dangerous salient astride the road leading north towards Rome. At this time it became clear that the attackers were now the defenders and that they would be hard-pressed to hold on to the limited ground gained, which extended only to a radius of about six miles from the small port of Anzio.

On the 3rd February, the enemy made their first major attack and drove in the British held salient. The pressure all along the central sectors increased steadily and some very heavy German attacks were made. The enemy deployed much more artillery than they were usually able to muster and even the Luftwaffe returned to the battle, causing a lot of misery and casualties with their anti-personnel butterfly bombs. The most determined effort to drive the Allies into the sea was made on the 16th, when four German divisions supported by 450 guns attacked on a narrow front. The field squadrons had by then already been deployed as infantry. By the end of the month the Germans realized that further attacks would incur more casualties than they could afford and from then on they were content to contain the beach head, harassing its defenders with artillery fire. There had been times when they were nearer a sweeping success than they realized, and in the very heavy battles both the British and American divisions had taken a most severe punishing.

During this month of intense and confused fighting, the field squadrons had been hectically busy. To begin with they were employed on engineer tasks, such as track construction through marshy woodland and route maintenance. As the nature of the battle altered, the work changed to the laying of defensive minefields and the construction of command posts. As the situation worsened the squadrons were put into reserve positions. From these, and without their transport or most of their G1098, they continued to work at engineer tasks whenever they were not required to man their positions. This was exceptionally fatiguing and men needed to be superhuman to carry out both roles at one and the same time. Most of a squadron of the First Division were overrun when holding a position of this kind; they fought well enough but were quite exhausted before the German attack came in. The nature of the engineer work changed too. Everything possible was done to assist the infantry to hold their ground against massed tank and infantry attacks. Barbed wire fences were put up under cover of darkness and protective minefields laid. The standard drills had to be liberally adapted to suit the conditions. The minefields for instance were laid by each sapper carrying forward four mines up to the setting out tape and then very rapidly and quietly laying 4 yds. of minefield 16 yds. deep. The whole party then moved to a flank and repeated the process. If there was any noise, the enemy reacted at once with his mortars or machine guns. Finally there came the worst crisis when the squadrons were nearly 100 per cent in an infantry role, lying low in their positions by day and patrolling and improving the defences by night. Gradually the situation improved and the Sappers were relieved in the line and reverted to their proper role. One of their tasks was to construct a new reserve defence line within the limited confines of the beach head. It was made complete with communication trenches, minefields and barbed wire.

Some episodes from the story of one field squadron can be taken to illustrate the conditions at Anzio during the critical month of February. This squadron was the affiliated squadron of an infantry brigade of the 56th (London) Division. The Division was hurriedly extracted from the battle on the Gustav Line and sent to reinforce the beach head. It had been continuously in action since the landings at Salerno the previous September and had not had an easy time. The advanced brigade landed at Anzio after dark on the 2nd of February. The squadron drove out of the L.S.T.s in its own transport and moved to a wooded harbour area about five miles away. The vehicles were dispersed and camouflaged ready for the dawn, the explosives were taken out of the section vehicles and placed in shallow pits and the men were ordered to dig in. This done, the men were fed and rested in their shell trenches. There was a certain amount of artillery fire from both sides. Meanwhile the officers attended an "O" group to plan the next day's work. Very shortly heavy shelling began and continued for much of the night that remained. Several vehicles were damaged, one catching on fire, and a number of men were killed or wounded; significantly none of them were in trenches at the time. The sergeant-major, a splendid man, was wounded trying to put out the fire and did not rejoin the squadron at Anzio. Altogether it was an unpleasant introduction, particularly as no one had yet seen the area in daylight. The stories that follow took place during the next six weeks.

The first concerns a troop, commanded by a sergeant, which was laying a protective minefield with an infantry standing patrol out just in front. Needless to say in these conditions all the sappers were armed too. A German attack came in and overran the standing patrol. The troop withdrew to its alarm post which was a small house to the rear of the minefield. They were soon surrounded and invited to surrender, a request to which an appropriate cockney retort was given. The Germans then lobbed grenades through the windows and stormed the house. They were beaten off except for a few who got on to the roof with the help of a ladder. A sapper lance-corporal climbed out of a shell-hole in the roof and dispatched these Germans in Dan Dare fashion. The troop held on to the house until dawn when the enemy withdrew and the troop were relieved. Their exploit was retold in formation orders. The second tale concerns a different troop which was holding a forward position at an intersection of some of the deep gullies that abounded on the west flank. One night the troop sergeant failed to make contact over the field telephone with a listening post of two men. The sergeant took out a small patrol down the hundred yards or so of gully to find out what had happened. The telephone cable was cut often enough during the day and night and this could have explained the silence. However on arrival at the post he found one sapper dead and the other unconscious. Whilst extracting them from the trench, the patrol was overpowered. It had been neatly ambushed. Rather ignominiously they were disarmed and led away. Very soon their escort was reduced and, at a cry from the sergeant, the captives overpowered their captors, disarmed them and marched back in high spirits to report to the troop commander, whose position meanwhile was being attacked in the darkness. This deed also was published in formation orders. The next story concerns the third troop. It has a touch of pathos. The troop had struggled day and night for seventy-two hours to construct in a cutting a super underground headquarters of three inter-connecting rooms for brigade headquarters. It had had no previous experience in this sort of work and it proved to be anything but easy as the soil was loose and waterlogged. However, by great efforts and probably with little skill, it was finished on time. Almost simultaneously with its completion being reported, frantic messages were received ordering the troop to get out with all possible speed, abandoning its vehicles if necessary. The Germans had achieved a breakthrough immediately to the left. The troop got out complete, but after so much effort it was galling to think that the only people likely to use the headquarters would be the Germans. The fourth episode appropriately concerns the squadron commander (not the author). The second defensive position taken up by the squadron and held for fourteen days was overlooked by the enemy by day but, by the same token, from the upper floor of the various houses the enemy too could be observed. Hence the house held by squadron headquarters with a troop was also the home of various F.O.O.s All the houses were regularly shelled by the enemy both by day and night by artillery and tank gunfire. Even so they were preferable to living in waterlogged slit trenches outside in the bitterly cold weather, though as a precaution each troop had alternative positions to occupy outside should the houses become untenable. Preceding one of the attacks, the houses were heavily shelled with larger guns. Both the F.C.O.s in the squadron headquarter house were killed together with a sapper subaltern and some others. The squadron commander, although in the same small room, was the only survivor. He could see the Germans forming up in the gully in front of the positions. He tried one of the wireless sets and luckily it was working. Although probably quite unversed in the "target target" procedure, he was able to direct the entire divisional artillery on to the target with devastating effect. Not one German came within small arms range of the squadron positions. Though the circumstances were tragic, this achievement in gunnery was both unusual and exhilarating for a Sapper! The last story will not be believed and never has been. On the 10th March the squadron with its parent brigade were relieved by a brigade group of a division new to the beach head. The depleted and exhausted brigade was to be withdrawn from Anzio to rest and refit. The squadron had to leave all its vehicles and G1098 to its successors. The night before the handover all the G1098 was laid out as if for an administrative inspection and covered over with tarpaulins. During the night the harbour area was bombed, the explosives blew up and most of the stores were buried. Thus any deficiencies were accounted for as an act of war, true but incredible to some!

Lessons from Anzio

The lessons learned from these six weeks were many. Perhaps these were the most important:—

(*a*) Field squadrons cannot effectively or fairly be expected to both fight as infantry and carry out engineer tasks at the same time.

(*b*) Field squadrons must be thoroughly trained in infantry defensive warfare. This training should include:—

Relief in the line.
All types of patrolling.
Preparation of a fire plan and its use.
Protective wiring and minefields.
Life in the line including sentries, sleeping, eating, cooking, care of weapons, listening posts, shellreps, mortreps, sanitation, etc.
Fieldcraft.
Weapon training in active service, not only range, conditions.

(*c*) A squadron is normally only committed to the infantry role in an emergency. Therefore there is little, if any, time for reconnaissance or for the full relief in the line drill. Standing orders for war must include:—

Detail of those going into the line.
Allocation of anti-tank and other weapons, ammunition and entrenching tools.
Provision for manpack wireless (the squadron is at least one set short on its G1098).
Provision for smoke (the squadron has no 2-in. mortars).
Reporting of vehicles and drivers to brigade B echelon.

(*d*) Security of the work in forward areas should be introduced into all training. Sappers cannot rely on the infantry to give them complete protection. The action to be taken on enemy attack and the selection of alarm posts must be thought out beforehand. It is advisable to guard the alarm post as a firm base from the beginning; it may sometimes also conveniently be the stores dump, transport area and medical post.

(*e*) In a battle of this type, nearly all engineer work is done by night. It can only be done quickly and well by training in similar conditions.

(*f*) Minelaying drills must be adaptable to meet unusual circumstances.

(*g*) When the infantry are driven really hard, the Sappers must step in and help them with tasks which, by the book, are infantry responsibilities, such as protective wiring and minefields.

(*h*) When working on engineer tasks in such close proximity to the enemy, speed and silence are essential. Everyone must know their job and orders be reduced to a minimum. The most meticulous care must be taken with the preparation of stores. For wiring tasks the coils must be loosened and ends marked, the pickets must be separated and the striking end marked with tape or paint, light monkeys provided for driving the pickets quickly, etc. For mining tasks, the setting out must be simple and quick, the mines taken from their crates clear of the task, fuses put in, etc. If any vehicles can get up to or near the site, it is best to use troop transport with well tried drivers.

(*j*) Everyone should have a basic knowledge of first aid, including the ability to apply field and shell dressings and to improvise splints and stretchers.

(*k*) Even when casualties are very heavy, it is most unwise to reinforce the troops in the line by taking drivers away from their vehicles. They are not usually properly trained as fighting soldiers, though no doubt in theory they should be, and if they become casualties the squadron is partly grounded when it resumes its proper role.

(*l*) Commanders at all levels must take proper rest. It should be exceptional for both the squadron commander and his 2I.C. or for both the troop commander and his sergeant to be on duty at the same time. If this principle is not applied, all the leaders in the squadron may be exhausted at the very moment of crisis. As a rule therefore it is quite wrong that an officer should be woken up when he is off duty and his second-in-command is present.

(*m*) Lastly, Sappers are very capable of defending themselves with credit. With their experience of field engineering and tradesmen they are able to make defences giving very good protection and at the same time use Sapper cunning to ensnare the enemy with devices such as booby-traps, mine necklaces and impenetrable fences.

The Future

The field squadron in a brigade group may be faced with two problems in the defence. First, when the brigade is holding a bastion type position in the defence on a wide front, the field squadron will probably be harboured at the rear of the brigade. It will have to prepare emergency defensive positions around its harbour area where most of its vehicles will probably be. So long as a field squadron is to be employed to its full capacity on engineer work, it is unable to shed more than one or two vehicles of B echelon. In this respect it differs very markedly from a unit of any other fighting arm. The second problem is when the squadron, as a last resort, has to take over an infantry role. This can happen in two ways, with prior warning as part of the defence plan or in extreme emergency with little or no warning. The first situation may arise when, as part of the plan, it is ordered that the field squadron takes over the defence of all or part of the rear battalion's position if the latter has to put in a brigade counter-attack. The second situation arises when, as at Anzio, there is a gap within the defended locality, or bastion, which must be plugged at once. The transport has to be sent back with its drivers and the squadron reorganized as a rifle company but with only three platoons. If an existing rifle company position is to be taken over, the question of numbers is a major problem both as regards the lack of one platoon and because, unless care is taken, the troop will move up with more men than there are prepared positions and unnecessary casualties may result.

Conclusion

Field squadrons are likely to have to fight from time to time as infantry in a future war and to do this successfully considerable study and practice are necessary. It is doubtful whether at the present time sufficient emphasis is given to this subject in training. There is a very sound principle that engineers should not be employed on tasks that are within the capabilities of others, unless they happen to have nothing more appropriate to do. The immensity of the engineer tasks in a nuclear war make this contingency unlikely. Nevertheless a proper balance between the various subjects covered in the training year is required and the study of the possible infantry role deserves a place.

Desantniki

By Perevodchik

One of the reasons why I volunteered to banish myself to the wilderness and learn Russian was a desire to know exactly how and what the formidable men behind the iron curtain do and say. I hope that this article may be of interest to others who would also like to know.

I have chosen an article by a Lieut.-Colonel A. Kolgushkin, which appeared in the Soviet army newspaper *Krasnaya Zvezda* (The Red Star) on the 15th November, 1957. The Russians were the first to form parachute units,[1] yet, strangely enough, little was seen of them in the last war. However, they consider that in the future airborne forces will play a prominent part in the enemy's rear during a break-through.

The fact that no large-scale Russian airborne operation took place during the last war is no reason to discount their present-day value. To do so would be foolhardy and dangerous. The Germans underrated the Russians and paid dearly.

Let the Soviet colonel speak first. I have kept to the Russian as faithfully as possible. The rather stilted style and repetition cannot be avoided. They are typical of any modern Soviet article and this is much better than most.

Thoughts on Constructive Thinking as Opposed to Drill Book Methods in Parachute Operations

The defensive position has been penetrated. The attackers strengthen the assault and cut off the "enemy" fire positions which have survived. The pursuit is organized and an attempt made to break through to the river as quickly as possible without giving the "enemy" a chance to construct a new defensive position on it. But the "enemy" on his part is not asleep. He brings his

[1]Large scale airborne manoeuvres were first held in the Soviet Union in 1936. A platoon was dropped by parachute on exercises in 1930.

reserves up to the river, and with the help of heavy engineering plant hurriedly constructs trenches and fire positions on the northern bank of the river.

The attacking forces decide to deliver an atomic strike on the "enemy" concentration area and to drop a parachute force to capture crossings and cut the withdrawal routes of the retreating "enemy" subunits.[1]

The plan is put into force and an atomic explosion simulated on the northern bank of the river.

The attackers' aeroplanes soon appear overhead. They achieve local air superiority and bomb the anti-aircraft guns which could oppose the parachute drop. The transport aircraft follow and the parachute force together with heavy weapons, anti-tank guns and ammunition is dropped in the area of the atomic explosion.

At the same time the "enemy" has taken steps to counter the parachute threat. The area of the atomic explosion has given the commander of the defending subunit, Major Zayetsev, an idea as to where the drop will take place. This officer, using his initiative, immediately begins to move his subunits towards the threatened area.

When the parachute troops appear in the sky the defenders' tanks are already approaching the DZ and, deploying into battle formation, attack the parachute force as it lands.

The parachutists are in a sticky position. They immediately bring their anti-tank guns into action and use grenades to beat off the tank attack.[2] The subunits under the command of officers[3] Reshetov and Kozlov and the gun detachment under Sergeant Pershin in particular act with great vigour. Immediately after landing the parachutists seek out the packs containing their heavy weapons, take up their fire position on the DZ, and themselves open fire before the "enemy". But their brave action would not have met with success if they had not been carefully and correctly organized and trained to co-operate intimately with the airforce and artillery.

Why did it happen that the landing force was threatened with destruction immediately after the drop? We must examine some general factors. Small parachute forces are employed tactically to capture and hold bridgeheads in order to disrupt the cohesion of the enemy's defence, to help the operations of other troops in the main land battle and to carry out a series of operations aimed at disorganizing the enemy's command and control of his own troops.

A parachute drop to form a bridgehead immediately after an atomic explosion is an operation generally recommended "by the book". But if this is done as a matter of course then the enemy will quickly find and use effective countermeasures.

A parachute drop in the area of an atomic explosion, carried out "according to the book", can itself invite a counter atomic strike or other equally dangerous countermeasures in this particular area immediately after the drop.

