The Royal Engineers Journal

VOL. LVIII MARCH, 1944

CONTENTS

Published Quarterly by
THE INSTITUTION OF ROYAL ENGINEERS
CHATHAM, KENT
Telephone: Chatham 2669

AGENTS and PRINTERS: W. & J. MACKAY & CO., LTD., CHATHAM.
LONDON AGENTS: HUGH REES, LTD., 47, PALL MALL, S.W.1.

THE ROYAL JOURNAL—MARCH, 1944. Pages 1—74.

PIPE LINES WITH VICTAULIC FLEXIBLE JOINTS FOR SERVICE WORK. The ideal joint for emergency purposes. The standard bolted joint can be fitted by unskilled labour in under two minutes per joint. The toggle joint, without bolts, is automatically fastened mechanically in a few seconds.

The War Office and India Stores Department have standardized Victaulic Joints for mobilization work.

Copy of our Victaulic Catalogue will be sent on request.

Air main with Victaulic Joints slung on two steel cables across the gorge of the Hikonege River, Japan. View shows a 200-ft span of 8-in. line.

THE VICTAULIC COMPANY LTD.

Brook House, 113 Park Lane, London, W.1.

THE ROYAL ENGINEERS JOURNAL

VOL. LVIII | CONTENTS | MARCH, 1944

The attention of all Contributors is drawn to K.R. Para. 547(c). Permission to publish can be applied for by the Editor.

THE COUNCIL OF THE INSTITUTION OF ROYAL ENGINEERS

(*Incorporated by Royal Charter, 27th February, 1923*)

Patron—HIS MAJESTY THE KING

President

Maj.-Gen. G. H. Addison, C.B., C.M.G., D.S.O., M.A., M.I.Mech.E., Col. Commandant, R.E. 1941

Vice-Presidents

Maj.-Gen. A. G. B. Buchanan, M.Inst.C.E. 1942

Maj.-Gen. C. J. S. King, C.B., C.B.E., M.Inst.C.E. 1943

Elected

Col. A. L. Abbott, M.C., T.D. 1941

Col. D. Portway, T.D., M.A., A.M.Inst.C.E. 1941

Brig. A. P. Sayer, D.S.O. 1941

Brig. A. C. Shortt, *p.s.c.*† 1941

Col. H. E. Moore, D.S.O., M.C. 1941

Lieut.-Gen. Sir Lionel V. Bond, K.B.E., C.B., *p.s.c.*†, Col. Commandant, R.E. 1942

Lieut.-Col. A. W. G. Dobbie, *p.s.c.* 1942

Col. H. W. Tomlinson 1942

Col. E. E. B. Mackintosh, D.S.O. 1942

Lieut.-Col. F. L. Stroud 1942

Col. B. C. T. Freeland 1943

Col. E. Rait Kerr, M.C. 1943

Brig. G. E. H. Sim, D.S.O., M.C., *p.s.c.*† 1943

Maj.-Gen. J. C. F. Holland, D.F.C., *p.s.c.*† 1943

Col. J. R. T. Aldous, M.C., *p.s.c.*† 1943

Ex-Officio

Brig. L. O. Clark, O.B.E., *p.s.c.*†.

Brig. H. E. Hopthrow, O.B.E., M.I.Mech.E.

Maj.-Gen. D. J. McMullen, C.B.E., D.S.O.

Col. W. D. Robertson, D.S.O.

Brig. H. T. S. King, O.B.E.

Major D. C. Cameron

Lieut.-Col. G. T. H. Capron

Corresponding Members

Maj.-Gen. T. R. Williams, C.M.G., D.S.O., *Australian Staff Corps* ... 28th January, 1930

Lieut.-Col. W. H. Blake, M.C., *Royal Canadian Engineers* ... ... 15th June, 1943

Col. G. H. Cotton, M.I.Mech.E., S.A. *Staff Corps* ... ... 7th June, 1939

Col. G. H. Clifton, M.C., *p.s.c.*†., *N. Zealand Staff Corps* ... ... 27th July, 1937

Permanent Honorary Secretary

Col. F. E. G. Skey ... ... 1st August, 1943

Secretary and Editor R.E. Journal :

Col. H. M. Fordham, O.B.E., M.C., A.M.I.E.E. ... ... 1st August, 1943

Bankers

Lloyds Bank, Ltd., Cox's and King's Branch, 6, Pall Mall, S.W.1.

2,325 1.3.44

The River Face, Old Fort William

EARLY ENGINEERS OF THE EAST INDIA COMPANY

By Lieut.-Colonel E. W. C. Sandes, D.S.O., M.C., R.E. (retd).

FOR more than a century after the East India Company had built a little factory in 1611 at Masulipatam on the east coast, there was not a trained engineer in India. Thomas Aldworth established the next small factory at Surat on the west coast in 1612, but he had no need for engineering as he was concerned only with trade. With the permission of the Mughal Emperor he hired a building in the town and devoted himself to conciliating the native rulers and extending his business inland, though obstructed at every point by the Portuguese, whose fleet had been defeated by the Company's ships, and whose trading monopoly he impaired. The Company had started its operations at Bantam in Java in 1603, but it could not compete with the Dutch in Malaya and turned for consolation to India. The Masulipatam venture failed and the importance of Bantam waned, so that in 1634 Surat became the headquarters in the East and was recognized as such until it was supplanted by Bombay in 1687.

Surrounded by warlike nations, the early British settlements existed only on sufferance. A policy of peaceful penetration was forced on the Company by the refusal of the Mughals to allow any Europeans to build fortifications, and consequently British trade clung precariously to the coasts, where it had the occasional support of the Company's ships, though it lay at the mercy of powerful European rivals and the fickle rulers of the country. There was not a penny to spare after the avaricious Mughals had been satisfied. The traders were wretchedly paid. They were separated from home by thousands of miles of ocean and humiliated by their obvious lack of military strength. They lost their self-respect; their morals deteriorated, and they drank deeply and gambled heavily. Few survived more than ten years against the assaults of cholera, dysentery and malaria. With no pension in prospect, they tried to amass by private trade sufficient money to safeguard them against penury in old age. It was only natural that, in such an atmosphere, discipline should become lax and cases of insubordination multiply. The agents, merchants, factors, and writers quarrelled and fought. They accused each other of illicit profit-taking, bribery, and theft. As there were few, if any, Englishwomen, some of the men married natives and relinquished all thoughts of home. Others took native mistresses or seduced the wives of their companions. Indeed, it soon became apparent to the Directors in England that, if they were to succeed in the race for Indian trade, they must maintain an armed force to protect their goods and police their settlements. Accordingly, every factory was surrounded by a wall and provided with a guard of native watchmen; but when the factories increased in size, and their contents in value, a better system of defence became necessary involving higher walls of superior design and workmanship. The local native potentates then began to cast envious eyes on the merchandise stored in the more pretentious factories. They had primitive artillery and were quite prepared to use it, and so the factories had to be armed with guns landed from ships and mounted and manned by sailors. The guns needed platforms and embrasures, which were made under the supervision of the ship's Gunner and his crew, so the Gunner took up his quarters ashore and remained there as the scientific expert of the community and its adviser in all matters of engineering. Thus the first British engineers in India were usually the Gunners of the Company's ships, though anyone was free to take a hand and ships' captains, doctors, chaplains, paymasters, and wandering adventurers of all sorts did so from time to time.

More than a century later, the military engineer was defined in the following terms by the *Society of Gentlemen* :—" An able, expert man, who, by a perfect knowledge of mathematics, delineates upon paper, or marks upon the ground, all sorts of forts and other proper works for offence and defence. He should understand the art of fortification so as to be able not only to discover the defects of a place but to find a remedy proper for them, as also how to make an attack upon, as well as to defend, the place. Engineers are extremely necessary for these purposes. Wherefore it is necessary that, besides being ingenious, they should be brave in proportion." The Gunners of the East India Company's ships in the early 17th century had no qualifications other than bravery and some ingenuity. They built walls, mounted guns, erected houses and huts and dug wells, and no more was expected of them. Mathematics did not interest them. They were hardy sailors, who were probably only too glad to exchange their customary diet of salt pork and biscuits for the plentiful fare of the " Company's table " ashore and the chance of making substantial profits as contractors.

The failure of trade at Masulipatam led to the foundation of the first fortified British settlement in India, and thus paved the way for the recruitment of a better type of engineer than the Gunner, though the process was very slow. Thomas Ivie, voyaging from Bantam to become Agent at Masulipatam in 1639, touched at a small settlement called Armagon, where Francis Day was agent, and agreed that Day should reconnoitre southwards for a new settlement where the interference of the Dutch might be less marked. Day found a suitable spot about 230 miles to the south, where he induced the local *Naik** to grant some land and certain privileges including the building of a fort, and he then went to Masulipatam and reported his success to Andrew Cogan, who had superseded Ivie as Agent. Cogan and Day dismantled the post at Armagon and sailed to the new site in February, 1640, with one or two other factors, a few writers, a Gunner, a surgeon, a native powder-maker, 25 armed men, and a rabble of servants. They were in three little ships, each of about 100 tons burden. On arrival at their destination, they disembarked through the surf and began to erect palm shelters on the beach and occupy some native huts which they had hired in the adjacent fishing hamlet of Madrasapatam. It seems that the *Naik* had promised Day that he would build a proper fort for him ; but when it transpired that the work would be merely a stockade of toddy palms, Cogan, Day and their following began to dig and build in earnest. Their factory house was designed to have three storeys and to be enclosed by a wall with bastions for guns at each corner. The natives supplied them with clay for bricks and lime for mortar, and stone was procurable inland.

The original enclosure at Madrasapatam was almost square in plan. The east side, about 108 yards in length, faced the sea and the west side overlooked a loop of the sluggish Elambore River. In the centre, placed diagonally to the square was the factory house, a lay-out which enabled the garrison to cover the gorge of each bastion with fire from the house. When the masonry work of the house had progressed sufficiently, the builders began to construct the south-east bastion of the enclosure, which was exposed to attack from the Portuguese at St. Thomé, a few miles to the south. This was finished within the next few months and the other sea-bastion was completed a year later, both being of brick-in-mud, cased with stone. By 1643 the north-west

* A Governor (*Circa* 1600)

bastion had been built; but a sum of £4,150 had been spent on the various works, and as this annoyed the Directors the Madras Council was obliged to call a halt. The building of the south-west bastion occupied several years, and as for the curtain walls, only one of the four was ready by 1652 and the entire enclosure was not finished till 1654. That 14 years were spent in making this small fortification shows how trivial a place military considerations occupied in the minds of the Directors and their servants, though it is probable that some delay was due to the diversion into other channels of money allotted to engineering and to a leakage into the pockets of the builders. Day was a bad character, and neither he nor Cogan is commemorated in Madras by statue, portrait or place-name, but he was the earliest British architect in India and as such he should be remembered.