In the case quoted the attackers acted "according to the book". Their actions were quickly foreseen by the "enemy" who took steps in advance to

[1]All units smaller than and including battalions are called subunits in the Soviet Army. The Soviet regiment is the only *unit* as such, larger units being called formations as in the British Army.

[2]The word grenade is not clear as it can mean rocket launcher bombs, anti-tank grenades or a cluster of several hand grenades which are sometimes used against tanks.

[3]The Russians, in written articles frequently refer to officers up to battalion commander inclusive as officer "so and so" rather than by rank.

destroy the parachute force. They could however have acted in other ways. In order to deceive the "enemy" the atomic strike could have been delivered in one area and the landing force dropped in another. There are, of course, many other variations. If the methods of operation are varied it is more difficult for the enemy to guess the attacking side's intentions and in this case it would have made the task of the parachutists considerably easier. The lesson learnt was not forgotten. To avoid a similar situation arising in the near future the commander of the parachute force, officer Galushkin, ordered the capture of the bridgehead to be accelerated, and the most vulnerable approaches to be mined. An hour and a half after the drop, having mopped up the "enemy" subunits who had survived the atomic explosion, the parachutists consolidated their position in the bridgehead, dug themselves in and made out a fire plan. They did not however succeed in capturing the bridge over the river. This had already been blown by the "enemy". Using his initiative in accomplishing his mission, the commander carried out an engineer reconnaissance of the river and found and marked out a suitable crossing point. The presence of a parachute force in possession of a bridgehead cannot help but worry the enemy and they will make determined efforts to destroy it and will bring up armoured forces from "in reserve" to do this.

A determined armoured attack developed one hour and fifty minutes after the landing. The landing force was cut in two and pinned back to the river. A critical situation arose but the commander never lost his head.

Contacting the main land forces by wireless he gave the co-ordinates for direct air and artillery support. Simultaneously he moved his sappers forward and ordered them to mine the "enemy" approach routes. Coming on to the mines the "enemy" tanks began to act with more caution and the momentum of the attack decreased. The parachutists took advantage of this to establish an effective system of co-operation between the subunits which had been cut off.

The "enemy" realized that any delay in the attack would be to the attackers' advantage and quickly started to organize another assault. But it was too late. Amphibious A.F.V.s of a land reconnaissance party had already made contact with the parachute troops. Directly behind them the leading infantry units entered the bridgehead. Once the junction had been made their combined efforts forced the "enemy" to withdraw.

This example shows that efficient co-operation between the parachute force, the troops engaged in the main battle, and the supporting artillery and air force is an essential factor of success. If this co-operation does not exist then a modern enemy with a considerable number of tanks and motorized subunits at his disposal can put in a strong counter attack immediately after the drop. Hence it is quite clear that the chances of a parachute force continuing the battle with superior, mainly armoured, forces are very limited and they can only hope to hold out for a few hours. Thus it is essential to determine the time by which land forces must effect a junction before a parachute force is dropped. Any extension of this period can lead to their destruction and the loss of the bridgehead they have captured. Of no less importance is the ability of the parachute force to take on enemy tanks. Experience shows that such a force will always feel the lack of men and equipment. They can only compensate for these deficiencies by increased mobility and by exhibiting a high standard of organization and initiative in operations.

Russian parachutists or desantniki as they are often called on exercise. Note the characteristic parachute helmet and overalls. The weapon carried seems very similar to the 7.62 mm. Kalashnikov sub machine gun.

Desantnik

Quite apart from capturing bridgeheads as has already been mentioned, parachute subunits can also operate in the enemy's rear to destroy important targets. In this role parachutists must show a very high degree of initiative, resourcefulness and daring, they must be very fit physically, have a knowledge of the enemy's language, and know how to use his weapons and equipment. The parachutists must be able to drive the enemy's vehicles, operate his wireless sets and be adept in the art of Sambo.[1]

Not long ago on a training exercise a force was dropped for a night operation in the "enemy's" rear. It descended on headquarters, captured signals centres, mined roads and bridges, and took individual soldiers prisoner. For several hours it so confounded the "enemy" that they were forced to deploy armoured units to sweep the area.

Quite apart from an exceptional standard of military training and knowledge, operations in these circumstances demand that a man must not lose his self control even in the most difficult situation . . .

(Some thrilling tales of dangerous jumps with crossed rigging lines, intertwined parachutes and so on follow. They are not however relevant to this article and as the reader may already have passed on to another article they are not translated.)

Comments

There are several comments I would like to make and these of course are my personal views.

In reading any Russian military article one is always struck by their *naïveté*. This must be a result of the general lack of intellect and low standard of education of the ordinary man.

Airborne troops are the élite of the Soviet Army and are of very much better quality and education than the ordinary soldier. It is obvious that a very high standard of training is required of them. In particular the attention they pay to a good knowledge of the enemy—his language, equipment and weapons—is worthy of note.

In most military articles the Russians repeatedly emphasize initiative and co-operation. This continual repetition indicates that these are two weak characteristics of Soviet troops. One has only to read Soviet publications to realize to what great detail everything is "written in the book". Political indoctrination further imposes a system of uniformity on one and all. There is little scope for personality or initiative.

The Russians stress the importance of field engineering and all infantrymen must have a sound basic knowledge of this. The division has its sapper battalion and the regiment its sapper company, in both cases an integral part of the formation or unit. In many cases it would appear that the battalion has an integral sapper platoon. Higher up the scale there are the engineer groups containing specialized units. At the lower level the sapper is used to construct temporary obstacles and lay mines even in the face of a direct attack. They have little regard for the safety of their own troops as far as scattered minelaying is concerned! The Russian is very good at improvisation; his sappers get far more practice in the use of local materials and do not depend to the same extent, as we in the West, on engineering equipment

[1]Sambo is the Russian abbreviation for self defence without arms and involves jujitsu and unarmed combat drills.

and prepared materials. It is a characteristic which will often give them the advantage of surprise if it is not fully appreciated.

Finally a word on training. The Russian is very much a twenty-four-hour day, seven-day week soldier. Before his national service he receives military training in a youth organization (D.O.S.A.A.F.) and after his period of colour service he is placed on the reserve until too old for military service. In theory he also receives training whilst on the reserve.

Welfare in the Soviet Army does not imply regular leave, weekends, family considerations, and N.A.A.F.I./E.F.I., etc., to the same extent as in the British Army. No doubt as their standard of living rises the more attention will they pay to welfare as such. At present this is not so. The Russian soldier appears to accept his service with equanimity as a debt he owes to the Motherland. His officers are a privileged class much better paid than most other classes. This the Russian soldier considers right and proper. "After all," he says, "the wretched officer must serve for twenty-five years. Am I not lucky indeed? I have only to endure between three and four years."

This article indicates a very high standard of training. The parachute force, presumably a battalion group, beat off tanks as they land, ninety minutes after the drop they have mopped up, consolidated and carried out an engineer reconnaissance, twenty minutes later they repel a deliberate armoured attack and are preparing for another. A crowded hour of glory indeed. It is, I know, only an exercise but on the whole their exercises seem to be made as realistic as possible. Furthermore they have larger and better training areas at their disposal than we in England.

Let us not overestimate the Russian, none the less we certainly cannot afford to underestimate him. He is tough, well trained, and well equipped; however, he may tend to react less readily in a situation where a set plan goes awry.

Thirty Days

By Major J. D. Townsend-Rose, M.C., R.E.

Author's Note

We read quite enough papers written in military style, and I have deliberately avoided the use of military format, clichés and abbreviations. This is an account of a month's training in Desert Warfare, written in narrative form, but with a number of military lessons introduced into it. I hope it may serve to revive memories of those who have been in the Desert in the past, and assist those likely to go there in the future. There will soon be no Sapper units stationed in Desert countries, and it will be serious for the Army as a whole if the technique of Desert Warfare is lost to us.

Nearer forty days, if you count the sea journey from Cyprus each way, but thirty days in the Desert, thirty days of uninterrupted training under conditions as near operational as is possible in these days of hawk-eyed Command Secretaries. Plenty of time to plan for it, too—it was postponed from August, 1956, to May-June, 1957, and even a recce was possible, made in June, 1956.

Preliminary Planning

Our aim was to learn to live, move and fight and do Engineer work in Desert conditions in War. None of us had ever served in the Desert before of course. That would have made it too easy. Not even the C.O., and he wisely dodged the issue, ". . . Training Programme will be the responsibility of O.C. 40 Field Squadron." The Military Pamphlet wasn't particularly helpful though it informed us with much gravity that water would be scarce and sand plentiful. So we read and re-read the exploits of such wartime figures as Popski, Fitzroy McLean, Kippenburger, Rommel and many others, reading between the lines, and above and behind them, trying to find out how to live and move and fight in such inhospitable country.

Nowadays a Field Squadron is more likely to be independent than it has been of late. We were to be directly under command of C.E. Libya, and were to be reinforced by a troop from 34 Field Squadron, with its two officers; the Regimental Signals Officer; a Q.M.S.I. driver-operator; a water-point with Paterson trailer; a Scammell and Size II dozer and the incomparable Mechanical Minelayer from the Field Park (also with an officer); three V.Ms. from the L.A.D.; a Radio Mechanic from Nan Troop (November Troop to the meticulous); and last, but by no means least, the Regimental Medical Officer.

On arrival in Tripoli, we were to get an ambulance and a recovery Scammel. Our final strength was thus to be ten officers (including the Doctor), ten Warrant Officers and Sergeants, 245 Other Ranks with 53 trucks, excluding motor-cycles and trailers. As events showed, we only needed an Infantry Workshop, an Ordnance Field Park, a Supply Platoon and a Field Cash Office under command to be completely independent.

Before going ahead with any of the planning, we wrote the Training Programme in outline, and it came out like this:—

Individual training in Sun Compass, debogging, map-reading, camouflage, truck-cooking	3 days
Long convoy journey by troops	6 days
Day and night foot patrols (inter-troop battle)	2 days
Minewarfare	4 days
Track-making and demolitions	2 days
War fitness test	5 days
Settling in	2 days
Settling out again	2 days
	26 days

This left four days for rest, re-fit and recreation and seemed about right, so we started asking for things. It's amazing how kind people are if you ask nicely, and we wrote to "Q" (Ops.) for "authority for issue in excess of scale" of Charguls, thermos flasks, bivouac tents (comfort first), sand channels, tow ropes and so on. They agreed that all this was essential, and we got it all.

We wrote to Tripoli to ask for the use of training areas, explosives, dummy mines, Pay, N.A.A.F.I. and A.K.C. facilities, the loan of ambulance and Scammell, permission to use Desert Wells, Workshops and Ordnance Stores, and all was granted.

We drew 5,000 compo rations which we took with us (1,000 just fill a tipper), and we took a truckload of tables and chairs; we sent a man to learn how to operate A.K.C. projectors and we explored the nearby Army Field Survey Depot for maps. We designed, and the Field Park made, carriers to fit on to Champs and Rovers, to take extra jerricans.

So far, most of the work was done in Squadron Headquarters, thinking, writing, reckoning and designing and we felt it time for some of the others to get working.

Tony ran a refresher course for all wireless operators; Derek mastered the art of the Sun Compass and taught all officers and sergeants; David got together a library, both technical and fiction; John planned the Officers' Mess stores and stocks; two troop sergeants worked out a list of stores needed to set up a water-point (given certain conditions and requirements) and Brian got the stores together.

We started preliminary training—basic minewarfare; hygiene lectures and films; we even managed to get the old film *Desert Victory*, which was shown to everyone. Three of the four troops marched across Cyprus at its widest part, from sea-level to over 6,000 ft., and down again, by sections; the best time being some thirty hours spread over six days. Each man began to feel that he belonged to the best section in the best troop in the best squadron in the best regiment, and chests swelled visibly through both pride and fitness.

We soon learnt that one L.S.T. would not carry us all, and that two would be needed, and so work started on staff tables; there were many details to be tied up on our arrival in Tripoli, so most of Squadron H.Q. were to go in the first ship. We went to Famagusta to look at an L.S.T., talk to Movements and find a Staging Area.

The Move to Tripoli

At last (or perhaps too soon), the week of our departure arrived and everywhere was bustle, collecting last-minute stores, clothing, M.T. spares, distilled water; loading watercans, camouflage nets, G 1098 stores; storing beds, wardrobes, tables and fans; checking wireless sets, pumps, mine detectors and pressure lamps; and having farewell parties. The days fled by and at one o'clock on Friday, 3rd May, the Squadron with its fifty odd trucks left camp. Quite a send-off party at the gate, and all looked very spick and span; each troop with its trucks at 50 yards spacing, some three minutes between the troops; wireless sets on, convoy flags and pennants on officers' Champs flying bravely.

The doctor's truck broke down first, after half-a-mile. Another mile, and one of the 21-year-old Morris compressors was at the roadside, bonnet open. As usual, too, the office wagon (she is too stately to be a mere truck), had to pause for breath, but the whole Squadron arrived at the port, 75 miles away, by evening, and we pitched our tents in a field.

Loading was comparatively uneventful, though the ramp up on to the top deck was alarming—a slope of 3 in 1. Small trucks went on the top deck and 3-tonners below; there was trouble loading the Scammell, trailer and dozer, and it took a long time reversing the load into position.

One ship couldn't get a berth end-on to the quay, so we had to drive on to a Z-craft, and then reverse from it to the L.S.T. This sounds difficult, and so it would be with any sea running, but inside the harbour it proved quite simple; intelligent adjustment of the two ships' ramps made the use of a pile of packing unnecessary.

There's only room for about 75 men below decks in berths, and the remainder slept on deck on stretchers—when it rained many of them rigged up bivouac tents, others cocooned themselves in the new ponchos, but the trucks got covered in spray and needed washing down with fresh water when we landed.

For the first day the sea was flat and the sun shone, and spirits were high, but then a slight swell started, and the L.S.Ts. would roll. Coffin-like, they are alleged to be uncapsizable, but even a small swell gave us fifteen degrees roll each way. The chains lashing the trucks down "worked" and all had to be tightened; stomachs "worked" too, and there were a lot of green faces.

But it didn't last long, and the five-day voyage ended happily; tombola and shooting over the stern at balloons (thoughtfully provided by the Doctor) kept us amused, and we landed without mishap in Tripoli, staging in a small emergency camp just outside the town.

The next day was a very busy one, fixing administrative arrangements, and also a very sad one, for Sapper Bannon had a stroke and died before reaching hospital. It was so sudden that he suffered not at all, fortunately, but the Squadron's high spirits were brought down with a bump, and the superstitious ones were convinced we were in for a run of bad luck; they were proved wrong.

The following day, a Saturday, the first ship-load moved inland to Tarhuna, a little Italian settlement, some fifty-five miles from Tripoli, into a barracks built by the Italians, destroyed by Arabs and partly re-habilitated by the British Libyan Garrison; the second L.S.T. only arrived on the Sunday and they moved straight to Tarhuna to join in the training that had already started.

Desert Recce

It is almost impossible to write training exercises from maps which say "detail taken from Italian 1: 400,000 maps, provisional edition, undated". There were no contours marked, not even spot heights, and roads and tracks built by the Italians in the twenties are not necessarily passable today. So, while the first few days' training was in progress under troop commanders, a managerial reconnaissance was carried out; the O.C's. Champ and the Signals Officer in a land rover taking part, loaded with food and water for six days, petrol for 650 miles and a wireless set. The total distance covered was in fact 550 miles, in three days, and the trip provided a lot of basic knowledge to be passed on to the men in due course.

First port of call was the Gebel Hotel, Garian, for breakfast on Saturday and then the Police Station at Mizda, a hundred miles inland, to arrange a staging post where we were going to set up the water-point, a wireless set and a petrol dump. The Police Captain was most helpful; we drank his coffee, agreed on a site, cooked our lunch and moved on southwards.