Trade at Madras expanded so rapidly that the population increased year by year. Long before the original fortified enclosure was completed, a "White Town," or European quarter, had sprung up north of the fort, and beyond it a "Black Town," or native quarter, was spreading northwards. To protect the inhabitants of these areas it became necessary, between 1644 and 1648, to build an earthern wall around the towns, and between 1654 and 1666 the original enclosure and White Town were surrounded by new or remodelled fortifications of a permanent nature. The expansion of trade, with its consequent additional commitments and responsibilities, forced the Company into large engineering schemes and the eventual recruitment of properly qualified engineers.

The first British military engineer in India was undoubtedly Jeremy Roote. He must have been the Gunner who arrived at Madrasapatam with Cogan and Day in 1640, for the Council wrote to Bantam in October, 1645: "Wee should have sent Jeremy Roote had hee not been at deaths dore at the departure of the *Advice*." Jeremy recovered sufficiently to be sent in the following year to help the King of Golconda, who was blockading the Portuguese in St. Thomé, and in 1651 he was again with the Golconda army. "But for Jeremy Roote," wrote the Council, "hee is at present with the Nabob of Gulcandah who would not willingly part with him, where hee does some good offices and cannot without some prejudice to your affaires bee at this time recall'd." During Jeremy Roote's absences, the engineering work at Fort St. George devolved on John Morris, Gunner's Mate, who must have had a difficult task if we may judge from a report made in 1648 regarding the chaplain of the Fort and the nature of his flock. "Mr. Isaackson is resident at ffort St. George," wrote the Surat Council, "whither hee was sent in the hopes hee might have wrought some reformation amongst those debast soldiers, but wee believe hee is of two mylde a disposition to worke upon such rugged natures." Serving under Jeremy Roote in the Golconda camp was an energetic youngster named Hugh Dixon, who succeeded later to the post of Gunner at Fort St. George; but Mir Jumla, the Nawab of the King of Golconda, would not be content with Dixon's help and refused to let Jeremy return to Madras. "Six more are still in the Campe," wrote the Council in 1652, "amongst which is Jeremy Roote, soe often writt for, whoe wee feare will not bee spared from that Imployment until the warrs bee over without much disgust to the Nabob." Jeremy was still in the Nawab's camp in 1654. After that year his name disappears from the records. Possibly he died, as so many did, of some tropical disease. The mortality at this period was prodigious.

With little hope of leave, and less of meeting English girls in India, most of the Company's servants found consolation with native women. In 1668, however, the Directors made the experiment of sending twenty single Englishwomen to Bombay who were said to be "of sober and civil lives." The old gentlemen were careful to explain that the sober spinsters had not been invited to go but had been encouraged to take the step because they would be chaperoned on the voyage by the wife of a "person of the quallitie above a soldier" who was proceeding to India with her husband. They added that the women should be treated civilly and "accorded the respect which their virtues deserved," and in due course the prospective wives reached Bombay, where it was stated that "the virtuous character given of them challenges all fair respect." But the virtuous character soon proved a delusion and a snare. The young women saw their opportunity and began to play havoc with the morals of the traders, for within a few months their conduct was reported to have grown "scandalous to our nation, religion and government" and the Directors told the Bombay Council "to give them all fair warning that they do apply themselves to a more sober and Christian conversation; otherwise the sentence is this, that they shall be confined totally of their liberty to go abroad and fed with bread and water till they are embarked on board ship for England." It is understood that the twenty sober and civil women then married in haste and no doubt repented at leisure, for there is no record that they were sent home.

Correspondence between the Court of Directors and the Madras Council shows that bribery was recognised as justifiable and necessary in dealing with the local native rulers. With such incitement it is not surprising that the Company's servants resorted to it in personal as well as official dealings and that their standard of ethics suffered accordingly.

An extract from the records of 1665 indicates that one Christopher Wilkins probably succeeded Jeremy Roote in 1655 as Gunner at Fort St. George. Wilkins was replaced later by Hugh Dixon from the Golconda Camp who became chief Gunner, or Gunner of the Inner Fort, in 1658, and, being blessed with an iron constitution, held the post until 1677, outliving most of his contemporaries. A Fort St. George Consultation in 1672 runs "Surveighed the Buildings and Fortifications, and findeing them goinge much to ruine for want of needfull Repaires of the last yeares, by advice of the Bricklayer, Carpenter, Leiftenant Sutton and Gunner Dixon, resolved to proceede to repaire them without delay." This entry proves that responsibility for engineering was divided and that Gunner Hugh Dixon had not devoted much attention to the work. The outer defences, erected between 1653 and 1666, were superintended by the assistant Gunner, one William Dixon, who succeeded Hugh Dixon as Chief Gunner in 1677. The Gunners and their crews could not cope with the amount and complexity of the engineering work. Walls were collapsing daily through undermining by the sea or faulty material and workmanship. It was evident that expert supervision was needed and the Madras Council asked that "some knowing and experienced person should be sent out to make peers (groynes) towards both Monsoons." To which the Directors replied in 1677 "Our business is Trade not Warr. Wee question not but the Commanders of our Ships, and others you may have with you, will contrive the carrying on of the worke to make it answer our ends without sending an Engineer from hence, those sort of men being alwaies found very expensive." The Directors had already had bitter experience of the high salaries demanded by the so-called professional engineers whom they had tried to recruit for their settlement in Bombay.

William Dixon remained as Chief Gunner at Fort St. George until 1684, when he completed the building of St. Mary's Church. He was followed by Edward Fowle, engaged as "Engineer and Master Gunner" to serve for seven years on a salary of 50/- a month for the first two years and £5 a month for the remainder. It will be noticed that the title "Engineer" here makes its first appearance and precedes that of "Gunner." Fowle died in Sumatra before the end of 1685, and Robert Ivory, an Assistant Gunner who had "behaved himself very Soberly and Dilligently" during Fowle's absence, was then appointed Chief Gunner at Fort St. George, on a salary of 8 *pagodas* (77/-) a month, with Giles Scudamore as his Chief Mate or Assistant. Ivory was accorded free diet at the "General Table"; but as he proceeded at once to marry Fowle's widow it is doubtful if the hilarious company at the table saw much of him. Robert Ivory died in 1690, and his successor, Captain Lewis Putsham, lived only another two months. The mortality among the Assistant Gunners was also heavy at this period.

At length, in 1696, the Court of Directors recognised the necessity of sending out a trained engineer, and early in the following year Captain Frederick Matthew von Werlinhoffe arrived in Madras as "Engineer and Miner Generall" with a place at the General Table and precedence next to the chiefs of factories. He proved a total failure, and was dismissed in 1702 as "Constituting a great Charge to the Company to no Purpose." The Gunners then resumed control, assisted by the *Buxey* or Paymaster, and not until 1719 did the Directors experiment at Madras with another engineer. "We have entertained Captain James Johnson as Chief Engineer, Bombardier and Fireworker at Ten Pounds a Calendar Month," they wrote. "He served under my Lord Galway several years in Portugal and has satisfactory Credentials. He promises our Committee he will teach any of the Young Men under him as far as they are willing and capable to learn his Art. He has contracted to remain in India for Five years certain. We are more especially desirous that when he has completed what is necessary at Dieu (Divi Island near Masulipatam) he should be sent for one Season to Bombay, where President Boone very earnestly presses Us for One to Instruct them in some Fortifications necessary for the defence of Our Island." Johnson arrived in Madras and soon showed that he was a truculent person. His career in the Company's service was short. He started for Bombay and was ordered by Boone to join an expedition against the pirate Angria. This did not suit him. He refused and resigned, and returning to Madras died there in penury in 1721 without having imparted any knowledge of his art to anyone.

Space does not allow many further remarks on the early engineers of Madras, nor can every name be mentioned. In 1742 the Directors sent out an infantry officer, Major Charles Knipe, who had had engineering experience in Flanders, but Knipe died in the following year after serving chiefly in Calcutta. Five years later, they made a bad bargain in recruiting Captain Alexander Delavaux who deserted to the French in Pondicherry within eleven months, charged with fraud and manslaughter. In 1750 a capable Engineer General for all the settlements in India was secured at last in the person of Benjamin Robins, who landed at Fort St. David in July and visited Calcutta. Robins, however, succumbed to malaria within a year of his arrival. These men did not work only in Madras, yet they may be classed as Madras Engineers because Fort St. George had far outstripped in importance both the Bombay Fort and Old Fort William in Calcutta and claimed more attention than either. Captain John Brohier, one of Robins' protégés, carried on the work in Madras until an able successor to the late Engineer General was found in 1753 in Lieut.-Colonel Caroline Scott; but fate intervened again, for Scott died in May, 1754, and Brohier resumed charge, assisted by Captain John Call, who soon replaced him and rendered good service for many years. In 1770 Colonel Patrick Ross was appointed Chief Engineer and shortly afterwards secured proper military status for the Corps of Engineers which then existed in Madras. Fort St. George had become a powerful stronghold, second only to the new Fort William in Calcutta, and the days of amateur engineering were passed and gone.

We turn now to Bombay, to which the headquarters of the East India Company were transferred from Surat some years after the town had been acquired from the Portuguese in 1661 through the marriage of Charles II to Catherine of Braganza. The Company's servants occupied Bombay Castle, described in 1665 as " a pretty well Seated but ill Fortified House, four Brass Guns being the whole defence of the island, unless for a few Chambers (light artillery) housed in small Towers, convenient places to scower the Malabars (pirates). About the House is a delicate Garden, voiced to be the pleasantest in India, intended rather for wanton Dalliance, Love's Artillery, than to make resistance against an invading Foe." Humphrey Cooke, the Company's Agent who was sent from Surat by President Oxenden to take over Bombay on behalf of the King, found that in the arcadian Castle he was completely at the mercy of the Mughals, Portuguese, Dutch and Marathas, but he set to work with a will and was soon able to report that on the seaward face he had built a platform " wherein could play 18 peeces of large ordinance " and which would last " for many hundered yeares." To landward he raised defences " all done with turffe and cocernutt trees " and remarked " It would have coste His Majesty 5000 l. but I hope it will not coste him 100 l. for I have taken such care to have all the islanders to worke by turnes, some dayes 1000 men, some dayes 800, without paye, only something to drinke." King Charles was not impressed, and having decided that the possession of Bombay might lead him into trouble with his enemies and be a drain on his Exchequer, he transferred the place to the Company in 1668 for an annual rental of only £10 and imagined that he had made a good bargain.

In 1669 President Oxenden chose a sailor, Captain Samuel Smith, as the first Chief Engineer of Bombay when the garrison of the Castle consisted of only 5 officers, 138 European soldiers and 54 *Topasses* or Portuguese half-castes. " Captain Samuell Smith, late commander of your *Little Charles*," wrote Oxenden, " is taken ashore and now appointed Chiefe Engineere of your island and Master Comptrouler of the Ordnance, hee being very aptly qualified in his ability and practical experience, and likewise hath the approbation of all that pretend to understand anything of fortifications or gunnery, being likewise well versed in all manner of fireworkes and in playing the granadoes if occasion shall require. For his encouragemant wee have promised to encrease his sallary when he shall finish any one worke that shall express his ingenuitie."

A scheme submitted by Samuel Smith was approved and by the end of the year the new fortifications of Bombay Castle were 12 feet above ground and faced with stone, but Smith was then in his grave, struck down by dysentery and malaria.

Captain (or Colonel) Herman Bake, a German adventurer, succeeded Samuel Smith. In 1671, the Company wrote " Wee have found him a very ingenious, pious and well disposed person and receive him in the quality of Ingineer and Surveigher Generall of your Island Bombay during your pleasure." The choice was a good one, and the pious and amiable newcomer showed Teutonic thoroughness and reliability, for in 1673 the Company stated " The good character you give of Captain Herman Bake makes us hope he may bee serviceable to us. As to his sallary wee must leave it to you to make him such allowance as shall be reasonable not exceeding £60 per annum with respect to the conveniency of his diet at the Company's Table. . . . And wee desire especial care to be taken that wee be not put to any unnecessary charge in fortifying the Island, for men under the Notion of Engineers are wont to be excessive in their charge."

A Dutch fleet attempted to take Bombay by a surprise attack in 1673 and failed before the improved defences raised by the German engineer. The bastions of Bombay Fort or Castle then had 120 guns on fixed mountings and 60 small field guns, and the garrison comprised 300 British soldiers, 400 *Topasses*, 500 native militiamen and 300 natives armed with clubs. Unhappily, Herman Bake died in 1677. The Bombay Council were then able to report that they were building their fourth, last and best bastion and needed only to finish the ditch and a ravelin to make the fort the strongest in India. An overstatement, as Fort St. George was undoubtedly larger and more powerful than Bombay Castle.

A mutiny of British troops occurred in Bombay at the end of 1683, and in 1689 a catastrophe overtook the settlement. The whole island, with the exception of the Fort, was captured by Sidi Yakub, an Admiral of the Mughal fleet, and the Company had to sign a treaty under which they apologized to the Emperor Aurangzeb and agreed to pay an indemnity of £17,000 and dismiss the unfortunate Governor of Bombay. Little is recorded of the western settlement during the next quarter of a century. The garrison was reduced until it consisted of no more than 70 British soldiers and a few *Topasses* and natives. Work on the fortifications ceased, and the defences fell slowly to ruin.

Brighter days dawned with the arrival of President Charles Boone in 1715, and during the next decade much money was spent on the defences despite the veto imposed by the Mughals. As already related, Boone tried in 1719 to secure the help of Captain James Johnson, Chief Engineer in Madras, but failed because Johnson resigned. Nevertheless, he deserves much credit for his energetic administration and his care for engineering. A few years later there was a threat of a Maratha invasion which caused the Bombay Council to ignore the ban on fortification and in 1734 to appoint a sailor, Mr. Archibald Campbell, as Overseer of Works " hee being an ingenious person having a good notion of architecture and other parts of mathematicks." This Archibald Campbell was not the Lieut.-Colonel Archibald Campbell who became Chief Engineer in Calcutta and afterwards Governor of Madras. In 1737, the invasion scare having passed, two large engineering projects came under discussion—a ditch around the town wall and the fortification or removal of Dongri Hill outside the northern boundary. One Joseph Smith seems to have been the engineer in charge, and he completed the ditch before his departure to Madras in 1744. Interest in fortification then lapsed and was not revived until Captain Jacques de Funck was made Chief Engineer in 1753. De Funck, as his name might indicate, shirked all responsibility. In return for a miserable salary of £40 a year he produced an enormous report, but only after he had spent two years in writing it. His recommendations were approved and work was started. Then the Directors suddenly lost confidence in him and sent Major James Mace to supersede him in 1758. Mace had large ideas and persuaded the Bombay Council to give him a free hand, thus drawing upon that unfortunate body a stern rebuke. " Your wall and other outworks," wrote the Directors, " begun and carried on without our permission, we deem an absolute breach of orders. Even Mr. de Funcke, so loudly complained of for expensiveness which you have already more than doubled, could never be brought into such measures " ; and after Mace's death in 1761, while Captain Andrew Werner was acting as Chief Engineer, the Directors added bitterly " On the least opening given them the engineers will be ever forming new projects. Once for all we do positively tell you that we shall call upon you in another manner if our orders are thus disregarded." The Bombay Councillors were not unduly perturbed. Horsewhipping is scarcely possible across 5,000 miles of ocean.

In 1764 a Chief Engineer was appointed to Bombay who was said to be "very well recommended for a gentleman of abilities in his profession." The new arrival was Captain Thomas Keating, who was to receive £300 a year as Principal Engineer and a further £200 a year as Captain of Artillery. Keating was an efficient engineer, and by 1769, though funds were scarce, he had converted Bombay into a good naval base and, with the advice of Lieut.-Colonel Archibald Campbell, Chief Engineer of Bengal, had solved the problem of Dongri Hill "one of the most obstinate works ever undertaken." Keating was also a good soldier, and in 1774, as a Lieut.-Colonel, he was the first engineer in India to command a mixed force in the field. He captured Karanja Island and a fort on Salsette Island from the Marathas and afterwards operated against them successfully in Baroda. His downfall came through dabbling in politics and, though acquitted by a court martial, he left the service after handing over charge to Captain Lawrence Nilson, who became in 1777 the first Chief Engineer of Bombay to hold military rank as an Engineer after the separation of the Artillery from the Engineers. In 1784 Nilson was appointed Commander-in-Chief of all the forces on the western coast while still acting as Chief Engineer and did not retire until he had completed 37 years' service in India.

The early engineers of Bombay had their relaxations. They hunted tigers in Salsette, coursed hares on Malabar Hill, gambled and drank *arrack* at Thana, visited the hot springs at Bankot, consulted astrologers on their investments and love affairs, and appeared in breeches and wigs at fashionable evening gatherings at Panel or the Royal Bastion; and on Sunday, in sober attire, they sat in church, with their feet on a mud floor, and slept through an interminable sermon or gazed at the flies disporting themselves on window panes made from the translucent lining of oyster shells in the absence of glass. Yet the ostentatious gaiety of their recreations, and the repose of their Sundays, were haunted always by a sense of fear and uncertainty. Life hung by a thread. Eventually poverty in England faced the over-scrupulous. The Company's servants of the 18th Century ate, drank and made merry for tomorrow they might die or within ten years be rotting in a London garret.

And now to Bengal, where engineering began in a small way. The identity of the original builders of Old Fort William in Calcutta is wrapped in mystery. At the end of the 16th Century the Portuguese had a fortified settlement at Hugli, a place on the Hugli River some 26 miles above the site of modern Calcutta. The British, coveting the Bengal trade, established an undefended factory at Balasore in 1637 and, following the Portuguese up the Hugli in 1650, pushed on to Cossimbazar and Patna where they tried to maintain a foothold in competition with the Portuguese and Dutch. The celebrated Job Charnock, founder of Calcutta, arrived in Bengal in 1685 when the Directors were planning to capture and fortify Chittagong to the east of the Ganges delta. They were thoroughly disgusted by events on the Hugli. There were no professional engineers in Bengal in 1685, and the need for their services ceased at the end of 1688 when Job Charnock and his following of 400 armed men were expelled by the Mughals and the British venture in Bengal seemed to have come to an untimely end. In 1690, however, the Mughals relented and Charnock sailed once more up the Hugli and camped on some high ground in a swamp at Sutanuti, close to the village of Kalikata. The little company was soon decimated by fever, and Charnock himself died there at the beginning of 1693. The desperate situation of the traders was saved in the autumn by the arrival of Sir John Goldsborough as "Commissary Generall, Admirall of the East India Fleet and Chief Governour" and the appointment of Charles Eyre as Agent. Goldsborough was a reformer who followed the Company's precept of "a Penny saved is two Pence gott," but he was wise in his generation and used his saved pence to build a mud wall around a brick house and some thatched huts which Charnock had acquired on the left bank of the Hugli at Kalikata. Thus he laid the foundations of Old Fort William. His death, three months later, was a serious blow to British interests, although in Charles Eyre the Company found a worthy successor. Eyre wrung from the Nawab of Dacca a grudging consent to the fortification of the growing settlement at Kalikata. He added a bastion to Goldsborough's mud wall and in 1697 applied to Madras for ten guns. The Nawab was bribed into acquiescence. "Your Present to the Prince was very considerable and made a large hole in our Cash," remarked the Directors, "but since you were necessitated thereunto you did well to take that advantage for getting his Grant. You may go on now in making any necessary Additional Strength to our ffortifications without feare of giving Umbrage to the Moors, because they can't pretend to make an inquisition in a Place where they having nothing to do withall." Charles Eyre, and John Beard who succeeded him in 1700, followed this sound advice and Old Fort William became gradually a powerful, if primitive, work of defence, though its field of fire was obstructed from the outset by houses which sprang up close around the walls.

The building of the masonry enclosure known as Old Fort William was completed in 1716 after many Master Gunners had been concerned in the later stages of the work.

For the next thirty years improvements to the Fort were often contemplated but none reached fruition. The Calcutta Council complained that no capable engineer in their service ever lived long enough to start work, and recommended that one should be discharged because he belonged to the category described by the Directors as "People with Expencive Scheems in their Heads."

In 1746, aghast at the surrender of Fort St. George to the French, the Company became nervous about the state of Old Fort William and obtained suggestions from a certain Captain Robert Hamilton for strengthening the works. Then, as already related, the Directors made the sad mistake of recruiting the treacherous Captain Alexander Delavaux as Engineer General, but that slippery individual never visited Calcutta though it was intended that he should do so in 1748. The northern settlement had to be content for a time with the services of Major Mosman of the 55th Foot. At last came the eminent Benjamin Robins, who visited Calcutta in March, 1751, and advised on the defences of Old Fort William before returning to the Madras coast and dying there of malaria. Colonel Caroline Scott, the next Engineer General arrived from Madras in 1753 but he also succumbed soon after his return to that place in 1754. Nevertheless, his visit of inspection to Calcutta was not wasted for he prepared two schemes of defence, and it is safe to say that if either had been carried out the tragedy of the Black Hole would have been averted. But Old Fort William fell to Siraj-ud-Daula on 20th June, 1756, after the engineer in charge—a man named Charles O'Hara from Madras—had deserted his post. British prestige then lay prone until Calcutta was retaken in the following year by Colonel Clive and Admiral Watson.