After skirting the old minefield and after some alarming moments in the sand-dunes in the Wadi Soffegin, we had quite good going along a very indistinct track for about fifty miles, and it was perfectly clear that we were lost. For the first hundred miles the sky had been clear and the sun brilliant, but now he only favoured us with an occasional glimpse and the sun compass showed us each time that we weren't on the track we were trying to follow.

Now, if you are lost in London you ask a policeman; you may well think that is impossible in the desert, yet it is just what we did. A dust cloud on the horizon approached and materialized into a police truck, bearing a sergeant who assured us that we were on the right road. It was obvious that this particular track was not marked on the map—it may well have been formed since the original map was printed.

Another fifteen miles took us up an escarpment on to the Hamada-el-Homra, a vast flat plain of hard sand, on which lies a thin layer of sharp stones up to the size of your fist. And there was the Police Post the sergeant had been visiting; a tent, a truck and a wireless set, with a few men guarding a pile of twisted aluminium; so we stopped again to ask the way and pass the time of day.

They asked us if we had rifles and bren guns because they wanted to go gazelle-hunting with us. (Libyan law prohibits gazelle-shooting, but perhaps the police consider the desert has rules of its own.) We had none, so we gave them some of the military version of fresh meat, and they started explaining the route to us. It took some time in Arabic, Italian and stunted English, but came out like this: "You see those wheel tracks? Follow them for twenty kilometres till you come to a jerrican. Then bear right and follow the camel tracks for a further eighty kilometres and there you'll find Bir-el-Khor."

On this kind of desert, trucks and camels alike press the stones into the sand and leave a slight track. We set off at about forty miles an hour, and sure enough the jerrican appeared—visible at about two miles' distance. By this time, it was late afternoon and there was still a lot of mirage; the shallow depressions that occurred every few miles looked like oases of palm trees, though the scrub bushes were really only 2–3 ft. high.

There were plenty of gazelle about—graceful, slender creatures which seem to move in a hop, skip and jump fashion; they were usually disturbed when our trucks were about half a mile away, and a Champ going at 55 miles an hour was unable to catch up with them.

Our map showed that Bir-el-Khor was only some eighty kilometres, all told, from the Police Post, so although the distance to the jerrican was found to be correct, we had forgiven the police for their error; but after the appropriate distance, no sign of the well. It was then time to stop and try to get in touch with Squadron Headquarters, so we got the cooker going, put up the wireless aerial and switched on the 19 set.

Promptly at seven o'clock we heard the tuning call "Golf X-ray, Golf X-ray, Golf X-ray". And we were "through" to Tarhuna, about 170 miles away, so our disappointment at not finding the well was offset by knowing we were in contact with the outside world. We gave our approximate position, heard the news of the Squadron move to Tarhuna, and settled down to our steak and kidney, "rich fruit pudding" (enhanced by a spoonful of whisky) and a can of beer each.

As we made up our beds, an inspection lamp throwing shadows into the apparently endless desert, a fierce cold wind suddenly came on us from the south bearing quantities of sand. We were caught napping for the sand got everywhere, especially in the open butter and jam tins, even though they were inside a box in a closed truck.

Next morning at dawn we rose, breakfasted and loaded up. We decided to continue following the camel tracks, and after a few miles the well hove in sight—just another, but slightly bigger, depression, with a stone marking pillar and the well-head. We estimated the water-level to be about 250 ft. below ground. Photographs, recognition marks made in the sand, and we were off again. The sky was clear and we went off by sun compass on a bearing almost due east. In another forty miles we had crossed the northern part of the Hamada and were among winding wadis; once again we realized the limitations of a sun compass, as it was impossible to keep on course for more than a few hundred yards. So we followed the wadi in the right general direction, navigating as we went (0.8 miles at 40 degrees; 0.3 miles at 80 degrees; 0.6 miles at 115 degrees, and so on), by dead reckoning.

The first signs of life were a few camels grazing among the scrub, and we almost crossed the "road" we were looking for without noticing it. The wadi here was about half a mile wide, with sand dunes in the middle, good going on either side and scaleable banks.

Later checking of our position on the road, together with calculations as a result of the morning's navigation, showed that the position of Bir-el-Khor is wrongly shown on the map; the police had been right after all.

Then followed a tedious afternoon's drive up this road, which had not been repaired since the days of Italian occupation, relieved only by a visit to a Police post to warn of the future visits by the field troops, and an inspection of the ground where Popski fought one of his battles, described in his book, on the "upper reaches" of the wadi Zem-Zem.

That night our drill was repeated, but we were ready for the sandstorm, and the following day brought us back to Tarhuna, mostly over roads and tracks. But we passed some interesting sites; the three wells of Bir Dereder, where the water table was only 15 ft. down, and the single (but much older) well of Bir Sedeena, about five miles away, where the water was 150 ft. down. Also a number of ruined Roman fortified farmhouses; no grain there now, but there obviously had been many years ago. On the top of a low hill, a ruined Roman Mausoleum, which from afar looks the size of Westminster's Victoria Tower, but proved to be about twelve feet high.

Individual Training

Individual training had, of course, started by the time we got back, and there was an air of great activity. Brian was briefed on setting up the water point and set off next day for Mizda. Trucks went daily to Tripoli to fetch petrol, rations and spare parts, newspapers, mail and stores, and to take men who had a day off to enjoy such flesh-pots as there are.

The training programme went off according to plan, with a few minor alterations, and the preliminary work put in before we went proved very worth while.

Long Convoy Journey by Troops

Each troop in turn followed the route we had taken, but taking six days over it; they called twice at Mizda for re-fuelling and water; the water-point was rigged with showers, which were very popular. Only one of the four troops found Bir-el-Khor, which was disappointing, and one troop tried to follow a camel track marked on the map to take a short cut; this led into a maze of wadis, and they couldn't get down off the escarpment, so they paid for the attempted cheating with some 200 extra miles of motoring.

Breakdowns were by no means uncommon, and petrol vaporization was frequent; but in spite of the country covered, the sand channels religiously carried by every truck were practically never used—towing or winching was quicker and more effective. The dust got into brakes, and was so fine that it acted as a lubricant rather than an abrasive, so that the brakes became very weak. Track rods of tippers proved weak; we bent four, mostly when the truck was being towed through sand. Some makes of tyres were torn to shreds by the rocky surface, others weathered the rough going well; cross country tyres were worse than road tyres in this respect, blow-outs occurred and altogether the Squadron used up about twenty tyres.

Those trucks without filters in the petrol tank suffered fuel stoppages, for the petrol we used had been stored in cans for some time. Scout cars, as expected, bogged down frequently, brake-bands for the bottom two gears required frequent adjustment; and the dust, mixed with oil vapour, clogged the radiator, causing overheating.

The value of motor cycles varied greatly—some kinds of going made them slower than a three-tonner, but then the face of the desert changed, and they were most useful. We should have had brackets on the back of some trucks to carry motor cycles in an emergency.

It was an interesting trip for the officers and sergeants who were navigating and organizing; tiring for the drivers and boring for the men in the back. But all senior N.C.Os. had some driving experience (giving the regular drivers a rest), open formations and flag signals were practised, and everyone saw the various different kinds of terrain, and there was no lack of stories to be exchanged on their return. Apart from breakdowns, there was but one accident; one truck following in another's dust-cloud (and the driver had been told about "dust-distance") swerved when the driver realized how close he was, and the inevitable Sapper Bloggs, *standing* on the tail-board, was thrown to the ground. He paid in pain for his contravention of orders, but his ribs healed quickly, and he was soon back at work.

At about the same time, another man, in barracks, became a casualty, while refilling a petrol-sand fire *inside* the barrack room! He was boiling his socks in a mess-tin, a praiseworthy pursuit, but recklessly executed, and he, too, suffered for his sins; his burns took longer to heal.

Day and Night Foot Patrols (Inter-troop Battle)

For this two-day exercise, two troops set off along the road leading south from Tarhuna, and after some forty miles, turned off right and left respectively. The road became a frontier between two opposing forces, the "Israbs" and the "Araelis", and patrols were sent out to determine the enemy dispositions. Listening posts were set up, and everyone had a long spell on his own at an O.P., and at least one longish patrol on foot. Each troop was in touch with Squadron Headquarters by wireless, but they had different Slidex codes, so that they could report their locations, casualties and so on, without compromise, although they were both on the same net.

This exercise was probably too short, but its aims, to give each man experience of being on his own in the desert, and to give N.C.Os. experience in leading foot patrols in featureless country, were achieved.

These two parts of the training, long convoy run and inter-troop battle, were being run concurrently; at the same time, two teams, each consisting of a dozer and a compressor and five men, were working from each end of the track to be built in the next stage of the programme; and the water-point at Mizda was still in operation. There were thus seven separate sub-units of the squadron all working at the same time. Communications were severely stretched, but this was deliberate, and we felt we were extended as much as possible without losing control. A daily visit to the Israbs and Araelis, twice daily to the dozer teams, every other day to the water-point, and daily to Tripoli for supplies, stores and amenities, was about as much as Squadron Headquarters could manage. Outstations on the squadron net were the four troops (two of which had two sets each), the water-point, O.C's. Rover and occasionally another Rover (2I.C. or Signals Officer), sometimes skywave and sometimes groundwave. Tony's recent R.S.I. course was invaluable and his services to the squadron showed that the way to use a Regimental Signals Officer is to attach him to squadrons in turn while they are out on such training.

Minewarfare, Track-making and Demolitions

The pace was now increasing, and for the next eight days deliberate difficulties were made for the field troops. Night work, no lights, fresh rations instead of Compo, transport restrictions, continuous wireless watch, and so on. Each troop laid a minefield of 600 mines, partly by day and partly by night; gapped another field by day and night and finally lifted their own field.

The Mechanical Minelayer worked quite well in some kinds of ground, but was extremely difficult to use at night. It is really only worth while if the mine strips are at least 600 yards long, otherwise too much time is wasted changing over truck loads of mines. It used up all our shear-pins even though we used the truck engine to help. We tried without the shear-pin altogether, and pulled the towing-eyes off the front of a tipper, but they were welded on again next day. It was at this time that the track-rods buckled when pulling through soft sand; they would have been straightened in the portable forge had we been able to get coke or charcoal.

The route for the track was recced by Brian in a Land Rover and on foot. It was about eight miles long and each troop had two days on it. The problem was to provide a track to get a Regiment of medium guns to a certain place, to keep them supplied with ammunition, using three-tonners for about three weeks; single track width with passing-places every 300 yards. Much of the work was plain dozing, filling in small wadis, but there were a few side-hill cuts needing explosive, and one or two places where manual work was needed to get the dozer across, so that it could work efficiently.

There were not sufficient materials to culvert all the wadis, so our track will be washed out when the rains come, but each troop made at least one culvert, using old sheet-metal chimney stacks from derelict camps. Wind-blown sand was one of the chief problems and during a minor gale the track was blocked by small sand-dunes, which gave everyone an insight into the difficulties of track-maintenance.

Visits

It was not to be supposed that we would not be made an excuse for other people "swanning". Jim came to see us, chiefly to see the fourth troop, which was from his squadron, and we took him down to Mizda to see his men there. Later the new C.O. came to see us. He had had no part in the initial planning, as he only arrived in the Regiment a fortnight or so before we left. He took great interest in our activities, and had many decided views on various aspects. To ensure that the training went on the lines he wanted, he wrote a long questionnaire to be answered by the umpires on the War Fitness Test (which we had sight of), and many small items were put into the training programme so that the answers to this questionnaire should show the squadron in good light.

The new Chief-of-Staff at G.H.Q., M.E.L.F. came through Tripoli on his way to Cyprus, and called to see us at Tarhuna. He made a quick tour of the barracks, had a mug of tea and left soon after. The purpose of his visit was to see the barracks, but as an ex-Sapper, he showed great interest in what we were doing.

As one of the Chief Engineer's staff, Harry came to see us on his way through, preparing our fitness-for-war test, and we were to see much more of him later, during that exercise.

Fitness-for-War Test

This rather strange terminology has its origins in the report of a senior officer who wrote some years ago of a certain unit "Through no fault of its Commanding Officer this unit is not at present fit for war." The expression must have taken the fancy of G.H.Q., M.E.L.F., for it is now frequently used, and properly applied, as ours was, such a test can be very effective.

In the test, every officer of the unit is "umpired" by another officer, usually of superior rank, from another unit. The unit being tested knows nothing of the form of the exercise other than the preliminary narrative, and the umpires are present at all activities from the initial "O" Group right through to the execution of the tasks.

For our test, a recurrent fever sent the O.C. to hospital for the first two days, which threw a very heavy load on the 2I.C. The squadron was dispatched on a mission of "intervention between two small sheikhdoms who are in dispute with each other over oil concessions". They left Tarhuna by night and during the four days of the exercise were tested in minelaying and lifting, desert navigation, harbour drill, convoy drill, battle drill, administration in the field; their reactions to air attack (by Vampires), ambush, night-attack and fatigue; communications, hygiene, feeding, welfare and the efficiency of the M.T. were all carefully examined by the umpires, and a consolidated report by C.E. Libya, the Chief Umpire, was finally made to the C.O.

Such a test requires extensive planning by the Chief Umpire's staff, and was, in our case, very well run and of enormous value to the squadron. The report on it must have given the C.O. a very clear idea of the state of the squadron and its shortcomings and it formed a very suitable climax to our thirty days.

Back to Cyprus

The fitness-for-war test finished at Homs, some seventy-five miles from Tripoli. We drove there and spent two nights camped within one of the big Italian barracks, while we completed our disengagement from the country—closing accounts, paying bills, returning stores, collecting repaired trucks from Workshops and completing Boards of Inquiry into accidents. For a total of over 100,000 miles on our fifty-odd trucks, accidents were mercifully few, but most of the mileage was covered away from traffic, so our miles-per-accident figure, which would have been a record in Cyprus, was a little false.

We found time for a little shopping, swimming and dining-out—there are several good Italian restaurants in Tripoli—and embarked for home on 8th June. Both ships sailed together this time, and we arrived in Cyprus on 13th June, the day on which the Queen's birthday was being celebrated. We drove back to Limassol that same day in convoy; although there were some stoppages *en route*, every truck came into camp under its own steam.

Lessons Learnt

Many lessons were learnt while we were planning for the Thirty Days, many during and even some after the event, and they are far too numerous to put down in full. But this article has been written in order to pass on experiences to others, and the reader will have seen in the text many of the small points which, when added together, make desert know-how. A few more general matters, which apply to squadron life in any part of the world, may be of interest.

(*a*) A squadron when living with its parent regiment is not independent and needs several weeks before going off independently to train its specialists and collect gear normally supplied to it by Regimental Headquarters.

(*b*) The strength of Squadron Headquarters must be increased to cope with second line repairs (L.A.D.), rations, canteen, petrol, Officers' and Sergeants' Messes, M.I. Room, and so on. Better to get this increment from R.H.Q. than to deplete the field troops.

(*c*) The Squadron must have its own FAMTO (First Aid Mechanical Transport (Repair) Outfit). If the regiment runs a centralized FAMTO, allow at least a month to split off a proportion and train your storeman—the accounting side is a long task.

(*d*) More value is obtained in having the Regimental Signals Officer attached to the squadron for a month, than having him run a whole succession of courses for wireless operators. Our signals set-up was poor when we started, but at the end the Chief Umpire declared the organization and operation of our signals to be "the best Squadron wireless I have ever seen". Besides, it gave the 2I.C. a chance to get on with all the other multifarious tasks.

(*e*) A squadron can supervise the training of four troops simultaneously if the programme is well planned. It can take on the administration of further sub-units, if necessary, only if its quartermaster and M.T. side is running well.

(*f*) Training is not an end in itself and it is impossible for a unit to be perfectly trained for all its possible tasks. The aim of any period of training must be clearly written down and understood by all Officers and Senior N.C.Os. engaged in it. In our thirty days, our aim was to train to "live, move, fight and carry out engineer work in desert conditions in war". Without other arms it was difficult to bring any realism to the usual Sapper maxim "To help the Army to live, move and fight, etc." So the more limited aim was substituted.

Conclusion

While we were away, the Regiment was very busy and there were a large number of tasks waiting for us which helped to dispel the feeling of anti-climax on our return. We were all glad to be back, but happy that we had the opportunity to go to a piece of desert and find out what it's like.

Not so long afterwards the Sultan of Oman found himself in trouble, and John took half his troop there for mine clearance, water supply and demolition work. So the desert training was not wasted, and no doubt he was able to apply some of the lessons. Perhaps he'll write the sequel to his Desert Training one day.

Major-General Charles George Gordon, C.B.

A Sermon preached by the Bishop of Rochester at the R.E. Memorial Service, on April 20th, 1958, in Rochester Cathedral.

He endured, as seeing Him Who is invisible.

Heb. xi. 27

THE late Bishop Gwynne, of Egypt and the Sudan, delighted to tell of a little girl who insisted on bidding a fond farewell to the Gordon Memorial in Khartoum, before leaving with her parents for this country. The Memorial at Khartoum is the same as yours in the Brompton Barracks, and depicts General Gordon seated on his camel. "Good-bye dear Gordon, good-bye", the little maiden waved; and then, as she walked sadly away, put her question: "Mummy, who is the funny little man riding dear Gordon?"

Certainly, Charles George Gordon was a "funny little man". He was *little*, though tough as whipcord; short in stature, of spare figure; and would have passed unnoticed anywhere, had it not been for his eyes—of which more anon. He was also *funny*, in the sense of being (as has been said) "the strangest in the long line of British eccentrics": remembering always that with him, as so often, eccentricity was the by-blow of a quite extraordinary genius. Gladstone, for example, regarded him as dangerously "funny", and feared lest he might involve the Government in an unwelcome war in Egypt, however righteous, salutary, and necessary.

Many, too, considered Gordon's incorruptibility and chastity exceedingly strange; and, still more "funny", his utter contempt for money or honours: though all this was half the secret of his uncanny ascendency over those he ruled. Both in China and Egypt he might, as others did, have become rich beyond the dreams of avarice; yet he relinquished his gilded suzerainties as penniless as when he accepted them; and still worried how to meet his manifold commitments to poor relations and numerous adopted pensioners. Because my generation did not understand him, it has sought to belittle his achievements and exaggerate his peculiarities. You will recall how Lytton Strachey, the Father of Debunkers, light-heartedly wrote him off as a drunkard: a manifest and malicious lie for which he has never been forgiven, not even in his obituary. But modern biographers, such as Lord Elton, and a fresh study of Gordon's voluminous letters and journals, have securely re-established him on his pedestal.

The Corps of Royal Engineers may indeed be proud of having nurtured and possessed one whom Frank Power, the correspondent of *The Times*, and the last Englishman to see him alive, described as "the greatest and best man of this (19th) century". His courage was unbelievable: he revelled in desperate adventures and forlorn hopes. His energy and endurance knew no bounds. He could cover 3,840 miles a year on his camel, though the pace of the creature was less than four miles an hour. As a commander of irregular troops, and a ruler of primitive peoples, he has never had his equal. And even unlikely persons like Cecil Rhodes fell beneath his spell; for, in the words of another of them, Thomas Huxley, they "saw in him something greater than ordinary humanity". Moreover his achievements were, truly, *super*-human; seeing that they sprang from an intense, overwhelming, and simple faith in our Lord Jesus Christ. As Viscount Esher, the friend and biographer of Queen Victoria, wrote of him: "he literally walked with God, and if it were not disrespectful one might say, arm in arm with God." Do you wonder that Sir Robert Ensor, in his history of the period, has chosen Gordon as the Saint *par-excellence* of the Victorian era, when England was at its greatest and most religious? Even as the English demand of their Saints, Gordon's mystic union with God issued forth supremely in practical conduct and good works. Indeed, Ensor could only explain him in the words of my text: "He endured as seeing Him Who is invisible."

Now, all this found its outward expression in Gordon's unforgettable eyes. As an artist who painted him exclaimed, "He was all eyes." They were light blue in colour, like diamonds, and of piercing directness. They charmed strangers, and especially children, with their tenderness; and yet blasted offenders with their flashing indignation. They mesmerized savages, Chinese bandits, Arab slave-dealers, and African chiefs. Their direct intensity, too, spoke of that penetrating simplicity which goes straight to the heart of a problem, and was Gordon's pre-eminent genius. Above all they were aglow with an inner light: the calm radiance of a spirit in constant communion with God.

If then General Gordon was Wordsworth's "Happy Warrior" "that every man in arms would wish to be," I would have you mark the four characteristic qualities for greatness and leadership inscribed on the pedestal of his statue, now on the Thames Embankment. They are Charity, Justice, Fortitude, Faith; and like the pedestal of his statue, they were the basic virtues which raised Gordon to be a figure of towering pre-eminence.

1. *First, Charity*. Gordon's Charity was proverbial. Between quelling civil war in China and breaking the slave trade in the Sudan, there were six quiet years (1865–71) in Gravesend, when he was engaged in building forts—quite wrongly sited, as he loudly and vainly complained. It was then that Gordon began his assiduous visiting of the sick: for, as he explained, "where are the sick, there is Christ." The Gordon Boys Homes, too, at Gravesend, founded in his memory, testify that it was also here that he became noted for befriending destitute boys, whom he called his "Kings" or his "Scuttlers"——"Scuttlers", as he first saw them; "Kings", as Christ saw them and he prayed they might become. But far more than his unwearied philanthropy, Gordon's charity consisted in his Christ-like identification of himself with others. As he wrote to Florence Nightingale, the true "element of all government" is "the putting of the governors into the skin of the governed". He continually asked himself, even of his enemies: "how would I feel in his place"; with the result that he was always turning poachers into gamekeepers, so that ex-rebels became some of the staunchest members of his bodyguard. Even at the end, when he realized that the tardy relieving force under Garnet Wolseley must arrive too late; he prolonged the agony of the defence of Khartoum beyond what seemed humanly possible, not because he was concerned with his own rescue, but because even to contemplate the fate of the populace, if he failed, afflicted him with a physical pain of the heart. I was barely a couple of months old when, in January, 1885, Queen Victoria wept as she accused her Ministers of allowing Gordon to perish. But I was

nearly 13 when, on the first Sunday of September, 1897, my father was handed a note as he concluded his evening sermon in an Oxford Church, and he announced from the pulpit that Kitchener had, at Omdurman, avenged Gordon and brought peace to the Sudan. At the same time, during all the years that I had been alive three-quarters of the peoples of the Sudan had been massacred, because Gordon's proposals had been rejected.

2. *Next, Justice.* Gordon's incorruptibility, which could boast that he left both China and the Sudan as poor as when he came to them as their deliverer, was reflected in the whole of his administration. Thereby, he gained the trust and allegiance both of his soldiers and his subjects by, first, insisting that his troops and his officials should be properly paid; and then visiting with condign punishment any in his service guilty of giving or receiving bribes. More than this, his strong sense of justice sprang from a deep compassion and sympathy for the under-dog. It kept him still in the Emperor of China's employ even when Li Hung Chang, the Governor-General over him, had played him false and betrayed his honour; for (though he felt little concern for the rich merchants of Shanghai) he could not bring himself to deliver the wretched inhabitants of whole provinces to the nameless brutalities of the rebels, whom his war-like genius was defeating. Seventeen years later, however, in 1882, he did refuse the administration of Basutoland, because he found he was expected to pacify the Basuto by force of arms, instead of by rectifying their just grievances. Similarly, two years previously, in a letter to *The Times*, he had propounded the urgent need for land-reform in Ireland, by reason of the sheer misery of a people driven to violence by starvation.

He was Chaucer's very perfect, gentle Knight who:—

> "loved chivalry,
> Truth and honour, freedom and courtesy.
> Full worthy was he in his Lord's war,
> And thereto had he ridden, no man so far,
> As well in Christendom as in Heatheness,
> And ever honoured for his worthiness."

3. *As for Fortitude,* Gordon's utter fearlessness was a legend over the whole world, and that both among friend and foe alike. Behold, then, Chinese Gordon, leading in his own person his ever-victorious army to the assault, armed only with a swagger-cane: his "Magic Wand", as it came to be called. Then also see Gordon Pasha on his camel, riding unarmed and alone, through lines of scowling black warriors, into the encampment of some great Arab slave-dealer: the lion tamer putting his head into the jaws of the untamed lion. His courage, moreover, was no mere reckless daring, but compounded of discipline and self-control, with a trust in God that had no limit. Steeling his fortitude was a subjugation of the body that was content with ten minutes a day for meals. He would wolf down a hunk of stale bread soaked in strong tea, with the reflection that "it would be all the same in half an hour"; and that, although, sometimes in the heart of the Darfur desert, he longed for four dozen oysters with plenty of brown bread-and-butter: which only makes us love him the more. Mind you, Gordon knew sometimes what it was to be so afraid that it affected him with a peculiar and physical pain around his heart, and yet it made not the slightest difference to his conduct, nor the calm serenity of his countenance and commanding eye.

4. *But it was his Faith* that was the real secret of Gordon's fortitude, as also of his charity and justice. "He endured, as seeing Him who is invisible." Here, General Gordon must speak for himself, and I cannot do better than pass on to you members of this Corps the three chief features of his faith, which he termed his "pearls".

His first pearl was the fact of the Indwelling Christ, as a personal Friend, at our very side. He based the "Great Secret" (as he called it) on the text from the first Epistle of St. John (iv. 15): "Whosoever shall confess that Jesus is the Son of God, God abideth in him, and he in God."

His second pearl was the injunction in the first Epistle of St. Peter (v. 7): "Casting all your care upon Him, for He careth for you." Gordon was convinced that God was utterly responsible for him and his affairs; so that he could affirm that "not a couple of hours pass without my addressing God," for some reason or other.

The third pearl was his discovery, in later life, of the strength and peace given by Holy Communion, as one means ordained by Christ Himself of His dwelling in us, and we in Him.

Thus, Gordon never wearied in trying to share with others the reality of this his friendship with Jesus. As he wrote to one of his Gravesend "Scuttlers":—"Talk to that Friend in any difficulty, and He will help you better than anyone else in the world."

General Gordon was killed in his very prime, just two days before his fifty-second birthday. But he was one who "being made perfect in a little while, fulfilled long years". It was only thirty years previously that he had begun his active service in the Crimean War; and yet his epitaph in St. Paul's Cathedral can say of him: "At all times and everywhere [he] gave his strength to the weak, his substance to the poor, his sympathy to the suffering, his heart to God. He saved an Empire by his warlike genius, he ruled vast provinces with justice, wisdom and power". As Tennyson wrote:—

"Warrior of God, man's friend, and tyrants' foe,
Now somewhere dead far in the waste Sudan,
Thou livest in all hearts, for all men know,
This earth hath never borne a nobler man."

Soldiers' Schools

By Colonel J. M. Lambert, O.B.E.

(This article in a slightly different form was originally published in *The Sapper*)

The term "Soldiers' Schools" embraces schools run exclusively for boys going into the Army and certain schools which offer particular advantages to soldiers' sons, some but not all of whom will be going on to an Army career.

The British Army has always relied to a considerable extent on the sons of soldiers eventually taking their fathers' places—particularly as officers and senior non-commissioned officers, and more often than not, in the same regiment or corps—and to this extent it has an interest in their education. It may also be thought to have some obligation in the matter, because the soldier has obvious disadvantages, compared with the ordinary citizen, in educating his children; and with the growing scope and benefits of state education these disadvantages become more marked. There was some correspondence in the Press not long ago on the subject of "Service children" and "Service parents". It was pointed out that nowadays the passing of exams., such as that for the G.C.E., has become of more importance for a boy's future than ever before. And how, it was asked, can a boy expect to pass these exams. when his education is being continually interrupted owing to the moves of his parents?

One correspondent thought that moving about the world was an advantage to a child in that it was "an education in itself"; but this view isn't likely to commend itself to many parents.

The problem becomes most acute for a boy who has reached an age at which, in a settled home, he might be going daily to a grammar school or technical college; and because of the earlier marriage age there is bound to be a higher proportion of serving soldiers with children of this age group than there used to be in the pre-war regular army.

Since the state education system does not, with minor exceptions, provide boarding schools, and since most private boarding schools are very expensive, many service parents see no alternative for their boys to the intermittent sort of schooling which their frequent moves necessitate. There are, however, a number of schools, none of them expensive and some of them free, which go a long way to providing an alternative, and it is the purpose of this article to give some information about them. All of them are connected in one way or another with the Army, but essentially they are all boys' boarding schools, and thus give a boy settled and continuous training and education during at least some of the years in which his abilities need to be directed and his character formed. They offer very great advantages not only to a boy who is going to make the Army his career, but to those intending, in some cases after some army service, to take up a job in civil life.

The schools to be described are shown in the table in two categories—those within the Army and those outside it. Schools in the first category are an integral part of the Army and when a boy joins one he must enlist on a regular army engagement. But these army schools are not, as is sometimes mistakenly thought, only for boys seeking a life career in the Army. A boy who has been to an army apprentice school for instance can return to civilian life when he is 27 with excellent prospects of a good job.

The schools in the second group are run as civilian schools on the lines of the ordinary "public school". They have a military bias and in most cases are subsidized or endowed from service funds. At only one of them (Welbeck) is an undertaking required that the boy shall go on to a service career.

Part I—Schools Within the Army

There are altogether twelve boys' schools forming part of the Army; some are called "squadrons" or "companies", but they are none the less schools. Details about them all are contained in an excellent pamphlet called "The Way to a Fine Career", which can be got from any Army recruiting office, or by writing to the War Office (MP6), Whitehall, S.W.1. A visit to a school can always be arranged by writing to the Commandant.

The three schools described here are those in which the Corps of Royal Engineers has a particular interest. They have to all intents and purposes taken the place of the "R.E. Boys" establishment, so well known before the late war, and which used to provide so many of the Corps' senior warrant and non-commissioned officers, as well as a good number of commissioned officers both in the Corps and in other arms.

The Army Apprentices' Schools at Chepstow and Harrogate are not exclusive to the Corps as were the "apprentice tradesmen" at Chatham, but from each of them about half the boys go on into the Corps. It is perhaps not quite the same thing, but it does mean that a boy has a good chance of keeping up with his friends during his service.

The Junior Leaders Squadron R.E. is exclusive to the Corps and is part of the Corps establishment.

Broadly speaking, the training at an apprentices' school is directed mainly toward teaching a boy his chosen trade, while at the Junior Leaders Squadron it is towards continuing the boy's general education and training him as a Sapper.

But none of these schools aim merely at turning a boy into a soldier or a craftsman. As one of them puts it in their "Letter to Parents"—"Our ambition is that your boy shall not only acquire skill and knowledge of which he shall be proud but that he shall form habits of integrity, self reliance and good manners which will stand him in good stead throughout his life."

The Junior Leaders Squadron R.E. aims at producing lads who will ultimately become senior warrant and non-commissioned officers in the Royal Engineers. The Corps thus has a very strong vested interest in this unit, and it is not surprising that it is extremely well found in the way of instructional staff, buildings, equipment and amenities.

Malta Barracks which were built in 1938 are in the countryside, west of the main road running from Aldershot to Farnborough, on the edge of what used to be Laffan's Plain. The officer commanding the squadron is always delighted for parents or boys to visit the barracks, which can be easily reached from either Aldershot or Farnborough.