When Clive had defeated Siraj-ud-Daula at Plassey he wished to build a new Fort William, but he could find no trained engineer in Bengal except Captain Robert Barker, who had accompanied him from Madras, and Barker as he was well aware, preferred gunnery to engineering. In Madras, however, was Captain John Brohier, a better exponent of the art, and consequently he induced the Calcutta Council to apply for Brohier and the latter arrived in Calcutta in June, 1757. Brohier's first proposal was to build an hexagonal citadel in the town itself immediately south of the ruins of Old Fort William. Fortunately, this scheme was defeated by Clive, and Brohier next produced a design for an octagonal fort south of the town. It was to be an elaborate work on the Vauban trace which was popular in Europe. The design was approved by Clive, and the Directors were informed at the end of 1758 that the main fortifications alone would cost them more than £200,000. They were appalled and said so in no measured terms, but they could see no way out of their difficulties except to suggest that, as in Bombay, part of the expenditure should be met by taxing the inhabitants. When Clive left India in February, 1760, the preliminary operations for the building of New Fort William had been in hand for a year, and Captain John Brohier had already begun a series of fraudulent transactions which brought ruin on himself and discredit on his country. He tried to bribe Governor Holwell to suppress the evidence accumulated against him, and having failed, was placed under arrest. Released on parole, he offered to refund about £7,000 of the money he was alleged to have embezzled; but while the offer was under consideration he broke his parole and absconded to the Dutch in Ceylon, having defrauded the Company of more than £30,000 in less than two years.

It is unnecessary to describe in detail the building of New Fort William. Many engineers were concerned in it. Captain Thomas Amphlett took Brohier's place in June, 1760, and was relieved in October, 1762, by Captain Anthony Polier. Both were honest, though inexperienced. Then came Captain Fleming Martin, an ardent reformer and economist, who arrived in September, 1764, and submitted a devastating report in which he advocated a less ambitious design and many financial retrenchments. With the tragedy of the Black Hole in mind, the Calcutta Council refused to agree to any curtailment of the original scheme; in consequence Martin resigned and handed over charge in February, 1769, to Lieut.-Colonel Archibald Campbell who has been mentioned already in connection with Bombay. Campbell infused new life into the work, and when he relinquished it to Major James Lillyman in September, 1772, he had evolved order out of chaos. Lillyman was also a happy choice. In four years he brought New Fort William almost to completion, leaving the finishing touches to be given by Lieut.-Colonel Henry Watson between 1776 and 1781. These master hands perfected and completed an undertaking begun by a clever scoundrel, and although New Fort William cost the Company more than £2,000,000, it was well worth the expenditure involved.

The fact that military engineers were defined in 1763 as men who designed and laid out forts shows that, until the Company's armies passed from the defensive to the offensive against the Marathas, they were regarded as attackers or defenders of fortresses rather than officers competent to command technical troops in the field. Poorly paid and exposed to every temptation, it says much for their strength of character that with a few exceptions they steered a straight course. In the latter part of the 18th Century the engineers were well educated and experienced men. They were greatly superior to the mariners and adventurers of the 17th Century who built mud walls around the first British settlements in India, mounted ships' guns on brick bastions, and lined their pockets at the Company's expense by private trade. The Company's servants of the 17th Century, if they survived the rigours of the climate and the effects of over-indulgence in liquor, either retired as wealthy Nabobs of the East Indies or lost their money at the tables and died in a debtors' prison. They were gamblers in health and wealth; yet it may be that they were fitted to the turbulent times in which they lived, and that some part of the subsequent success of England in the East was due to their hardihood and reckless daring.

WELDING OF ARMOUR PLATE

By Brigadier W. M. Blagden, O.B.E.

Structure of Pre-War Armoured Fighting Vehicles

UP to the beginning of the present war the hulls and turrets of British Armoured Fighting Vehicles were made up of relatively thin plates of armour, bolted and riveted to a mild steel framework, composed of flats and angles. The armour was either of the cemented type, known as C.T.A., having a very hard carburized outer face, or of the homogeneous type, "Homo-hard," which was of uniform hardness and carbon content throughout its thickness.

The standard of protection aimed at in those days was designed to provide immunity from attack by armour piercing projectiles of the small arms class, with the thinnest and therefore the lightest possible plates. The thickness of vertical armour required to defeat the .303" and 7.92 m.m. A.P. bullet of those days was of the order of 12 m.m. of C.T.A. or 14 m.m. of "homo-hard." Horizontal plates, and any which were set at an angle to the vertical, might safely be made thinner than this, so that plate thicknesses down to 4 m.m. were encountered.

Anxiety was never absent as to the possible weakness of joints between plates, but the backing provided by the framework was considered to compensate for this. Apart from keeping out the cores of A.P. bullets, however, it was necessary to keep the molten lead splash from the ordinary ball S.A.A. from getting into the hull; the gap between adjacent plates had therefore to be kept down to within very small limits, and this called for extremely accurate profiling of the plates.

The C.T.A. plate would have a hardness value of about 600 Brinell on the outer face and 400 on the inner, whereas the homo would be about 450 Brinell on both sides. Either steel was most troublesome to machine in the hardened state, the C.T.A. being naturally the worst, and the armour plate manufacturers had to instal highly specialized machinery for the purpose. This made armour plate costly and difficult to produce. It meant that the shaping of tank armour could only be carried out by those manufacturers who were suitably equipped, and that the work had to be confined to the plate-making firms themselves, who had not enough capacity to cater for our enormous re-armament programme.

Welding would remove the need for these close joints, whilst completely avoiding the possibility of entry of lead splash. It would eliminate rivets and bolts which, when the plate in their immediate neighbourhood is struck by a projectile, are apt to fly inwards at great velocity and cause casualties. Considerable saving of production time and cost would result from flame-cutting the plates to shape instead of machining, and the elimination of a framework would reduce the weight of a completed vehicle.

In spite of these obvious advantages the adoption of welding for tank hulls and turrets in this country was delayed for the following reasons:—

(1) It was considered difficult to make a mechanically sound weld in armour plate.
(2) It was feared that the heating of the plate during welding would seriously impair its immunity.
(3) It was considered that the weld metal would be ballistically inferior to the rest of the plate, so that in the absence of a backing strip the joints would be more vulnerable than the rest of the structure.

In the face of these objections it seemed unlikely that welding of Armoured Fighting Vehicles would ever be permitted, but fortunately a start was made in 1939 on the use of electric arc welding in two Armoured Wheeled Vehicles—an Armoured Car and a Scout Car—both of which carried "homo-hard" armour of no great thickness. The first intention in respect of the former vehicle was to build it up in the conventional manner by riveting the plates to a framework and then weld over the joints to make them "splash proof." Mechanical strength was thus ensured by the framework, and it was hoped that the very light welds used would reduce the immunity of the plate so slightly that the presence of the framework, behind the zone weakened by heat, would fully compensate for the loss.

The scout car was, and still is, an extremely small vehicle with an open top, the body being bolted to a chassis frame which was to supply most of the structural strength. The designer of the body did not feel he could bear the idea of sacrificing any space or weight to a riveted internal framework and boldly specified welded construction. This got by the General Staff on the pretext that the vehicle made no claim to giving 100% immunity, and that the ballistic risks involved in the use of welding might therefore legitimately be accepted.

Whilst the specification of these two vehicles was still being argued, considerable advance was made in the technique of welding armour plate, so that when it actually came to manufacture, the armoured car was also given an all-welded body without any riveting or framework; this practice has since been followed in the manufacture of most other British armoured cars.

The Problems of Welding Armour

(a) *Mechanical*

At the outset of the war the composition of most of our rolled armour plate was of the order of Ni 3.5%, Cr 1.5%, and Mo .5%, with carbon round about .3%. Such a material at the tensile level at which it was used is very unyielding, and when cooled in air from high temperatures it becomes very hard and brittle. In welding two plates of armour together, the weld metal is put down in a molten state and the joined edges of the plates are made very hot; the stresses set up by contraction on cooling cannot be met by the plates without cracking.

Cracks usually appear in the junction and fusion zone, but in the case of a severely restrained structure like the hull or turret, cracks transverse to the welds may form in the body of the plates. These may not necessarily appear as soon as the weld has cooled, but may form later under the influence of stress or vibration.

The first step towards the solution of this problem was actually made in the Research Department, Woolwich, before 1930, and involves the use of special welding electrodes designed to make an austenitic deposit in the weld; this retains a high degree of ductility at all temperatures below its freezing point, and the weld can therefore yield to the cooling stresses without cracking either itself or the parent plate.

The earliest austenitic electrodes used in welding armour plate were made up to give a deposit of which the most important constituents were 18% Cr and 8% Ni. Many manufacturers produced electrodes of this class, which are known as "18/8." In their attempts to improve the welding process certain British and American Firms made use of more richly alloyed electrodes; examples of these are the Murex "Nicrex" and Lincoln "Stainweld" which contained 25% Cr and 20% Ni and were referred to as "25/20."

(*b*) *Constructional*

If two plates of armour are welded together at any given angle, the contraction of the weld metal on cooling will cause this angle to change, and this must be allowed for in manufacture. It was found necessary to provide jigs in the form of frameworks to which the plates of a hull could be clamped in their correct relative positions during the process of welding.

It is also necessary, in order to control the distortion and cracking of welds, to arrange the welding technique and procedure, which involves the method of building a weld, the sequence of depositing the runs, and their direction.

It has been found that satisfactory joints in armour plate can best be ensured by the use of down-hand or gravity welding, so that it becomes necessary to mount the jig on a mechanical manipulator that can turn the whole assembly about in such a way as to bring each seam to an approximately horizontal position.

(*c*) *Ballistic*

Firing trials soon showed that the welding process had very little effect on the immunity of the plate. In theory "homo-hard" which, after quenching, is tempered at about 200°C., would be reduced in hardness by heating above this temperature so that a zone of reduced immunity would appear on either side of the weld. In practice, the metal nearest the weld gets heated well above the critical temperature, and so re-hardens by cooling in air, whilst the temperature gradient in the rest of the plate is steep enough to ensure that the zone of softening is too narrow to have a really serious effect.

A ballistic junction weakness is experienced, however, which may be anything up to 15% of the immunity of the plate, owing to the fact that the shot penetrates the plate near its edge. This edge is supported by comparatively soft weld metal and is bulged into the weld metal, thus permitting an easier penetration by the shot.

The weld metal, thickness for thickness, is certainly weaker ballistically than the plate. The butt weld, however, in plate up to 14 m.m. thickness, where the weld reinforcement forms a considerable increase in the weld thickness, compares very favourably with the parent plate, particularly at normal attack. At angle attack a slight ballistic weakness is to be expected.