The organization of the squadron is similar to that of a company at the R.M.A. Sandhurst, and the training follows much the same lines—a general education (the younger boys spend a third of their time "in school" under instructors of the Royal Army Education Corps); basic military training, which includes training in field engineering; the encouragement of initiative and self-reliance mainly by means of small group expeditions, camping,

School	Approx. number of boys	Normal age on entry	Latest age for leaving	Is boy committed on entry to an Army career?	Any stipulation re "Service" parents?	Main conditions for entry
A. Schools within the Army						
Junior Leaders Squadron, R.E., Malta Barracks, Aldershot	350	15–16½	18	Yes to age 24	No	Intelligence test. Enlistment to age 18 and thereafter for not less than 6 years with the Colours and 6 years in the Reserve, and with right to continue
Army Apprentices School, Chepstow	1,000	15–17	18	Yes to age 27	No.	Qualifying examination. Enlistment to age 18 and thereafter for not less than 9 years with the Colours and 3 years in the Reserve, and with right to continue
Army Apprentices School, Harrogate	1,000	15–17	18	Yes to age 27	No	
B. Schools outside the Army						
Duke of York's Royal Military School, Dover	450	11 some at 9	18	No	Yes	Boy's father must have served in the Army in the ranks. There is a "waiting list"; boy should be registered if possible at age 8
Queen Victoria School, Dunblane, Perthshire	250	9½–12	18	No	Yes	Boy's father must be Scottish and have served in the ranks of Army, Navy or Air Force. There is a "waiting list"; boy should be registered if possible at age 7
Gordon Boys' School, Woking, Surrey	206	12½	17½–18	No	No	Entrance examination. Special considerations for Service parents
Welbeck College, Worksop, Nottinghamshire	150	15¾–16¾	18–19	Yes for regular commission	No	Boy should be up to G.C.E. Ordinary Level in Mathematics, Physics and English. But report by boy's previous headmaster is the main consideration. Parents must sign undertaking that the boy, if recommended, goes on to R.M.A., Sandhurst

sailing or mountaineering. In addition some elementary training is given in one of the Corps basic trades. As a boy gets older he spends less time in school and more on weapon training, field-craft and field engineering; and as a Boy N.C.O. or Warrant Officer he learns to wield authority.

Entry to the squadron is by enlistment at an Army recruiting office. There is an intelligence test and a "medical", but no qualifying exam. The boy enlists as a rule when he is 15, undertaking to serve until he is 18 and thereafter for either six years with the Colours and six in the Reserve, or nine years with the Colours and three years in the Reserve. At any time during the first three months of a boy's service his discharge can be bought, without question, for twenty pounds.

The boy is paid from the date of enlistment; the minimum rate is 4s. 6d. a day, and there are increases for length of service, qualifications and rank, which may bring it to more than 10s. a day.

In addition the boys get ration allowance whilst on holidays; these are ten weeks divided between Christmas, Easter, and Summer. During term time there are no expenses whatever to parents. There is a leave centre at Hastings for boys whose parents are abroad.

The Army Apprentices' Schools at Chepstow and Harrogate each train up to a thousand boys in various Army trades.

In general the "building trades" are taught at Harrogate and the "metal working" trades at Chepstow.

Those applicable to the Corps are given below:—

Chepstow	Harrogate
Blacksmith	Bricklayer
Draughtsman (mech.)	Carpenter and joiner
Engine fitter	Draughtsman (arch.)
Vehicle mechanic	Electrician
Welder	Painter and decorator
	Plumber and pipe fitter
	Quantity surveying assistant
	Survey trades (draughtsmen and surveyor)

The aim is that a boy should get his Class III trade rating before he leaves the school; he should then have no difficulty in reaching at least Class II during his service in the Corps. This may be of great importance to him should he then decide to return to civil life. For a man who has reached Class II trade standard and done five years training and experience in a recognized trade, and has passed through an army apprentices' school, is eligible for skilled membership of a trades union on leaving the service. But, as well as training a boy to a trade, the apprentices' schools continue his general education and by this and by training him in leadership, they give him a good start on an Army career. A high proportion of the Corps' warrant officers and technical commissioned officers come from these schools.

To become an army apprentice a boy must be between 15 and 17 at the time he joins the school. He must first take the qualifying examination which is held three times yearly in February, June, and October; he would normally take his examination during his last term at a state school. There are three subjects—mathematics, physics, and English, and the average boy who has had a normal education up to school leaving age usually passes. But for certain special classes at the Army Apprentices' School, Harrogate, a higher education standard approaching G.C.E. level is required. These classes comprise the survey trades and, at present, boys seeking appointment to the Establishment for Engineer Services.

Before a boy joins he will be required to enlist to serve with the Colours to the age of 18 and thereafter for nine years with the Colours and three years in the Reserve. He will be asked what trade he wants to learn and although it cannot be guaranteed, most boys get their choice.

Conditions regarding pay, holidays, etc. are the same as described earlier for the Junior Leaders Squadron, R.E.

Part II—Schools Outside the Army

The Duke of York's Royal Military School, Dover, and *the Queen Victoria School, Dunblane, Perthshire*, are both exclusively for the sons of service men. For a boy to be eligible for the Duke of York's School his father must be serving or have served in the ranks of the Army; if the father held commissioned rank he must have, prior to being commissioned, have enlisted on a normal engagement in the Regular Army. The stipulations for the Queen Victoria School are similar but include other rank service in the R.N. and R.A.F., and the father must be Scottish.

These schools are run on public school lines taking boys from normally 11 or 12 until they are 18. But, like many other public schools, each has a "junior" which takes a limited number of boys at 9 or 9½ until they are old enough to join the main school. Both schools are civilian but have a strong military bias. The boys are not committed to take up a service career but they are encouraged to do so, and a great many of them do.

As regards education, buildings, playing fields, etc., these schools bear comparison with any; yet the cost to parents is negligible.

The Duke of York's School was founded in 1801 and established at Chelsea. The present school was built in 1909 on the Downs above Dover, near the castle. It is a fine example of a modern public school. There is great competition for vacancies and (except where there are compassionate circumstances) a boy has little chance of being taken unless his father has given good service to the Army, in the ranks, and the boy himself is well up to average. He is given educational and medical tests before being considered for admission.

The normal age of entry is 11. A limited number of younger boys (9–11) can be taken in the junior school. In any case a boy should if possible be registered soon after he is 8, by writing to the School Secretary from whom all details can be obtained.

Education and maintenance during term are provided free. So is most of the clothing. Parents thus have very few expenses during term. Boys return to their parents or guardians for the normal school holidays.

The majority of the boys remain at the school until the age of 18 and take the G.C.E. at "advanced level"; most of these are aiming at entry either to Sandhurst or a university. Others leave at 16 after taking the G.C.E. at "ordinary level". These are encouraged to enter the Army through the army apprentices schools but may take craft or student apprenticeships in civilian life.

The Queen Victoria School is a Scottish school which gives free boarding-school education, clothing and board during term-time to the sons of Scottish service men and ex-service men who have served in the ranks of the Royal Navy, the Army and the Royal Air Force. Officers' sons are not eligible unless their fathers have had considerable other-rank service. The school has a charitable endowment which is a great help to it but the main cost of its maintenance is borne by the Army vote on behalf of all three services.

Boys can be registered for entry at 7 years old, but are admitted only between the ages of 9½ and 12. The school takes 250 boys when at full capacity but is at present limited to 220 pending the building of a new junior house. There is a considerable waiting list for entry as there are places for only about half the boys who apply.

The school has a strong military bias. The boys wear military uniform on ceremonial occasions and when walking out during term time and they do some drill. In general, however, the school differs little from a normal boarding school. The boys are organized into houses, each under a housemaster assisted by a house matron, and have their own monitors and prefects.

The school gives the boys the full Scottish educational curriculum. It presents boys for the Scottish Leaving Certificate at the lower and higher levels and for the General Certificate of Education at ordinary and advanced levels. Exceptional boys go straight from the school to universities. Boys can remain at the school up to the age of 18 to take examinations at their appropriate levels. Those who are not up to examination standard generally leave at 15. All are encouraged to enter the services, but no pressure is put on them to do so if their parents have other plans for them.

The Queen Victoria School has not been greatly used by the Royal Engineers of recent years. There are, however, six Sappers' sons in the school at the present time. Further particulars can be obtained from the Commandant, Queen Victoria School, Dunblane, Perthshire.

The Gordon Boys' School was founded in 1885 after the death of General Gordon at Khartoum, and it thus has a link, which has proved more than merely a sentimental one, with the Corps. It is a private boarding school run on military lines with its own customs, traditions and uniform. It is in this respect unique among the boarding schools of the British Commonwealth. It is non-denominational and makes a sincere effort to turn out boys who know and understand the Christian Faith. The Gordon Boys' School differs from any other school described in this article in that there is neither a requirement that a boy's father should have been in the services nor that the boy should join them on leaving. But the school tries to help service parents of all ranks, to give their sons a settled and comprehensive course of education and character training at a cost which they can afford. Fees are graded in the case of service parents according to the rank of the father; and serving officers and other ranks are entitled to the education allowance of £75 a year. There is also a foundation which helps boys whose parents are in difficult financial circumstances.

The normal age for entry is 12½, but there is a waiting list and it is advisable to register a boy soon after he is 11. There is an entrance examination which the boy takes at his present school.

Academically, the school aims at getting boys to the ordinary level of the G.C.E. by the time they are 16. This would make a boy eligible for consideration for Welbeck College, and so to a regular commission via R.M.A. Sandhurst—as some have done. Others can go for a more practical training, including training in certain trades, and if taking up an army career can then go on to one of the army apprentices' schools. But there is no obligation to join the services on leaving and many boys take good posts in civil life.

Further details about the school can be obtained by writing to the Commandant, Gordon Boys' School, West End, Woking, Surrey.

Welbeck College was opened in 1953 at Welbeck Abbey, a large country house formerly well known as the home of the Dukes of Portland. It is run as a civilian public school, but the boys stay only two years—from about 16 to 18. It thus provides the last two years of a boarding school education to boys the great majority of whom have previously been day boys at grammar schools.

The object of the college is to provide suitable candidates for regular commissions, via Sandhurst, in the technical Corps of the Army—that is in the Royal Corps of Signals, the Royal Army Ordnance Corps and the Corps of Royal Electrical and Mechanical Engineers. A small number of boys from Welbeck have gained commissions in the R.E., but only "at the discretion of the Army Council".

When a boy is accepted for the college his parents are asked to sign an undertaking that he will, if recommended, go on to Sandhurst. He must then serve at least five years as a regular commissioned officer on the Active List after leaving Sandhurst or after a university course should he attend one.

There are various conditions for entry of which an important one is that the boy must be up to the pass standard of the G.C.E. (ordinary level) in at least mathematics and physics (or a science which includes physics). But his former headmaster's report is what counts, and it is not essential for the examination to have been taken.

Parents contribute towards the cost of their boys' education up to a maximum of £30 per term. Clothing, holiday travel, and other incidental expenses are provided free and there are no extras.

There are two entries each year—in January and September and application forms must be sent in about eight months previously. Full details may be obtained from The Headmaster, Welbeck College, Worksop, Notts.

Two hundred years of banking for the Armed Forces

How much pay and allowances was the Iron Duke drawing at Waterloo? What was the cost to the East Indian Company of the cannon supplied to Colonel Clive for his expedition against Gariah in 1756? Or of the "lanthorns Muscovy, aprons of lead and linstocks without cocks" issued then to Lieutenant Thos. Hussey "to march with the party who have not had the small-pox"?

The answers to these questions together with countless other fascinating glimpses into the past (e.g. rate of exchange for the *pagoda* in 1761) are to be found, down to a penny, in the ledgers preserved at Cox's and King's branch of Lloyds Bank in Pall Mall.

The story of this banking office goes back exactly 200 years, to the day in 1758 when Mr. Richard Cox was appointed secretary (*de facto* financial agent) to the 1st Foot Guards (Grenadiers). Such was the origin of the bank which was in time to earn the affectionate sobriquet "Uncle Cox" in the course of its service to tens of thousands of British officers in peace and war.

Mr. Cox received his appointment at the hand of Jean Ligonier, famous cavalry leader, whose eminent services had in the previous year been acknowledged by a Viscountcy, promotion to Field-Marshal and succession to the Duke of Cumberland as Commander-in-Chief, and Colonelcy of the 1st Foot Guards.

Such colonelcies were by that time sinecures: the extensive work of accountancy for pay and purchases was delegated under Power of Attorney to a secretary.

For Mr. Cox this agency was a reward for devoted service as personal secretary to Ligonier in the field and at home.

Cox was a man of distinction: among his friends were Dr. Johnson, Burke, Goldsmith, Garrick, Reynolds and other notables. That he was also a very competent business man the rest of his life story proves. By 1803, when Richard Cox died, his bank was agent to numerous regiments. And by 1815, when his cousin Charles Greenwood was senior partner, the firm was agent to the entire Household Brigade, the majority of cavalry and infantry regiments, the Royal Artillery and the Royal Waggon Train (forerunner of the R.A.S.C.).

In presenting Greenwood to George III, the Duke of York described him as "the gentleman who keeps my money". Greenwood commented drily "I think it is rather His Royal Highness who keeps my money". Among his royal customers was the Duke of Kent, Queen Victoria's father.

As the multifarious duties of the regimental agent (they included such details as trusteeship for "officers labouring under Mental Delusion") were gradually taken over by the Army itself, the personal banking business of Cox's expanded.

It reached a peak with the First World War during the course of which the names of more than 250,000 officers passed through the books. The address was by now 16 Charing Cross. Here a twenty-four-hour service was given, including Sundays and holidays, for officers returning from the front; and "Dear Mr. Cox", as the bank was often light-heartedly addressed, was patriotically understanding in the matter of subalterns' overdrafts. Associated in their minds with the hectic pleasures of leave in London, he became "Uncle Cox". A gallant young Colonel who fell on the Somme, had a habit of singing, when there was a moment for conviviality:—

> The soldier boy is full of joy
> As pleased as Punch you'll find him,
> With Father Grim in front of him
> And Uncle Cox behind him.

At the height of the war 50,000 cheques a day were cleared and up to 20,000 letters dealt with. Branches were set up behind the lines in France, and on any front an officer could draw on his account without troubling to prove his identity.

Cox's did far more than merely issue pay and keep an officer's banking account. The Insurance Department would arrange to insure his kit, the Income Tax Department would deal with his tax returns, and the Standing Order Department would see that the instalments to his tailor were paid regularly. A kindly and spontaneous service was to send a cashier with a supply of money to every hospital ship as it arrived, in case wounded officers wanted cheques cashed.

Cox's provided another humanitarian service. A careful record was kept of all officers posted as missing. Often the bank had the first indication that the missing officer was alive and a prisoner, by the presentation of a cheque he had negotiated and which reached 16 Charing Cross through neutral channels. Mrs. Reginald Cox, the wife of the senior partner, played her part in keeping the families of missing officers posted with any information reaching the bank.

In 1912 Cox's were appointed agents to the Royal Flying Corps, and when the Royal Air Force was established in 1918 they were privileged to continue this appointment.

Cox's was taken over by Lloyds Bank in 1923. But it preserves the memory of its founder in the title Cox's and King's Branch, and remains an "institution". Among banking offices it is in many ways unique. At 6 Pall Mall (the address since 1924) there is still a separate office labelled "Guards and Cavalry", and separate counters for sections of the military—lettered F for the Foot Regiments and the Rifle Brigade, R for the "Royals" (R.A., R.E., etc.), R3 is Royal Air Force; and, as throughout Cox's history, the ledgers are bestrewn with illustrious names. The accounts of many military families date back to Richard Cox himself. It is, incidentally, the largest branch bank in Europe, and has its own emergency electrical plant, and artesian water supply.

In 1939, faced again with the prospect of enormous expansion in the number of officers, the branch had already equipped itself by the installation of the most modern mechanized accounting system. Large numbers of additional staff had to be recruited not only to replace those who joined the Forces but to handle the additional work. Dispersal was inevitable. The Pay Department which at one time dealt with the pay of 153,000 officers spent most of the war in Bournemouth. But, once more, in London an all night service was given to officers.

The extension of the war into many theatres and the frequent interruption in communications brought difficulties, but with goodwill they were surmounted. This letter came from the Middle East:—

"Gentlemen,

"I return herewith a cheque book recently sent me by you. I regret to say that this book met with disaster at the hand or rather mouth of a hungry cow . . . I would like to point out, in view of the instructions given on the cover of the cheque book, that my permission to eat same was not first obtained."

Service to the Army has been the *raison d'etre* of Cox's for just 200 years. This is a tradition of which Lloyds Bank is very proud. The close association between officers and the bank persists; a recent letter from a customer serving abroad testifies:—

"As I think I mentioned to you, whenever I enter the portals of Cox's & King's I immediately feel at home."

Readers of *The Royal Engineers Journal* may like to be reminded that Cox's have been agent to the Corps for 150 years.

Memoirs

MAJOR-GENERAL G. A. T. PRITCHARD, C.B.E.

Gordon Arthur Thomas Pritchard was born at St. Margarets, Middlesex, on 14th November, 1902, the son of Mr. and Mrs. Thomas Pritchard, of Glanaber Park, Chester.

He was educated at Kings School, Chester, and the R.M.A. Woolwich, and was commissioned in the R.E. in August, 1922, and completed his Y.O. Course at the S.M.E. Chatham, with No. 7 J.O. batch.

Both at the "shop" and at the S.M.E. "Pritch", as he became known, clearly showed that he was by no means the "Conventional Sapper". He was a brilliant improviser on the piano, and there is no doubt that his gaiety and readiness to be "in" on all batch activities rendered him a popular member of his batch.

He left the S.M.E. in September, 1924, and proceeded to India where after a period of attachment to Q.V.O. Sappers and Miners at Bangalore, he was posted as Garrison Engineer, Quetta (Civil). He spent the next nine years, until January, 1934, attached to the Military Engineering Service, either in Baluchistan or in the North-West Frontier Province of India. During this period he gained a sound knowledge of Civil Engineering work, learnt Pushtu, and developed his great powers of organization.

After a short period of active service in 1930 in the Khajuri operations with K.G.O. Bengal Sappers and Miners, he volunteered to go to Chitral as Garrison Engineer, Drosh. With characteristic determination he had his piano transported there over a 10,000-ft. pass and along many hundreds of miles by track. In 1933, he returned to India as Assistant Garrison Engineer, Risalpur, was promoted Captain and in the same year married Lucette, daughter of Major Whitburn. The happiness and gaiety of their married life is known to countless friends who have experienced with gratitude the welcome and hospitality of the Pritchard home wherever it may have been.

In October 1934, he returned to the U.K. to spend eighteen months with the 11th Field Company at Aldershot. However by April, 1936 he was back again in his beloved North-West Frontier Province, as Garrison Engineer, Nowshera, remaining there until early 1939.

Shortly before the outbreak of the Second World War he was posted to the Staff of the Chief Engineer, Northern Command, India; he quickly earned promotion to S.O.R.E.1 (Works) serving under Brigadier, later Major-General Sir Horace Roome, K.C.I.E., C.B., C.B.E., M.C., D.L.

General Roome writes:—

" 'Pritch' joined Northern Command, India, at much the same time as myself in 1939. By the winter the outbreak of war had brought a mass of problems on the Works side demanding instant solution. The chief of these related to the hutted accommodation for mixed brigades in various localities remote from existing cantonments, where each formation could assemble and train for an overseas theatre. Much ingenuity was displayed in the use of the

Major General GAT Pritchard CBE

local materials, mass produced where possible, and it was due in large measure to 'Pritch's' inspiration and drive that the camps were in a fit state to receive the various units as they arrived. By the end of 1941, when the emphasis of the war had shifted from the North-West Frontier of India to that little-known country that divided India from Burma, it had become evident that the Army in Burma at the best would have to be supplied by land from India, by means of driving a road from Imphal in Manipur State to the Chindwin. It was natural to think of 'Pritch' as an experienced engineer, who should be posted to the Engineering team for that task. 'Pritch' was accordingly sent as C.R.E. to join Brigadier G. R. Gilpin, C.B.E., M.C., who was charged with the task—which was successfully completed—of providing this road before the onset of the Monsoon in 1942."

During 1943 and 1944 "Pritch"—promoted to T/Colonel—was employed as Deputy Chief Engineer, Airfields, Assam. He returned to India in June, 1945 on his appointment as D.C.E., Airfields, 14th Army.

From January to July, 1946, he was appointed Brigadier, as Chief Engineer Allied Land Forces, Netherlands East Indies. He was awarded the C.B.E., in recognition of "gallant and distinguished services" in this appointment. He then became Chief Engineer, Burma Command until October, 1947, when he was seconded from the Army as Chief Civil Engineer to the East African Ground Nuts Scheme.

The appointment came at the moment when the Overseas Food Corporation had taken over responsibility from the United Africa Company; contractors had been in the Kongwa area for just under a year, working on a cost-plus-percentage on an extremely nebulous development plan. Pritchard's task was to control all Civil Engineer work and to get development and contracts on to a sound basis as quickly as possible. He put his forward planning on a realistic basis and brought in contractors on fixed price contracts to set a new standard in speed, economy and contractual behaviour.

The curtailment of the major part of this scheme in 1948 resulted in Pritchard's departure, and 1949 saw him in the War Office for the first time, responsible for Works Overseas in the D.F.W.s branch, and back to his substantive rank of Colonel.

In the spring of 1950 he was posted as Chief Engineer in Cyprus and did much of the on site planning for Dhekelia Cantonment; the Abadan dispute in 1951 caused a local accommodation crisis for Cyprus, but Pritchard was able to house the Parachute Brigade in austerity Nissen camps in less than three months, a very fine achievement under peace-time conditions.

Later in 1951 he took over D.D. Works, Middle East Land Forces, in which capacity he did all the initial planning for the joint headquarters at Episcopi, as well as the measures for the civilianization of the Canal Zone Base. He was promoted Substantive Brigadier in 1952.

1953 saw him back as Deputy to the D.F.W., followed fairly soon by a posting to be Chief Engineer Southern Command.

He became D.F.W. in November 1955 (being promoted substantive Major-General in December, 1956) and very soon met rough water. The repeated frustration of works projects by policy changes, coupled with the trend towards '"lightening the tail" by means of civilianization, led to the forming of the Weeks Committee to inquire into the whole works organization; but the very existence of this Committee only accentuated the day to day difficulties of Pritchard's Directorate.

His last D.F.W.s Conference, held four days before his death was both typical and appropriate. It was a model for any conference, and before closing it he issued his own "unofficial" Christmas card of a figure in the act of taking cover in a manhole against a falling projectile labelled "WEEKS" with the caption "MORITURUS TE SALUTO."

He died on 17th December, 1957. In addition to his widow he leaves one daughter.

D.C.T.S.

BRIGADIER R. A. BOGER

ROBERT ALBANY BOGER, born on 14th August, 1882, was commissioned in the R.E. in February, 1901 and served in Aldershot and Somaliland. In 1912 he was A.D.C. to Major-General H. M. Lawson commanding 2nd Division at Aldershot. In 1914 he did an aviation course at Upavon and was then posted as a Flying Officer with the R.F.C. and went to France. He was taken prisoner in 1915.

After the war he served with the Allied Military Mission in Paris and on the German-Polish Boundary Commission and also was specially employed under the Foreign Office on the Irish Boundary Commission. He was employed on works services in Aldershot and was C.R.E. in Egypt, first at Moascar and later in Cairo.

He was promoted Colonel in September, 1930 and was A.D.F.W. at the War Office from 1931–5 and then Chief Engineer Southern Command with the rank of Brigadier from 1935 till he retired in June 1939.

Soon after the outbreak of the Second World War he was re-employed like certain other senior R.E. officers as a Major on works services in Southern Command.

He married Diane the daughter of Major-General Sir Reginald S. Curtis, K.C.M.G., C.B., D.S.O. and the Hon. Lady Curtis on the 4th August, 1914, and had one son and two daughters who all survive him.

He died on 19th September, 1957.

LIEUT.-COLONEL G. MASTER, D.S.O

GEORGE MASTER was born on 9th September, 1882, and commissioned in the R.E. in February, 1901. He spent much of his service at Aldershot, and with mounted units. He was in South Africa in 1906 for four years, and then remained at Chatham for three years with the 5th Field Troop. He was Adjutant, R.E. Troops, at Aldershot for the two years prior to the outbreak of war in 1914.

He served with 38th Field Company in Macedonia, gained a D.S.O. in 1917, and towards the end of the war became C.R.E. 21st Division, Expeditionary Force, until in 1919 he went on Special Duty to Berlin as a member of the Allied Control Commission.

In 1921 he became D.A.A.G., A.G.7 at the War Office, and in October 1922 returned to Aldershot as O.C. R.E. Mounted Depot until he retired in February, 1926.

Scientific enthusiasm for railways coupled with his clear, analytical mind fitted him admirably for his work in the Ministry of Transport, and when in 1949 he became Chief Inspecting Officer of Railways his gifts and knowledge had worthy scope. His loyalty, generosity, and humanity were characteristics which inspired his staff, and his wise and unselfish advice helped them constantly.

His inquiry into the Harrow disaster focused attention upon Bob Wilson, but few realized the great strain imposed on him or appreciated the depth of his sympathy with all who suffered in that tragedy. His health was impaired by this profound investigation, but he resumed work after some weeks' rest. He continued to watch over the measures for railway safety and held further inquiries into accidents, including that at Barnes in 1955 and most recently that at Lewisham which unhappily he did not live to complete. The strain and distress occasioned by this last investigation may well have contributed to his untimely death.

Bob Wilson was a delightful and informed companion, a keen fisherman, and an ardent yachtsman, well known at Bosham, where he was often at the helm of his 16ft. dinghy Isabel. He was no mean linguist and an eager traveller whose sympathies were international. His friends mourn a Christian gentleman who cherished and furthered the high traditions of his calling."

He married in 1923 Isabel Marion, daughter of William Berry, by whom he had a son and a daughter.

COLONEL C. E. COLBECK, M.C.

Charles Edward Colbeck was born on 11th April, 1881, and was commissioned in the Corps from Coopers Hill College in September, 1903.

While at Chatham he won the Fowke Medal as the best student of his batch in the Construction School.

After leaving the S.M.E. he did a locomotive course with the Great Northern Railway in England, followed by a similar course with the North Western Railway in India, and after serving on that railway for a few years was transferred first to Military Works and then to the Bengal Sappers & Miners at Roorkee. After doing a wireless course at Aldershot he returned to Roorkee and served with the Balloon Section there.

In 1912 he was appointed Assistant Inspecting Officer Indian State Sappers, and in 1915 he commanded the Sirmoor State Sappers in Mesopotamia and was taken prisoner at Kut.

After the war he was Inspecting Officer and later Military Adviser to the Indian State Sappers. Returning to U.K. in 1924 he served first with 1st A.A. Searchlight Battalion and was then Chief Instructor, School of Electric Lighting at Gosport.

In 1929 he was C.R.E. 1st Division at Aldershot and in 1933 an Instructor (Colonel) at the Senior Officers School at Sheerness. In 1935 he joined the R.E. Board and retired in 1938 but remained as a member of the Board.

In 1941–2 he commanded 2nd A.A. Training Group at Retford.

He married Beryl Scrimgeour in May, 1919 and had one son and a daughter who all survive him.

He died on 16th November, 1957.

In the Second World War he was re-employed to command 3 M.T. Training Depot, R.E.

He was a keen horseman and enthusiastic cricketer, and played cricket for the Corps. The George Master Horn is presented to the first R.E. officer home in the Members Race at the annual R.E. Point-to-Point.

He married Alice Mary (Molly) Phipps, in April, 1920, who survives him.

He died on 17th January, 1958.

LIEUT.-COLONEL G. R. S. WILSON, C.B.E.

George Robert Stewart Wilson died very suddenly on 20th March, 1958, while serving in the Ministry of Transport as Chief Inspecting Officer of Railways.

Born on 17th April, 1896, he was educated at Marlborough and the R.M.A. Woolwich and was commissioned in the R.E. on 17th November, 1914, when he was only 18½ years old.

He saw service in field companies in France and Macedonia during World War I, after which he did first a supplementary course at the S.M.E. and then a railway course at Longmoor.

He then served as a Staff Captain in the Transportation branch at the War Office from 1924 till 1930 when he was posted to Malta for two years returning again to Longmoor first as a student and then as an Instructor.

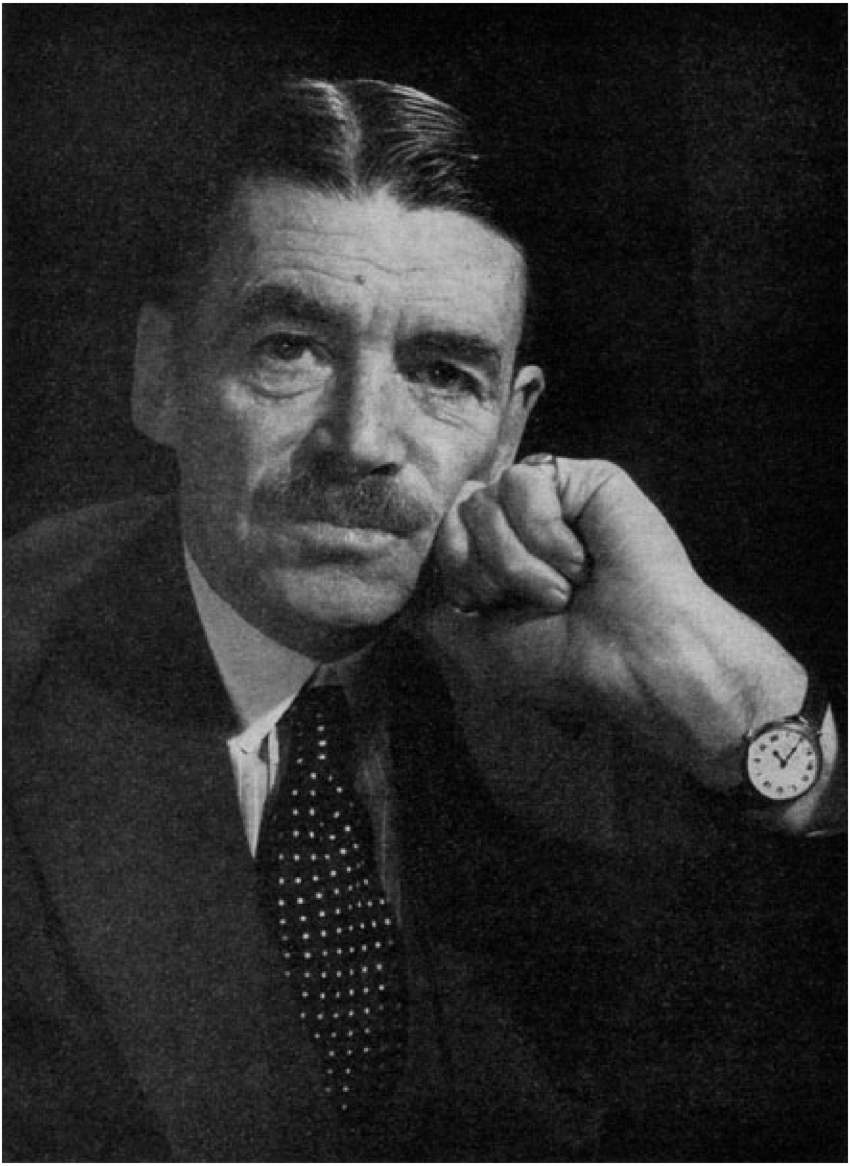
He returned in 1935 to take up an appointment as Assistant Inspecting Officer of Railways, one of the appointments held continuously by retired Sapper officers since Major-General Sir Charles Pasley first held it in 1841.