25/20 weld metal is worse in this respect than 18/8, so the earliest practice was to finish off the weld with a few runs of very hard material from a special electrode of a different type (such as the Quasi-Arc Company's "Duroid"). This was soon found to be productive of cracking and was abandoned in favour of the plan of building up the weld reinforcement to a greater thickness than the plate, thus compensating for its weakness. Hard surfacing materials are effective only against angle attack, but against normal attack they offer little or no advantage for the same reason that machineable quality thin plate is equal to "homo-hard" under normal attack.

Although the armour of our wheeled Armoured Fighting Vehicles has remained fairly thin, that of our Tanks has made enormous increases in thickness since the outbreak of the war, to keep pace with the increasing severity of attack by armour piercing weapons. Initially, the thicker armour was made of the composition noted in (*a*) above, but latterly the alloy content has been considerably reduced. To give better resistance against the heavier projectiles, and to avoid cracking and flaking under such attack, the hardness is essentially less than that used for thin plates designed to resist light attack, and such armour is machineable in its final heat treated condition.

These changes improved the position with regard to welding, for the following reasons :—

(1) " Machineable Quality " armour, as it is called, is far less likely to crack under welding than " homo-hard," and the greater thickness enabled joints of greater mechanical strength to be made.

(2) The greater thickness of parent metal reduced the tendency to lower the ballistic properties adjacent to the joint.

(3) The ballistic strength of the joint itself becomes relatively less important, the overriding consideration being that of resistance to shock.

Earliest Welded Tanks

There is ample evidence to show that the Germans started welding their tank hulls and turrets long before the outbreak of this war. Generally speaking, German armour plate is of the chromium molybdenum steel type, containing chromium and molybdenum in varying proportions from 1 to 2.5% and .3 to .6% respectively with carbon varying between .3 to .5%. The carbon content is generally higher than that used in this country and this factor, in combination with the fairly extensive use of face-hardened armour, appears to have given the enemy considerable difficulty in effecting satisfactory welds. Battle behaviour and fairly extensive trials have shown that under heavy attack the welds readily split away from the parent metal.

It might be added that, speaking in general terms, the German armour of the homogeneous type is, thickness for thickness considerably harder than that used on British Tanks. While this provides a rather better resistance against calibre attack than does our own armour, it has the grave defect that when overmatched it cracks and breaks up in a manner which would not be considered desirable by British designers.

America has gone over to welding on all current production, starting with the later Marks of General Sherman Medium Tanks and General Stuart Light Tanks. The same applies to all American Armoured Cars. The welding is of the highest class, and has given ample evidence of its mechanical and ballistic soundness in the Mediterranean campaign.

In Britain, the firing trials which have been carried out since 1941 against prototype heavy tank hulls and turrets, and on numerous specially constructed targets, have shown without doubt that heavy armour can be quite satisfactorily welded in this country, and, moreover, the type of joints used which incorporate fillet welds ensure 100% immunity.

The first step towards the welding of heavy armour in actual production was taken with the design and construction of all-welded turrets for the Churchill Tank, which were fitted as an alternative to the earlier cast ones. Welding was not introduced by the manufacturers of tank hulls owing to their fear of dislocating production by changing over to new methods, which would entail the purchase of new plant and the training of operatives in unfamiliar processes. Although the loss of output would only have been temporary, the urgency of the demand for Armoured Fighting Vehicles was considered to make it undesirable.

A compromise form of construction was therefore employed, in which an inner skin of an easily weldable and ballistically inferior alloy—usually low carbon manganese steel of the Admiralty " D " type—was bolted or welded together into the shape of the hull or turret, and the thick armour plates were secured to it by high tensile set-screws with large conical heads on the outside. This inner skin had the advantage of preventing flakes from flying off the back of the armour plate under heavy attack and wounding the crews.

The pressure on tank production having now become somewhat easier, it is possible to consider a changeover to all-welded construction. Improvements in armour quality have greatly reduced the risk of flaking and so removed any justification for the use of an inner skin; it can therefore safely be assumed that all new British Tanks will, in future, be designed and built with single skin armour plates and castings welded together without rivets, bolts or supporting structures.

Present Day Armour Steels

Armour for A.F.V's. is made to-day to the following specifications :—

(a) *Homo-hard.*	Now only used for certain thin skinned wheeled vehicles in which weight considerations are predominant.
(b) *Machineable Quality.*	Used for plates of all thicknesses.
(c) *Cast Armour.*	Used for making turrets and sections of hulls as well as certain special fittings.

Except in the case of " homo-hard " armour, which is still being made to the original 3½% nickel chromium molybdenum steel composition, our armour is now being made to different analyses which do not require so much of the alloying metals, which are in short supply.

All these steels are weldable with approved austenitic rods, provided that the carbon content is kept down to 0.35%, but steels with higher carbon content may be welded satisfactorily if adequate pre-heating is used. In addition to this, compositions with lower carbon can be welded with ferritic rods; this is a new development which will further ease the alloy position.

Certain types of carbon manganese steel, not strictly classifiable as armour, but having better ballistic characteristics than mild steel, have been used for inner skins of hulls and turrets, and also for belly plates. These are based on the Admiralty " D " and " D.W." steels, and two types are used; the present tank specification calls for a 1.5% manganese steel which is either heat treated to give a hardness figure of approximately 280 Brinell, or left in the " as rolled " condition with a hardness of about 180 Brinell according to the use to which it is to be put. They are weldable with electrodes conforming to B.S.S.639 (1935) Class A, provided that the carbon in the plates does not exceed .26%.

Electrodes

The original 18/8 electrode has now been modified by significant additions, to make up to about 2 to 3% molybdenum or 4% manganese, and is now almost universally used. The molybdenum modified type is preferred in this country as it reduces the tendency to hot cracking when large deposits are made with big electrodes and heavy welding currents. All types of this electrode are coated and can be used with either A.C. or D.C.

Some 25/20 electrodes are still available in the country and can be used in the welding of thick armour plates by the pre-coating process. In this, the edges of the two plates to be joined are first coated or "buttered", with the 25/20 electrodes, and then welded together with 18/8 electrodes. This process has been superseded by a more recent technique making use of large gauge 18/8 electrodes—5/16" to ⅜" diameter—which is quicker, gives better ballistic properties, and results in a substantial saving of chromium and nickel.

An alternative type of austenitic electrode has been developed which contains about 12% maganese, 3½% nickel, and no chromium; this so far has only been produced in the uncoated form and can only be used with D.C. Its advantage lies in the great saving of chromium and nickel, and experiments are in hand for the development of a coated form which can be used with A.C.

Ferritic electrodes have been approved for use with certain armour plate in which the carbon content is not more than .25%. If the plate thickness is not greater than 14 m.m. straight butt welds can be made between square cut plates with deep penetrating electrodes, over 3/16" diameter.

The thicknesses of these electrodes vary according to the thickness of the armour that is being welded. For plates up to 30 m.m., 18/8 electrodes of ⅛", 5/32", 3/16" and ¼" are used, whereas armour thicker than this requires electrodes of ¼", 5/16" and ⅜" diameter. Tables of proprietary brands of electrodes approved for various purposes are given at the end of the article. In the case of the 18/8 electrodes, the current range appropriate to each thickness is also given, (See Table I).

Joints and Profiling

Plates up to 15 to 20 m.m. are usually butt welded together with ordinary single Vee preparation. The electrodes used are large enough to ensure that there need only be two runs in the Vee and a sealer run on the back. Vee angles of 60° – 70° are preferred but these figures can be exceeded. In an armoured hull or turret, the natural angle between two adjacent plates is often such as to enable their edges to be left square; if the Vee angle needs adjusting, it is usually possible to put the bevel on one plate only.

For thicker plates, or for jointing thin plates to thicker ones, as in roof plates to side plates, fillet welds are preferred. Although double Vee full section butt joints may give greater mechanical strength for resisting the impact of heavy attack, fillet welded joints are more economical in time and electrode consumption, and permit of much wider tolerances in profiling and assembly. Fillet welded structures have been proved to be ballistically and mechanically sound, both on the trial ranges in this country and in the course of the North African battles.

Profiling of both square and bevel edges is done by machine gas cutting. The tolerances worked to are ± 1/32" for plates up to 14" and ± 1/16" above this thickness. Various fuel gases can be used for straight edges, but acetylene is essential for bevels. Bevel edge plates can be cut out direct in one operation whenever suitable machinery is available; it is, in fact, possible to cut two or more bevels simultaneously on one edge of a thick plate.

Welding Procedure

The hull to be welded is usually broken down into sub-assemblies, such as side panels, nose-piece, back, etc. The plates for each sub-assembly are built up into position on jigs and held there by clamps which, in the case of light plate work such as for armoured cars, are loaded by spring, air, or hydraulic pressure, to a predetermined value which will hold them firm whilst enabling them to slip sideways under thermal strains. The jig is often mounted in trunnions.

The plates are first tack welded together at suitable spots, determined by experiment, and the runs are laid down in the order which is found to give the best results from the point of view of freedom from cracking and distortion. The first run is joined to the ends of the tack welds and must not be laid over the top of them.

When a sub-assembly is completely welded up on the outside, it is turned over and the sealer run applied. If the jig does not allow access to the back a second jig is clamped to the front to keep it from distortion during this process. The various sub-assemblies are next mounted together on a main assembly manipulator to form a more or less complete hull. This manipulator enables the remaining seams to be brought to a nearly horizontal position, the limit of tilt allowed by specification being 15°.

Plates thicker than 30 m.m. have their edges heated up to 100°–150°C. before welding. It is important that the assembly shop should be maintained at a steady temperature in the region of 15°C. and kept free from draughts. Post-heating to relieve stresses has been found unnecessary, except in the case of thin structures made of "homo-hard" plate which need to be soaked at 200°C. for some hours to ensure freedom from cracking.

A typical shop for the assembly of heavily armoured hulls should be able to turn out from 8–10 of these per week of 100 hours with three main assembly manipulators. A shop of this type would have to be manned by about 12 fitters and 30 welding operators, with 22 300-amp welding sets and 8 600-amp sets, the latter being needed for the thick vertical armour.

The weight of electrode required for a hull varies according to type, but the heavier types of modern tank would require something of the order of 5-cwts. of austenitic electrode in the hull alone.

Welding of Mild Steel Fittings to Armour

Mild steel fittings can be secured to the interior of hulls or turrets either by welding them direct or bolting them on to studs welded on the armour. The adhesion of such fittings is a matter of vital importance as any which become detached, under the impact of a heavy projectile on the outside of the plate, will fly across the hull with great violence and may cause fatal casualties.

It is therefore stipulated that all such fittings must be welded on with approved austenitic rods of the type used for welding armour, and this applies equally in the case of inner skins made of the carbon manganese types of plate. When studs are used they may be fixed by automatic stud welding plate, such as the Cycarc or Nelson Stud Welder, or the Projection Resistance Welder.

The same provision applies to external mild steel fittings which are subjected to load, but non-stressed external fittings may be welded on with suitable ferritic electrodes, of which a list is given in Table V.

It may be mentioned here that in the Middle East, fittings of all kinds were welded on to both the inside and outside of hulls and turrets with ferritic electrodes which were used like so much seccotine; austenitic electrodes were in extremely short supply and reserved for joining armour to armour.

Repairs in the Field

Electric welding has proved of the greatest value in repairing battle damage in field workshops, by patching up holes with pieces of plate or filling them in with weld metal. Holes in rolled plate are usually gas cut to a clean outline and covered with a suitably overlapping patch of the same thickness. A fillet weld is run round the outside of the patch and another one round the inside of the hole.

This process, when carried out on the vertical side wall of a tank, calls for an amount of both vertical and overhead welding. Certain types of electrode are recommended for this work, which are listed in Table II. It will be noticed that these are all of small diameter.

Holes and scoops in cast armour are filled up by weld deposit, and electrode can be saved by welding in odd pieces of armour steel, high tensile bolts, and pieces of armour piercing projectiles, like " plums " of rock in mass concrete. This is usually done with austenitic electrodes but it has been found possible also to repair armour castings using a mild steel electrode containing molybdenum.

Some very good repair work of this kind was done on Grant and Sherman Tanks in the Middle East, both in base and in field workshops ; the welders, who were nearly all R.E.M.E. personnel, attained considerable skill, and the external finish of the welds had the appearance of a beautifully darned sock.

We saw one case of a Crusader which had a German 50 m.m. armour piercing shell lodged half way through one of its front plates ; the workshops officer told us that he proposed to weld it in position. Had it been one of our solid shot, such as the 6-pdr. A.T., this would have been a good idea. Being a German projectile it was provided with a bursting charge which had so far failed to go off. We explained this, and recommended a more delicate approach.

TABLE I

Austenitic 18/8 Electrodes with recommended currents for normal Welding of Armour.

Electrode and Manufacturer	Colour Identification	Gauge	Current Range (amps)	Optimum Current (amps)
Armorweld	None	5/32"	120–165	130
		3/16"	150–215	180
		1/4"	230–325	240
		5/16" (a)	300–400	350
Lincoln Electric		3/8" (a)	350–450	400
Co. Ltd.		1/2" (a)	–	–
B.P.2/4	None	10 s.w.g.	100–130	120
		8 s.w.g.	130–170	150
		6 s.w.g.	160–210	190
		4 s.w.g.	205–290	250
Metropolitan		5/16" (a)	320–450	375
Vickers Electrical		3/8" (a)	400–600	480
Co. Ltd.		1/2" (a)	550–830	650

TABLE I—Continued

Electrode and Manufacturer	Colour Identification	Gauge	Current Range (amps)	Optimum Current (amps)
Armex 2	Slate coating yellow tip	10 s.w.g.	75–110	95
		8 s.w.g.	120–155	140
		6 s.w.g.	165–200	190
		4 s.w.g.	200–250	230
Armex 3	Red coating yellow tip	10 s.w.g.	70–110	90
		8 s.w.g.	100–155	130
		6 s.w.g.	120–200	160
Armex 4	Green coating yellow tip	5/16" (a)	300–450	350
		3/8" (a)	350–560	480
Murex Welding Processes Ltd.		1/2" (a)	—	—
Armoid No. 1	Red Band red tip	10 s.w.g.	90–110	100
Type H.		8 s.w.g.	110–150	135
		6 s.w.g.	130–205	175
		4 s.w.g.	160–250	205
		5/16"	300–500	400
		3/8"	380–600	500
		1/2" (a)	—	—
Armoid No. 2	Red Band black tip	10 s.w.g.	80–120	100
		8 s.w.g.	110–170	140
Quasi-Arc Co. Ltd.		6 s.w.g.	140–215	185
		4 s.w.g.	170–270	230
Armend A	Blue tip	10 s.w.g.	95–115	105
		8 s.w.g.	130–160	145
		6 s.w.g.	170–205	185
		4 s.w.g.	220–265	245
Armend C	Green tip	5/16" (a)	350–415	380
		3/8" (a)	450–535	490
		1/2" (a)	680–800	740
Armend D	White tip	10 s.w.g.	100–120	110
		8 s.w.g.	135–165	150
		6 s.w.g.	175–210	190
Rockweld Ltd.		4 s.w.g.	225–270	250
Hadmang	Bare wire	10 s.w.g.	75–100	90 D.C. only
		8 s.w.g.	100–150	120 D.C. only
		6 s.w.g.	150–220	175 D.C. only
		4 s.w.g.	175–240	200 D.C. only
Hadfields Ltd.		3 s.w.g.	200–300	220 D.C. only

TABLE II

AUSTENITIC 18/8 ELECTRODES FOR VERTICAL AND OVERHEAD WELDING OF ARMOUR

Manufacturer	Name	Colour Identification	Electrode sizes Approved
Lincoln Electric Co. Ltd.	Armorweld (U.K.)	None	5/32", 3/16"
Metropolitan-Vickers Electrical Co. Ltd.	B.P. 2/4	None	10, 8, 6, s.w.g.
Murex Welding Processes Ltd.	Armex 3	Red coating yellow tip	10, 8, 6, s.w.g.
Quasi-Arc Co. Ltd.	Armoid No. 2	Red band black tip	10, 8, 6, s.w.g.
Rockweld Ltd.	Armend A	Blue tip	10, 8, 6, s.w.g.

(U.K.) Refers to electrodes manufactured in this country.

TABLE III

AUSTENITIC 25/20 ELECTRODES FOR PRE-COATING HEAVY ARMOUR

Manufacturer	Name	Colour Identification	Electrode sizes available
Murex Welding Processes Ltd.	Nicrex	None	10, 8, 6, 4, s.w.g.
Lincoln Electric Co. Ltd.	Stainweld D	Grey coating red tip	1/8", 5/32", 3/16", 1/4"
Alloy Rod Corporation	Arcoloy 310	Off white coating red tip	5/32", 3/16", 1/4"
Arcos Corporation	Chromend H.C.N.	Green coating red tip	1/4"
Crucible Steel	Rezistal No. 7 Type 310	White coating red tip	1/4"
McKay Co.	McKay Type 310	Grey coating red tip	3/16", 1/4"

TABLE IV

FERRITIC ELECTRODES FOR WELDING LOW CARBON ARMOUR

Manufacturer	Name	Remarks
Quasi-Arc Co. Ltd.	Celto	Normal
Lincoln Electric Co. Ltd.	S.A.85	Deep Penetrating
Murex Welding Processes Ltd.	Fastex 2	Deep Penetrating

TABLE V

FERRITIC ELECTRODES FOR WELDING MILD STEEL NON-STRESSED EXTERNAL FITTINGS TO ARMOUR

Manufacturer	Name
Arc Manufacturing Co. Ltd.	Red-White
Lincoln Electric Co. Ltd.	Shield Arc 85
Metropolitan Vickers Electrical Co. Ltd.	E.H. R.L.
Murex Welding Processes Ltd.	Fastex 2 Fastex 5
Quasi-Arc Co. Ltd.	Celto Viking 1 Viking 2
Welding Rods Ltd.	W.R. 70 Universal Molybdenum

THE ALCAN HIGHWAY

By Major-General A. G. B. Buchanan, M.INST.C.E.

Foreword

FROM time to time the needs of war provide a stimulus for the execution of works, which would not, and often could not, be attempted in peace. Such a work is the military road to Alaska, commonly known as the Alcan Highway, and as this vast project was organized and almost entirely executed by our brothers-in-arms, the Corps of Engineers of the United States Army, it is considered that an account of it would be of great interest to the readers of *The Royal Engineers Journal.* For the information contained in this article we are indebted to *The Military Engineer.*

Decision to Construct

At the beginning of February, 1942, it was decided to construct a highway to Alaska on a route connecting a series of airfields from Fort St. John, British Columbia, to Big Delta in Alaska. The work was assigned to the Chief of Engineers. The Canadian Government furnished all rights of way, and the United States paid for the construction.

Two-Phase Plan

The magnitude of the project, 1,645 miles (farther than from London to Moscow as the crow flies), the need for speed, and the limited accessibility (see below) necessitated a two-phase construction programme, the first phase being the provision of a rough minimum or pioneer road to make possible the distribution of the additional labour which in the second phase would improve and complete the highway.

As engineer troops were both trained and equipped for rapid road construction, and were available for prompt despatch, they were given the mission of building the pioneer road. Instructions by the Chief of Engineers to commanders were as follows :—

" A pioneer road is to be pushed to completion with all speed within the physical capacity of the troops. The objective is to complete the entire route at the earliest practicable date to a standard sufficient only for the supply of troops engaged on the work. Further refinements will be undertaken only if additional time is available."

The Public Roads Administration employed contractors to improve the pioneer road in the rear of troops, to construct certain mileage without the aid of troops, and to furnish various engineering services.

Difficulties

In addition to the magnitude of the task the principal difficulties to be faced at the start were

1. Inaccessibility. There were only four practicable points of access by land to the entire route, viz. :—

   The terminals at Fort St. John, Fairbanks, and Whitehorse.

   Some undetermined point on the Teslin river or lake which could be reached from Whitehorse by water. (See map, page 26).

2. The uncharted nature of the route. This meant that exploring parties had to go forward at once by automobile, aeroplane, and dog team.

Troops Assigned and Equipment

In all 7 engineer regiments were assigned to the work, the 18th, 35th, 93rd, 95th, 97th, 340th, and 341st. The establishment of a regiment is 1,290 officers and men, and all regiments were similarly equipped.

The principal items of interest in the equipment of a regiment were :—

20 D8 diesel tractors and bulldozers.
24 D4 and R4 tractors with bulldozers and trailers for transportation.
3 motor patrols.
50 to 90 dump trucks.
Various cargo trucks.
11 to 20 jeeps.
12 pick up trucks.
2 ½-yard gas shovels.
1 truck crane.
6 12-yard carry-alls.
6 tractor drawn graders.
1 portable sawmill.
2 pile drivers.
Water purification equipment.
E.L. plant.
Radio receiving and sending set, mounted in a jeep.

Nearly all this equipment was new, which was fortunate, as spare parts were often unobtainable, and repair facilities inadequate.