In 1939 he returned to the Army as Asst. Director of Railways with the B.E.F. in France until the evacuation from Dunkirk in June, 1940, when he resumed his Inspection job, being promoted Inspecting Officer in 1941 and Chief Inspecting Officer in 1949, and in 1951 he was one of the two British Government representatives on the Permanent Commission of the International Railway Congress Association. He was appointed C.B.E. in 1953.

In *The Times* of 26th March, 1958, Brigadier C. A. Langley writes of him as follows:—

"The sudden death of Lieutenant-Colonel G. R. S. (Bob) Wilson has deprived the railway inspectorate of an inspired leader and friend, and has removed a man admired and respected by railwaymen of whom all ranks have enjoyed his courtesy and consideration.

His distinguishing love of railways was early exemplified when in his school days he contrived to frequent a Wiltshire signal box, and he continued throughout his life to correspond with the signalman who first taught him the rudiments of railway operation. His remarkable bent for mechanical engineering found expression in his delighted study of locomotives, of which he was a connoisseur. He was completely at home on the footplate and he often astonished us, his colleagues, by his detailed knowledge of engines. Even in Continental trains his ability was illustrated when he helped the driver to locate and adjust a fault in the engine of the Sud express behind which he and his family were travelling to the Basque country on holiday.



Leiut Colonel GRS Wilson CBE

COLONEL E. ST. G. KIRKE, D.S.O.

Edward St. George Kirke was born on 27th January, 1883, and passed out of the R.M.A. Woolwich top of his batch, winning the Pollock Medal and the Queen Victoria Gold Medal (renamed the King Edward Medal).

He was commissioned in the R.E. in July 1902 and won the Montgomerie prize for writing the best article in the *R.E. Journal* in 1904 by an officer below the rank of major.

He was one of the few R.E. officers who did a mechanical engineering course at Chatham Dockyard and a little later a similar course at the Railway Workshops at Lahore as well as a locomotive course there. Shortly afterwards he was employed on Military Works in India.

During the 1914–18 war he served with the 28th Railway Company in East Africa and was awarded the D.S.O. in 1917.

After the war he served at Shoeburyness and later as C.R.E. at Quetta, and then C.R.E. 2nd Indian Division. From 1934–7 he was Chief Engineer at Hong Kong with the rank of Colonel.

He retired in 1937 but was employed with the R.A.F. during World War II and held the rank of Wing Commander.

He played cricket many times for the Corps and headed the batting averages in 1922.

He married Ethel Jessie Longley in December, 1911 and had two daughters.

He died on 12th November, 1957.

ARTICLES FOR THE R.E. JOURNAL

1. Articles for the "R.E. Journal" will be typewritten and submitted in duplicate, one copy being the original.

2. Line drawings must be in black ink. Ink tracings on linen are very suitable. All lettering must be clear and bold to allow for reduction in size when reproduced. Scales will be drawn and not worded.

3. If tracings are submitted one print should be sent for the duplicate copy.

4. Photographs should be on glossy prints, and no writing should be on the photograph itself. Any reasonable size print may be submitted.

Not more than four photographs can normally be reproduced with any article. More photographs may be submitted and the Editor will make a selection.

5. Contributors to the Journal are reminded that under Queen's Regulations any information of a professional nature acquired while travelling or employed on duty is regarded as the property of the War Department and will not be published in any form without the previous sanction of the War Office.

It is suggested that prospective authors should read carefully Queen's Regulations, 1955, paragraphs 679 and 680.

6. War Office sanction to publish can be obtained, if desired, by the Editor, but authors must obtain a statement from the authority under whom the applicant is immediately serving that such authority has no objection to War Office permission being applied for.

Book Reviews

THE WELDING HANDBOOK

Fourth Edition—Completely Recast

By Arthur L. Phillips

(Published by American Welding Society. Price 72s.)

From a strictly non-service point of view this book is very thorough in its approach to general welding practice. The data given and the way in which the various welding terms and definitions are laid out in alphabetical order is most useful and the general engineering and metallurgy section is of particular use for easy reference by all types of metal trades. On the other hand the section on the properties of welded joints and thermal mechanical treatment is too far advanced for the average welder but is of interest to the welding instructor.

Although this is a recently published book there is no mention of the Argon Arc and Argonaut welding of aluminium and its alloys. With the increasing use of these materials, in modern military engineering it is felt that this subject may well become one of great importance in the Corps. This is however only Book One of the new edition and no doubt the subject will be dealt with in one of the other books.

The Safe Practices Section is very good and is well laid out; layout is in fact a strong point throughout the book and the numbering of the chapters and diagrams and the provision of sections with headings make this an easily followed reference manual. The diagrams in particular are excellent both in detail and clarity and greatly increase the value of the book for the practical man.

In conclusion this book is a useful one to have in a technical library, but from the service point of view it delves rather too deeply into some matters and would not be of use to the average service welder in his day to day work. J.G.L.

NUCLEAR WEAPONS AND FOREIGN POLICY

By Henry A. Kissinger

(Published by Oxford University Press (for the Council of Foreign Relations, New York). Price 40s.)

This is a most important book for all those interested in British defence policy. It deals with the ferment of ideas on strategic doctrine now occurring in the United States. Similar reappraisals are taking place in the United Kingdom, particularly since the publication of the 1958 Defence White Paper. It is therefore of great interest to compare the premises and conclusions now being argued on both sides of the Atlantic.

Mr. Kissinger sets out to explore methods whereby American military strength can support United States political objectives without excessive risk of global thermonuclear war resulting. He accepts that the age of nuclear stalemate between East and West is already here. The nuclear deterrent, he thinks, is highly effective in deterring its like—nuclear attack by Russia. But the rub of his argument is that if the nuclear deterrent is the sole counter to enemy aggression, then such a policy will invite limited aggressions which by themselves would not seem worth a final showdown. He therefore proposes a doctrine of graduated deterrence which should keep the Soviet bloc from adopting this course. The will and the ability to wage limited nuclear war is the kernel of his strategy. He believes that it is possible to confine a limited nuclear war within clear cut geographical limits so long as Russia can be brought to appreciate the fundamentals of the new strategy.

His diagnosis of the strategic dilemma facing the West is generally accepted in this country. Indeed, the definition by the Prime Minister in the defence debate in February this year of the circumstances in which the nuclear deterrent might be used prove conclusively that an intermediate strategy is now needed. Is limited nuclear action practicable to halt limited aggression? This is the core of the great debate now raging on Defence Policy.

No solution to this problem can be offered without a clear definition of the nature of the Sino/Soviet threat. Mr. Kissinger provides this in his penetrating analysis of the strategy of ambiguity. He shows himself to be fully appraised of the dangers arising from the campaign of world wide subversion and the supply of arms to newly emergent states in the Middle and Far East.

Yet his advocacy of limited nuclear counter measures is based solely on direct aggression by Sino/Soviet forces beyond their present borders. He fails to follow up the more subtle and likely dangers arising from Communist bridgeheads already established beyond the Iron Curtain. He therefore under-rates the political difficulties of using nuclear missiles against such bridgeheads. His own test case is N.A.T.O. Here he argues that a strategy of local defence based on nuclear weapons would suffice. Few Europeans, however, are likely to agree to a strategic doctrine involving the nuclear devastation of their countries while America remained inviolate.

This book is therefore invaluable in setting out clearly the strategic dilemma now confronting both Britain and America. The solution offered is unlikely to prove generally acceptable. D.J.W.

STATICALLY INDETERMINATE STRUCTURES (3rd EDITION)

By R. Gartner, D.Sc.

(Published by Concrete Publications Ltd. Price 18s.)

This book is concerned with the analysis of statically indeterminate structures using for the most part the Principle of Virtual Work. This method of analysis is a variation of the strain energy method employing a "unit load" or "unit moment" and is often referred to as the Sik method. Once the system of symbols and suffixes has been fully understood it will be found that the analysis of problems using this method is clearly explained.

Included in the book is one short chapter on Moment Distribution. Although a large amount of information is packed into this chapter it is not considered to be self sufficient and further reading would be essential for anyone wishing to learn this method of analysis thoroughly. At the end of this chapter there is an example of the analysis of a three bay portal frame using the Virtual Work method. It can only be assumed that this is an inadvertent error and that the example should have been included in that part of the book dealing with the analysis of frames by this method.

There is a very useful chapter, not often found in books of this sort, on the analysis of beams curved in plan. Diagrams are given showing the bending moments and tension moments for circular beams with four, six and eight supports.

In this edition the chapter on "Elasticity Equations with only one unknown in each equation" has been omitted and a new chapter has been included on "Design by the Plastic Hinge method". This at first sight seems a little incongruous in books devoted to the analysis of structures, but has been included to show how the Virtual Work method of analysis is applied to this problem.

This book would be useful to anyone wishing to learn the Virtual Work method of analysis or faced with the analysis of curved beams. J.M.

OPERATION SEA LION

By RONALD WHEATLEY

(Published by the Clarendon Press, Oxford, 1958. Price 30s.)

On the whole Hitler handled the problem of invading Britain very sensibly. Under his direction the Wehrmacht produced what appears to have been a practicable plan, which could have been carried out during the last week of September 1940. Since the whole enterprise was only conceived in June, the planners did well to work to such good purpose so quickly. Perhaps we must discard the myth that the Germans cannot improvise? Admiral Raeder and the German Navy, however, had no illusions about the difficulties of the proposed invasion. The Admiral firmly refused to be stampeded into failure, either by the impossible requirements of the Army or by the over confidence of Goering and the Luftwaffe. So the feasibility of the operation soon came to depend on whether the as yet indeterminate power of the air could reduce the R.A.F. and the Royal Navy to impotence and the British people to a state of moral collapse. Goering thought that he could effect these transformations. The prize was great and Hitler let him try. When by mid-September the Luftwaffe had failed in their task, a seaborne invasion in the classical manner was out of the question. Germany just had not got the requisite maritime power. Who can doubt that Hitler had Napoleon in his mind's eye, when he, too, then turned his back on the Channel? Napoleon marched the Grand Army only to the glories of Austerlitz, but he, the modern master of war, would blitzkrieg even the inviolate Russians into submission. In his attempt to do so, Hitler left Great Britain, his chief enemy, still a world power and still undefeated in the West. That was his first grave error in strategy. More were to follow.

Mr. Wheatley's book on the invasion, which never took place, is a thesis for expert historians. It dots the "i"s and crosses the "t"s of the accounts, which have already appeared in Bryant's *Turn of the Tide*, Fleming's *Invasion 1940* and Collier's official history of the *Defence of the United Kingdom*. No important new facts emerge and the subject is rather a narrow one for a whole book. Nor is the writer's style above criticism. Quiller-Couch would surely have jibbed at "This relation emerges more clearly when the problem is regarded from the viewpoint of the influences underlying the adoption of these methods" even taken out of its context.

Soldiers would like to know more about the training and tactical set up of the battle groups of the first echelon. If the author could have quarried some information about these matters from the stony fields of research, he would have done a useful service. In conclusion it would be interesting to know what use the Germans finally made of the 252 amphibian tanks. Guderian certainly mentions one of them. What happened to the others? B.T.W.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering*, December, 1957

Substitute Frames in the Analysis of Rigid Jointed Frames

The method described in this article is an extension of the now familiar moment distribution technique used in the analysis of framed structures. The author proposes the use of a simple frame in substitution for the more complicated frames met in practice. This artifice permits many ready-made solutions to be used, and thus arrives at an approximate solution quicker than by any other method in existence. The next stage is to correct the moments found for the simple frame, to arrive at a closer approximation to the moments that will occur in the frame that it is desired to analyse. This is done by simple rules based on the stiffnesses of the members. The author illustrates the method by a worked example to determine the stresses in a Virendeel six bay girder, the top chord of which is a different section to the lower chord. The claims made for the method are certainly justified by the simplicity of the working. Students of moment distribution familiar with the Hardy Cross system may find difficulty in following the distribution table given in the text because this is based on the newer "no shear" method, and they would be advised to read one of the references given at the end of the article before attempting to follow the example. The article is to be concluded.

Field Vane Shear Tests

The difficulty of obtaining values for unconfined compression tests on sensitive soils, such as black cotton soil, may be familiar to officers who have met this peculiar material in India or East Africa. The difficulty of carrying out laboratory tests is the susceptibilities of the soil to volume change between the time of sampling and testing. The article describes the application of a field test method first developed at the end of the war by A.O.R.G. The essential measurement is the development of the torsion required to rotate a vaned cutter in the soil, the resistance to torsion being provided by the shear strength of the soil over the surface area of the volume moved by the vanes. This has been established by Skempton as being $4\pi r^2 (h + 2/3r)$ where h is the height of the vane (3 in.) and r is the radius of the vane (1 in.). Details of how the tests were conducted, together with a photograph of the equipment used in India and the results obtained on black cotton soil are included in the article. It is concluded that this type of *in situ* test was the only one that had any value for these sensitive soils.

Moving Span 10 of the Jacques Cartier Bridge

One of the most intricate engineering operations in the project to raise the level of the bridge across the St. Lawrence seaway with the least hindrance to traffic, was the replacement of the deck bridge by a through type bridge. The method used was to build the new bridge alongside the old bridge on trestles, with a vacant trestle position on the other side. This enabled the two bridges to be pulled laterally along rails simultaneously. The total weight of steel moved was 3,100 tons. This was supported on roller trucks running on two runways, of seven rails each, and was moved by jacks with a total capacity of 500 tons and a stroke of 4 ft. The jacks were connected by chains to both old and new bridges in such a manner as to allow them to be retracted and reconnected at the end of each 4 ft. stroke. The new span was complete as far as steelwork was concerned, and it also had its roadway laid ready to receive traffic. The operation which was scheduled to take 7 hours, was completed in 5 hours. The article is illustrated by four diagrams and four photographs.

Pipe-line laid into Bed of River Wear

The emergency pipe-line across the River Wear between North and South Hylton was laid by a novel technique. The 24-in. diameter pipe-line, 230 ft. long was transported in short sections and welded together on a construction site $1\frac{1}{2}$ miles downstream from its final position. Blanking-off plates were welded to both ends and the pipe was floated into position by tugs. The launching of the pipe was completed in $12\frac{1}{2}$ min. using three Coles cranes, with a total lifting capacity of 70 tons. The bed for the pipe was a 4 ft. deep trench excavated in the bed of the river by a grab dredger. The whole operation was completed in six days from launching.

Notes from *Civil Engineering*, January, 1958

Model Tests in Portugal

This review of the work done by the National Civil Engineering Laboratory at Lisbon is an authoritative and interesting account of model testing applications and techniques in the compass of a short article. There is an introductory discussion on the desirable properties and the relationship that should exist between these properties on the model and the prototype, from which recommendations on scales are made. The work in the laboratory has ranged from such diverse problems as behaviour of structures to percolation through soils. Model materials which have been used successfully have been plaster of Paris, mortars, celluloid, alkathene. Deformations have been measured by depth gauges, acoustic and electric strain gauges, while a general pattern of the stress picture has been often determined by using brittle varnishes. The laboratory favours electrical resistance strain gauges because of their small dimensions. The article is to be concluded.