Winter March of 35th Engineers

A winter trail from Fort St. John to Fort Nelson 265 miles away was in existence. As this became impassable with the spring thaw in April, it was decided to send the 35th Engineers off early so as to get to Fort Nelson before the road broke up. The regiment began to arrive at railhead, Dawson Creek, on March 10th, and succeeded in marching to Fort Nelson by April 5th with all their equipment and 900 tons of supplies. This fine performance undertaken in a temperature of 35° below zero by men inexperienced in winter operations was the " key " to the early opening of the road, as it established another point of access, and cut 265 miles from the long 1,000 mile inaccessible section of the route.

Tasks

Except for this early despatch of the 35th Engineers nothing could be gained by sending in additional constructional troops before the passing of the severe weather, but because the 35th would be inaccessible except by aeroplane until a road was opened to Fort Nelson, every possible effort had to be made to push a road through from Fort St. John. Two regiments were assigned to this section, the 341st which arrived on May 1st, and the 95th (coloured), which supplemented them, and arrived a month later. The 341st led the way, and got through to Fort Nelson by 26th August, while the 95th were engaged on Culvert construction, grading, and drainage work, thus permitting the advanced regiment to get on rapidly without danger of having its supply line bogged down. While this was in progress the 35th pushed north-west, and by 24th September it had completed 305 miles from Fort Nelson, and met the troops of the 340th working eastward from Teslin Lake. Thus so far we have accounted for 3 regiments and 570 miles of road.

Turning now to the 340th regiment just mentioned, it arrived at Skagway in April with light equipment owing to an unusual shipping opportunity.

It remained there till June, and when its heavy equipment arrived it moved up to Lake Teslin where it erected its base camp. It then worked eastward, crossing the Liard river near Watson Lake, and joined hands with the 35th Regiment after completing 240 miles. It then retired to improve its own road.

The 93rd Engineers (coloured) arrived at Skagway with the 340th and on receipt of equipment moved to Carcross, and by the end of July had constructed 99 miles of difficult road to a point on Lake Teslin. Part then improved their pioneer road, and part that of the 340th.

Another regiment, the 18th, also arrived at Skagway in April, and reached Whitehorse by the 29th of the month. Its mission was to build the road N.W. of Whitehorse. It advanced rapidly and completed 220 miles by 1st August after which it encountered very difficult going, till 25th October when it met the 97th working southward at a point 313 miles from Whitehorse. The cause of the difficulty was permanently frozen ground requiring special treatment.

The 97th Regiment (coloured) landed at Valdez, Alaska, late in May, but was held up by snow in the passes. Having arrived at Slana it began construction of a road through Mentasta Pass at the end of June. It had considerable difficulty with frozen ground, but having crossed the Tanana it opened up the road along the north bank, crossed the Canadian boundary, and met the leading elements of the 18th on 25th October at a point 194 miles from its start.

The Public Roads Administration was assigned the 114 mile section S.E. from Big Delta, and also the 50 mile stretch S.E. of Whitehorse.

Location

As already mentioned, location was one of the primary difficulties of the undertaking.

Although the road was to serve certain specified airports, it did not necessarily have to touch them, as they could be supplied by branch roads: thus considerable latitude in location was possible.

Taking the road from the Southern end at Fort St. John it was soon apparent that the route of the winter trail to Fort Nelson was impracticable for an all year round, and that the higher ground to the West would have to be used. But having reached this decision this section remained the most difficult for detailed location, as much of the route was in rolling, heavily forested country, and did not always follow well defined ridges or streams.

Between Fort Nelson and Watson Lake there were apparently two possible routes.

1. Starting N.W. through an extent of swampy country.
2. Starting W. through mountainous terrain.

It was finally decided in June to follow a series of water courses through the Rocky Mountains. The highest point on the entire road was 4,212 feet at Summit Lake, 102 miles West of Fort Nelson.

Having settled the general location as far as the Liard river (which is about 400 yards wide) much time was spent on trying to find a route along the South bank in order to eliminate the necessity for a second major bridge (access to Watson Lake airport requires one crossing of the Liard). This, however proved to be impracticable owing to swamps and excessive rock excavation, and the route had perforce to follow the north bank which has dry gravelly soil.

In the beginning the most uncertain part of the whole route was between Watson Lake and Whitehorse. Available air route maps indicated that any reasonably direct route would have to cross a mountainous plateau 6,000 feet high which might be impassable in winter. It was then thought that a detour to the South, which would mean adding a length of 500 miles to the route, might be necessary. Fortunately, however, aeroplane reconnaissance soon discovered a fairly direct route through forest growth. As this does not exist much above 4,000 feet it meant that the road summit should not exceed this height. Actually it turned out to be only 3,500 feet. The route was unknown to the local inhabitants, and its discovery was an important factor in the early completion of the highway.

Northwest of Whitehorse better maps and reconnaissance reports, made by the Alaskan International Highway Commission and the Alaska Road Commission, made the task of location much easier. After considerable exploration the route recommended by the former body was adopted with certain minor exceptions. This follows an old trail to Kluane Lake, thence along the South shore of the lake and the South bank of the river of the same name, and then N.W. along the North bank of the Tanana to its confluence with the Tok river. Crossing at this point the road then follows the South bank of the Tanana to a junction with the Richardson Highway near Big Delta.

The general route having been selected, the detailed location was left to regimental commanders, who had aeroplane photographs and generally used no more elaborate instruments than the compass and hand level.

An early effort was made to get the Army and Public Roads Administration engineers to work together on detailed location in order that the pioneer road might follow directly upon the location decided for the final approved road. The effort was soon abandoned owing to the delay imposed on the clearing operations. The Army units therefore located the pioneer road by reconnaissance methods, and even so had great difficulty in keeping ahead of the bulldozers! In spite of the rapid methods used, the pioneer road of the Army was located so well that the bulk of its mileage will be improved directly to the standard of the final road.

Operations

In this typical operation of a regiment employed in breaking new trail through the forest, the lead was taken by the locating party which indicated the centre line by blazes or pieces of cloth. Next came the clearing crew with three shifts of tractor operators. One large bulldozer ran along the marked centre line clearing a narrow trail. Other large machines were then given tasks along this trail. Pushing the trees laterally to both sides they made a clearing 60 to 90 feet wide. Having finished a task a bulldozer would leap-frog forward to its next job. On much of the route the forest growth was dense, but the trees were not large nor deeply rooted. On firm ground 10 to 12 bulldozers could clear from 2 to 3 miles through solid forest each day.

Smaller machines were used to follow the large tree movers, cleaning off moss, muck, and the lesser debris. The clearing crew were generally several miles beyond the reach of trucks, and had to be supplied by pack, or Tractor-drawn sleds, or Athey Trailers. The men slept in tents, and moved camp nearly every day.

A party consisting generally of a company followed the clearing crew, constructing log culverts and small bridges; it was followed in turn by another crew engaged in ditching, corduroying if necessary, and rough grading sufficient to permit passage of truck traffic in weather not too bad.

The remainder of the regiment, perhaps two or three of the six companies, might be distributed along the road 30 to 40 miles behind the clearing crew, and be engaged in widening any narrow places, reducing the worst grades, gravelling soft spots, and smoothing with motor patrols. This operation completed the pioneer road which was generally 18 to 24 feet wide.

As means permitted later in the season still further improvements, both in grade and alignment, were undertaken by the Army and Public Roads Administration, and the entire road has received a light surfacing with gravel.

Two light ponton companies, each equipped with 675 feet of floating bridge material, were parcelled out to the regiments. The ponton detachments promptly put in floating bridges over streams that could not be forded, or ferries where available material was not sufficient for bridges. Pile or trestle bridges were constructed as soon as possible to release the ponton equipment.

The rate of progress is best indicated by mileage under construction at the end of each month, since the road was usable for supply purposes in a very short time after clearing was completed.

TABLE—MILEAGE UNDER CONSTRUCTION

To date.	*Miles*	*Remarks.*
30th April, 1942	8	35th Engrs.
31st May,	95	Four regiments.
30th June,	360	Seven regiments.
31st July,	794	
31st August,	1186	
30th September,	1479	Road passable to Whitehorse, 24th September.
25th October,	1645	Road passable to Fairbanks.

CONCLUSION

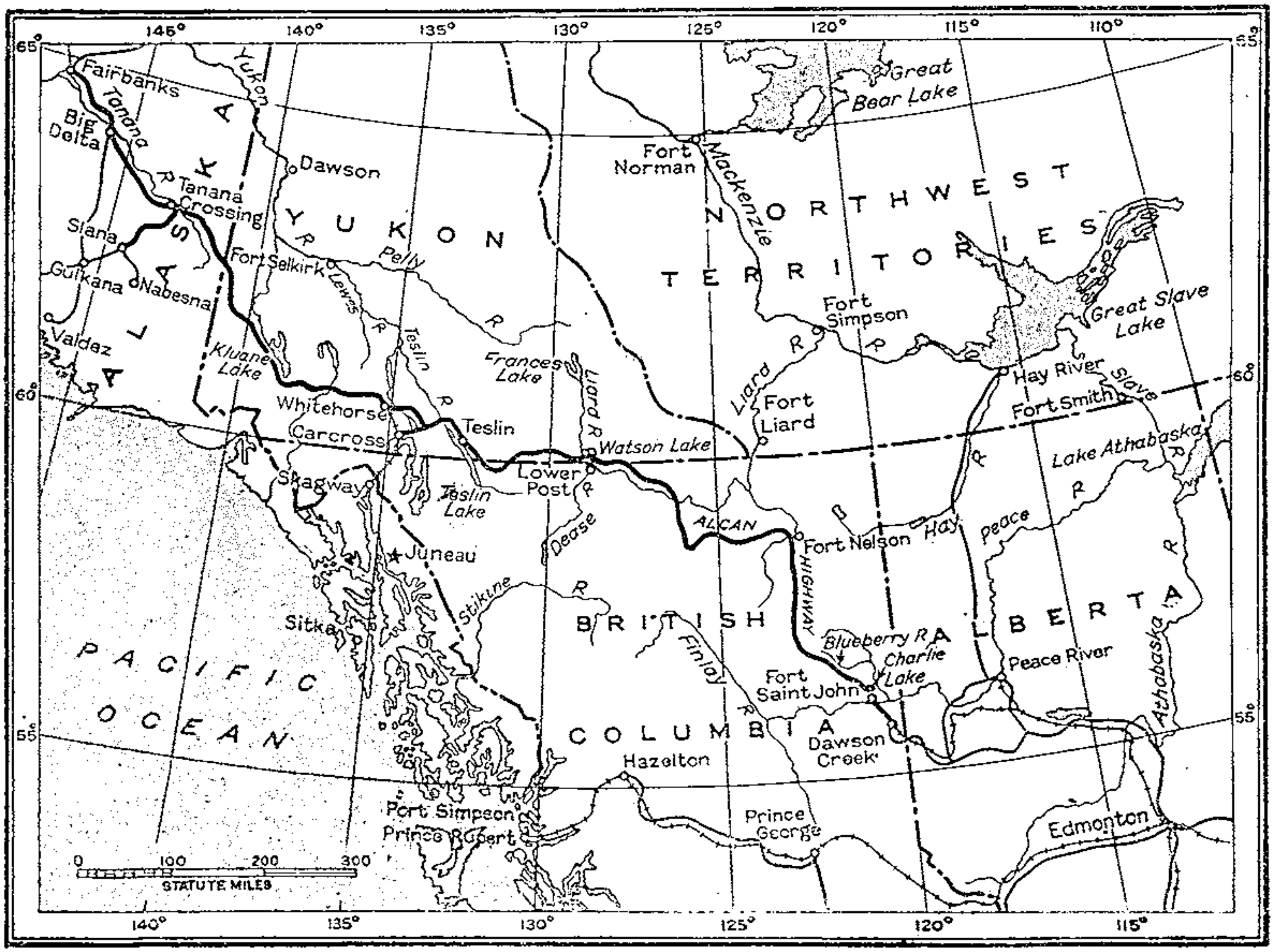
It is considered that no one can really appreciate the magnitude of the work, and its difficulties, without actually making a trip over the road. Progress would have been even better if there had not been a lack of adequate water transport to Alaska, which delayed the start of effective work in the Whitehorse area.