A Conveyor Belt System for the Removal of Tunnel Spoil

The knowledge that a future war will probably confront the sappers with large scale underground excavations makes this article on removal of spoil from the Potters Bar tunnel especially interesting. The excavation of the 26 ft. dia. tunnel through stiff London clay produces on the average 15 cu. yd. of spoil every hour of the 24 hours that the three shifts work. Although perhaps not a large volume by normal standards, the key to success of the work is that the work must be practically continuous. This has been achieved by a combination of manual digging, conveyor belts and skips. The digging is expedited by use of pneumatic spades at the face, it then falls by chutes to a conveyor belt which transports the clay to a hopper, whence it falls by gravity to skips brought underneath the discharge gate. A feature of the light gauge railway system used is that a rail runs along each side of the tunnel, one for incoming traffic and the other for outgoing skips, transfer between the two lines within this narrow width being accomplished by an electrical traverser. Refinements in the method are the retractable conveyor belt which permits the placing of the lining with the minimum interference to the spoil removal, and the fact that the whole of the conveyor belt and its accessory equipment is drawn along with the shield as it is propelled forward. The article includes some excellent photographs of the work in progress, and a diagram of the skip loading part of the system.

The Development of Pre-stressed Concrete in Switzerland

Readers familiar with the several systems of pre-stressing used in this country will be aware that the only points of difference between any two systems often only involves the question of detail in the anchor grips and the type of jack used. Ingenuity is often applied merely to prevent infringement of copyright rather than to improve the technical efficiency of the system. The article describes the B.B.R.V. system widely used in Switzerland. The essential difference is that the anchor grip is formed by upsetting the ends of the wire to produce a button, the existence of which prevents the wire from being drawn through a hole drilled in the anchor head. The whole cable is tensioned by attaching a jack to the anchor head by a threaded bolt. The existence of this bolt together with a large bearing nut gives the system its one advantage over other methods. This is that jacking may be carried out by stages, or the cable may be completely detensioned if desired. A disadvantage in the system is that buttons have to be positioned rather accurately, and a comparatively large machine is required to form the buttons; on the other hand, there is no recurring cost for anchor grips. A series of excellent diagrams and photographs adequately illustrate the article which is to be concluded.

Rail Mounted Viaduct Inspection Unit

Pictures of this equipment used by British Railways have appeared in the National Press, and readers may be familiar with them. The Inspection unit resembles, on appearance, a back actor excavator with the cab pivoted on a rail flat wagon instead of a tractor. There is an inspection platform instead of a bucket, which enables the inspector to board the platform at rail level, and then to be transported under the bridge to carry out the inspection. Duplicate controls on the platform permit the inspector to be moved in any direction in space whilst under the arch. The payload on the platform is 600 lb. and its dimensions are 7 ft. by 2 ft. 10 in. An immediate military application of such a machine that comes to mind is its use for placing demolition charges rapidly, or even to assist in taking measurements on bridge classification. The article includes only one general photograph showing the equipment in operation.

Notes from *Civil Engineering*, February, 1958

Prestressed Concrete Jetty at Erith

The design is in precast concrete, post-tensioned by the Lee McCall system. The superstructure is mounted on concrete cylinders sunk vertically in the hard chalk below the river bed. The cylinders were sunk by grabbing and weighting, and were finally sealed off by Colgrouting aggregate deposited in the bottom, keyed to the roughened inner surface of the bottom ring of the cylinder, and were finally pumped out and filled with concrete.

Points of interest in the design were:

1. The key to the design was the rate of discharge of the ship—this specified the gantry cranes, and the jetty was then designed to accommodate the gantry selected.
2. A turntable for road vehicles is provided at the end of the jetty to cut out reversing down the jetty.
3. The "novel and ingenious shock absorbing device" is not, unfortunately, fully described.

The article is well illustrated with photographs and drawings.

The Measurement by Optical Reflection of Water Levels in Hydraulic Models

The aim was to measure water levels, by measuring changes in the reflection of an illuminated vertical scale in a theodolite telescope, without disturbing the water surface with a pointer. The method described enables readings to be taken very quickly at a number of points, but the accuracy of each reading appears to be no greater than that obtained by a pointer.

Designing a Slab Using the Fracture Line Theory

The problem of designing a slab supported by pillars set at irregular spacings, with a variable loading pattern, is tackled by applying the fracture line theory. Typical failure patterns in the slab were analyzed, using the principal of virtual work. The distances the various fractured parts of the slab would move for a small deflection at the point of application of the load were calculated by geometry. The conclusions reached tended to confirm that the normal code of practice is conservative. The article would be of more value if the quality of steel given by this closer design were related to that given by the code of practice (and more simple design). The mathematics involved in the article are simple, and clearly set out.

The Introduction of Universal Beams

Messrs. Dorman Long (Steel) Ltd. have now completed their new rolling mill at Lackenby and British engineers will therefore be in a position in the near future to select from a much wider range of steel sections, many of them with increased section moduli compared with current sections of equal weight.

Aluminium Dome of Novel Design

The article describes the design of a domed roof made up of small aluminium panels bolted together. The dome was erected by thirty-eight men in six days (including erecting and dismantling the portable mast). It was 145 ft. in diameter, 49 ft. 6 in. in height, and provided an auditorium of 2,000 seating capacity. The dome weighed 39,000 lb., made up of 575 panels, using ten different panel sizes, each coloured for ready identification. Tested to 100 lb./sq. ft. loading, there are no internal supports required.

Ground Water Lowering for a River Weir

The article is very difficult to follow. It gives a line on the calculations involved in determining the size of pump required to lower ground water to the level required for dry working. It is notable that the answer arrived at in the particular case was 9.6 cu. in. per hour—and "for practical purposes, pumps with a capacity of 20 cu. in. per hr. were ordered". Later tests on the site corroborated the theoretical answer.

The Construction Cost Guide

The table gives a very useful guide from the financial aspect, seldom considered by Sapper Officers, to the cost of items of earth moving plant, derricks, decauville engines and the like.

Notes from *Civil Engineering*, March, 1958

Engineering Developments in the U.S.S.R.

The article describes the use of no-fines concrete in polar regions. Ease of transport, prefabricating under warm conditions, small fire risk and reasonable thermal properties give no-fines concrete advantages over timber and normal concrete. The article also describes methods of heating during pouring and curing the concrete, and favours electricity as the method, subject to conditions described.

The New Pannier Market at Plymouth

The vaults of the barrel roof are tilted to form a north light profile, thus achieving a well illuminated area of 224 ft. by 152 ft. without internal supports.

The main problem in design is the calculation of stresses in the main frame, for which the method known as "Column Analogy" by Professor H. Cross is described. Although the analysis is complicated, the next chapter may produce simple rules by which answers may be obtained with sufficient accuracy.

Bridges with Prefabricated Steel Floors

British Railways (Western Region) have achieved economies by standardization in designing both the main beams and the floor units for standard pattern bridges ranging from 26 ft. to 100 ft. span. The floor panel, consisting of cross girders and troughing, simply bolts to the flanges of the main girder stiffeners. The advantages are:

Simple (and fewer) drawings required.
Repetition work, saving jigs.
Experience gained with practice.
Similarity makes examination and inspection of bridges easier.
Speed of work on site—often critical in railway work.
Factory control of welds.
The article is well illustrated by photographs and drawings.

Soil Cement

Part I of the article by S. Raymond deals, in very general terms, in simple soil stabilization. He gives a list of properties which are required for reasonable results by cement stabilization.

The author recommends the addition of calcium chloride, or extra-rapid-hardening cement, with soils whose organic content lies between 2 and 4 per cent. He also refers to lime as an additive where the pH value of the soil lies below 7. The article describes design methods based on tests in the laboratory and on site. Treating the resulting pavement as being flexible permits the C.B.R. method of design to be used. The author is to continue his article—apparently with more detail as to how some account may be taken of the rigidity of the pavement (and the thickness thereby reduced).

The picture of the Howard train included in the text is not very detailed. The two graphs included are, however, very informative as to the effect of water/cement content on the strength of the material.

Yangtse River Bridge

Dr. Yi-Sheng describes the design and completion of the first bridge over China's biggest river, entirely by Chinese efforts.

The description is well illustrated by photos and drawings, and this first chapter deals, very interestingly, with some of the major decisions taken in establishing the basic design. These were:

(*a*) The limited size of gusset plates that could be rolled in China pointed to a rhombus truss instead of a Warren or Pratt truss.

(*b*) Ease of fabrication of identical sections discouraged the use of K. trusses of varying sizes.

(*c*) Ease of fabrication, erection, and maintenance encouraged the use of H section members.

(*d*) Difficulties in constructing the pier foundations lay in both the excessive rise and fall of the Yangtse and also in the nature of the very uneven river bed, whose bed rock is very laminated, with a nearly vertical dip. This led to the rejection of the traditional "pneumatic caisson" method. The process adopted is to be described in the next article.

Design of Airports and Runways

This first chapter of a series of articles deals in generalities with the requirements and principles guiding the design of an airport; the factors considered are in essence those set out in the *R.E. Recce Pocket Book*, with the addition of several non-military factors such as aviation schools, private flying, aerial photography, the growth of satellite urban development, the costs of bus fares, etc.

The Weinland Bridge

This competition produced twenty-one solutions to the problem set. The results have yet to be analysed as to cost, ease, architectural beauty, etc. It is interesting to note that the normal reinforced concrete arch ring bridges were quickest off the drawing board, and that some prestressed concrete designs look decidedly cumbersome.

Concrete Wine Vats made on Inflated Balloon Templates

Another use has been found for the process of inflating a shaped balloon, spreading wire mesh, gunniting the surface, and withdrawing the bag after the concrete has set. In this case the sides of the vats are vertical and the floor circular. It seems possible a "barrack hut shape" could be inflated, with doors and windows already framed and wired to the reinforcement and concreted.

Concrete Mixing Train

British Railways again tackle limited working periods by mechanization. The article describes a mobile batching plant with everything rail-mounted. The ballast trucks feed the mixer by a conveyor belt which runs the length of the train. Water and cement are also carried in the train itself and are batched together continuously by a screw feed mixer. The train, designed for planting electrification masts, combines with a mechanical auger-borer, and steelwork erection rail-mounted crane, to form a composite "train" for rapid concrete work spread at intervals along the track.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, December, 1957.

Queen Elizabeth Hotel, Montreal

This issue includes four papers dealing with the design and construction of a twenty-one-storey hotel, with 1,216 guest rooms, built above eleven railway tracks at the Central Station.

The general description given in the fourth paper deals only with the functional and amenity aspects, and includes neither a site plan nor a clear summary of the over-all engineering problem.

The first paper describes particular features of the foundations, the construction of a 380-ft. long retaining wall, some fifty feet high, to replace a natural earth bank without causing movement of the adjoining cathedral, and the "tailoring" of foundations to the condition of the underlying limestone, which was in places weakened by seams and pockets of plastic material. A particularly interesting and novel feature is the use of isolation pads, comprising five layers of dissimilar materials in compression, to exclude from the building structure noise and vibration from trains passing underneath.

The second paper gives details of the method used to overcome wind pressure on a particularly tall and narrow building. Flat plate bracing bars, used initially for temporary erection bracing, were later pretensioned to serve as permanent bracing, the operation being carried out by heating, clamping, and welding *in situ*. This method enabled the bracing to be enclosed within 6-in. partitions.

The third paper is an outline of electrical and mechanical services. The main electricity supply is taken from two underground cables at 12,000 volts, and steam from a boiler plant some three-quarters of a mile away is delivered at 375 p.s.i.g. and 500°F. Services and amenities are provided on a lavish scale.

The Oak Street and Middle Arm Bridges, Vancouver

Limited bridge capacity across the Fraser River had seriously restricted traffic between Vancouver, the international airport, and the route to the U.S. border, until two new bridges were opened in 1957. The Oak Street bridge provides a four-lane outlet to Lulu Island and the United States, and the Middle Arm bridge is a two-lane connexion from Lulu Island to the airport on Sea Island.

The choice of design in each case was governed mainly by economic considerations, and the paper is largely concerned with that aspect, so that its arrangement, from the engineering point of view, is not ideal, but clear line drawings augment the text.

The Oak Street bridge approaches are both made up of continuous 60-ft. spans of reinforced concrete, rising at 1 in 50. The North approach is about 1,900 ft. long, and the south approach over 3,000 ft. The actual river crossing is in two sections. The northerly 706 ft. comprises R.C. decking, supported by two continuous riveted steel plate girders, the span over the main navigation channel being 300 ft., and the flanking spans each 203 ft. The southerly 600 ft. consists of five 120-ft. simple spans of composite concrete slab and welded steel girders.

The main feature of the two-lane Middle Arm bridge is a hydraulically operated swing span, of steel plate girder construction, which gives a 60-ft. waterway on either side of the central pier. The approaches are graded at 1 in 33. The eastern approach, 560 ft. long, consists of 40 ft. simple span pretensioned concrete stringers, carried on prestressed concrete friction piles and supporting R.C. decking. The western approach has eight 40-ft. spans of exactly similar construction, and one 88-ft. simple span of post-tensioned concrete. This span provides a minimum vertical clearance of 17 ft., for the passage of small craft without opening the swing span.

Notes from *The Engineering Journal of Canada*, January, 1958.

This issue contains four papers which, while not of primary interest to the military engineer, provide valuable information in particular fields.

Recent expansion of Canadian overseas telecommunication facilities indicates clearly the potential value of Canada in Commonwealth communications, and discusses briefly the development of trans-ocean submarine cables.

Battle River Steam Station describes the planning, design, and equipment of a power plant burning pulverized coal.

Forces involved in pulpwood holding grounds is an interesting exposition of an unusual and complex mathematical problem.

Air pollution control at a nylon intermediates plant demonstrates what can be done by scientific investigation and design to minimize contamination.

Notes from *The Engineering Journal of Canada*, February, 1958.

Winter Construction

This paper is not concerned with construction in the permafrost zone, but is a plea for the continuation of normal building throughout the year, in order to reduce the present serious seasonal unemployment during the Canadian winter. Measures adopted in Scandinavia and the U.S.S.R. are described, and the methods recommended include the use of enclosed protective hoardings, welding and grouting of prefabricated columns and panels, electric heating of concrete, and "cold concreting".

The latter method is interesting since, although calcium chloride in quantities up to about 2 per cent by weight of cement has been widely used as an accelerator, "cold concreting" employs much larger quantities of salts as anti-freeze. Calcium and sodium chloride are used, in proportions varying with temperature conditions, and the total amount of salts may be as much as 20 per cent by weight of the water in the mix. Some figures for compressive strength are given.

Installation and Operating Experiences with Kemano 2,500-ft. Head Impulse Turbines

This is an interesting account of the installation of three 150,000 h.p. vertical impulse turbines, and it is extremely well illustrated by photographs. Operating tests are summarized, and metallurgical teething troubles are briefly described.

Manufacture and Metallurgy of Flash-welded Line Pipe

In flash-welding, coalescence of abutting surfaces is produced by heat from resistance to electricity flow between the surfaces, reinforced by pressure. To weld a 40-ft. length of pipe a current of 1 million amperes may be needed.

The development of this process has been mainly instrumental in meeting the enormous demand for large diameter pipe for the oil and gas industries, and the same method is commonly used for the manufacture of aircraft bomb casings and oil-well drill stems. Particular advantages are that no chemical composition change occurs between the weld and its parent metal, and heat treatment properties remain similar. Besides its obvious advantages, cold bending of pipe in the field retains the high-strength properties of flash-welded pipe.

Christmas Cards

The choice of the right Christmas card is a problem for most of us: how to decide which is the best design or the best size or the most appropriate words? These problems should not arise if you are in Her Majesty's Forces where Naafi's Printing Branch is at your service. Here you will find skilled craftsmen with years of experience who are familiar with all aspects of Christmas card design and are eager to give you the benefit of their knowledge. Each year they print over a million Christmas cards for Servicemen and women the world over from a unique collection of Service and Regimental crests, dies and ribbons.

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