Whilst inaccessibility and lack of surveys were the initial difficulties, the main difficulty in actual execution proved to be supply rather than construction. Spare parts for transportation and construction equipment were particularly hard to obtain owing to the scarcity resulting from war conditions.

The credit for pushing this road through the wilderness in the short space of one working season belongs first and foremost to the ten thousand odd American soldiers who took their fine equipment and did the job. They worked early and late: neither heat nor cold nor all the challenges of the pathless wilderness could stop them. During March the men experienced bitter winds and temperatures of "35 below"; in July and August, gloved and swathed in netting against swarms of mosquitoes and flies, they sweltered under 90° heat; the rainy weather found them slogging through bottomless mud.

America can well take pride in the way its soldiers have performed in the building of the Alcan Highway.

THE ALCAN HIGHWAY



SOME MORE WAR BOOKS

By J.E.E.

TO a great extent the output of books on the war has continued to follow the seasonal fluctuations of the publishing business; but the writers—experts, theorists, fighting men and war correspondents—have certainly not slackened their efforts and we are provided with more "fine confused feeding" than ever. There is a host of books to dip into, quite a number to be read and—perhaps a very few—to be read and kept.

The theory of war is still being expounded. *Ordeal of Battle*, by Captain Falls, military correspondent of *The Times* is short, up-to-date, and remarkable for clear thinking and a reasoned exposition of strategy and tactics. Major-General J. F. C. Fuller has published a new edition of his lectures on operations between armoured forces which appeared in 1932 under the title *Lectures on F.S.R. III;* he calls the new book *Armoured Warfare* and is not ashamed to remind us how far from accurate were some of his previous prognostications. *A Layman's Guide to Naval Strategy*, by Bernard Brodie, himself a layman, urges everyone to make a study of war; he has no service prejudices, understands the meaning of "sea-power," and arrives at sound conclusions. Now that strategic bombing has assumed such importance *The Command of the Air* (in translation), by General Giulio Douhet, is of particular interest; first published in 1921 under the auspices of the Italian Ministry of War, the book claims rather too much for an independent air force, but we can now be wise during—if not after—the event.

Similarly *Flying Crusader*, by Isaac Don Levine, which although a biography of the American General W. Mitchell, who commanded the U.S. Air Force in France in 1918, is chiefly of interest to us in that he had ideas in advance of his time as regards the potency and scope of air power.

Of the contemporary records of the war, that edited by Mr. Philip Graves and published by Hutchinson maintains its high standard; the last instalment completes *The Fourteenth Quarter*, January to March, 1943. Professor Edgar McInnis continues his survey with *Third Year* and as usual is careful of comment, whilst, as a sequel to his *Wavell in the Middle East*, Major-General H. Rowan Robinson, in *Auchinleck to Alexander*, extends his view to take in the war as a whole and again pleads for a Minister of Defence. Another notable publication of this kind is that of Caxton's, edited by Geoffrey Dennis, the writers including Rear-Admiral H. G. Thursfield, Hartley Withers, Lord Horder, and Air-Commodore L. E. O. Charlton.

An Encyclopædic Dictionary of Science and War, by C. M. Beadnell, may well become a standard work of reference, although it can hardly remain up to date in these days of invention and of the swift adoption of new methods and appliances during the pursuit of victory in the field.

The biographers have a large and varied array of personalities from which to choose and it is not surprising that the most popular subject should be our Prime Minister. *Battle; the Life Story of W. S. Churchill*, by Hugh Martin, and *Concerning Winston Spencer Churchill*, by Sir George Arthur, are both to be commended; *Mr. Churchill: A Portrait*, is Philip Guedalla's impressionist contribution; Robert Sencourt and Lewis Broad, each of whom has written a *Churchill*, are not so successful. Lord Halifax has found biographers in Stuart Hodgson and Alan Campbell Jackson, who have done well with less colourful material. In his *General Smuts*, R. H. Kiernan outlines the career of the South African leader and assesses his political reputation at home. Stalin, still rather a man of mystery, has been drastically handled by Boris Souvarine, a Frenchman and a disillusioned Communist, who includes a critical study of Bolshevism; D. M. Cole writes of the great Russian with a better appreciation, although he is not very well informed in some respects. Basil Woon gives a creditable presentation of the American President in *Roosevelt: World Statesman*. There are two volumes on General MacArthur: Bob Considine, an admiring journalist, has written a better book than its title, *MacArthur the Magnificent*, implies; *MacArthur on War* contains the General's monthly reports during the periods when he was U.S. Chief of the Staff and may be regarded as complementary to the personal tribute. Philip Barris has "done" Charles de Gaulle. *Great Soldiers of Two Wars*, by H. A. de Weerd, an American writer, is mostly concerned with personalities of the last war, but Wavell is included and also Churchill and Hitler, who are said to qualify as "statesman-warriors." Hermann Rauschning, a former adviser of the Führer, fills in and completes the revelations of *Mein Kampf* with *Hitler Speaks*; Papen is the chosen subject of Oswald Dutch in *The Errant Diplomat*, a happy title if ever there was one; and Dr. Paul Schwarz, a former German diplomat and now an American citizen, exhibits the Nazi Foreign Minister as a "slick careerist" in *The Man Ribbentrop*.

Interest in Russia, in her struggle against Germany, and in her Army, is hardly to be satisfied by the books available. *Mother Russia*, by Maurice Hindus, is a study of the Russian people at war, the result of six months' residence in 1942; *The Great Offensive*, by Max Werner, a translation previously published in the U.S.A., contains a fair appreciation of Russian strategy; *Moscow Dateline* 1941-43 gathers the impressions of Henry H. Cassidy, the American journalist who asked Stalin about the "second front." For the actual fighting there is a translation of *The Last Days of Sevastopol*, by Boris Voyetchkov, a young Soviet journalist who was present during the final three weeks before the fall of the fortress, and *The Defence of Leningrad*, wherein Nikolai Tikhonov, an eye-witness, has collected the experiences of others. In *The Unknown Army*, a translation published in New York, Nicholas Basseches gives little more than an historical sketch. There is nothing to compare with William Necker's *The German Army of To-day*, which is a detailed study of the latest German manuals procurable, reinforced by the piecing together of additional information from many sources up to July, 1943, and contains a detailed tabular list of infantry weapons. From America comes an expensive production called *Economics in Uniform*, which describes Germany's organization of economic power in preparation for war and bears witness to the wide reading of its author, A. T. Lauterbeck. Another New York publication of note is Hans Ernest Fried's *The Guilt of the German Army*; well documented, it is not easy reading, but it shows beyond doubt that the Nazi Party and the German Army are not hostile to each other and that the officer class has degenerated.

Turning to the occupied countries, pride of place may well be given to Italy. *Balcony Empire: Fascist Italy at War*, is by Reynolds and Eleanor Packard, two American journalists who were interned in Italy; they discerned no national enthusiasm for Fascism, see no good to come from the Royal Family, consider Rome a legitimate military target for bombers, and recommend an American approach to restore the internal situation.

Those interested in the plight of Czechoslovakia may consult *Two Years of German Oppression in Czechoslovakia* and *Four Fighting Years*, both published by the Czech Ministry of Foreign Affairs; also *Germany's First European Protectorate* and *Prague Braves the Hangman*, both by Dr. Eugene V. Erdely. The last named, which is well documented, covers the Heydrich régime, upon which an official memorandum has been published.

The Battle of France, by Jacques Lorraine, in translation, explains the policy of the Vichy Government. Another book on France, also in translation, is *Léon Blum before his Judges, March* 11 *and* 12, 1942, an echo of the Riom trial. A connected account of the German invasion of Norway will be found in Herman K. Lehmkalil's *Hitler Attacks Norway*, including implied criticism of British naval action. *Greece Fights On*, by "Symmachos" describes the fall of Athens and relates the grim story of German and Bulgarian oppression; in *Greek Fire*, a collection of addresses and broadcast talks by André Michalopoulos, Minister of Information, 1941-43, will be found personal impressions of Metaxas, Korizio, and the King of the Hellenes. *The Struggle of the Serbs*, by K. St. Pavlovitch, is a record of events since the bombing of Belgrade in April, 1941, and reveals the horrors of the occupation of Jugoslavia by Hungarian, Italian, and German troops.

Defence Against the Night Bombers ought perhaps to be classed with the books upon the theory of war, for Pemberton Billing calls for light and yet more light, so that enemy raiders may be engaged in the air with our fighters unhampered by balloons or A.A. fire. Michael Seaven, however, who has a pretty taste in titles, describes actions enough in *Hell and High Altitude;* he has done operational flying in this and in the last war and gives us an interesting study in contrasts. The Fleet Air Arm appears now to be coming into its own. It is the subject of *Eastern Mediterranean*, by R. J. Hurren, a serving officer who is able to relate some incidents not previously disclosed; and the Stationery Office booklet *Fleet Air Arm* is one of the best of the M.O.I. series, with excellent pictures and a fine tale of achievement.

The Royal Navy is represented by Nicholas Monsarrat's *East Coast Corvette*, which repeats the success of the author's *H.M. Corvette;* by *Men Dressed as Seamen*, in which S. Gorley Pitt, college don transformed into an ordinary seaman, describes his experiences on a destroyer; and by *Men of Action*, a series of pen portraits and brush drawings of nineteen distinguished naval officers, by Commander Kenneth Edwards and "Douglas Wales." A good story of the sea is related in *Dynamite Cargo*, by Fred Herman, an American merchant seaman who lost his ship in a convoy to North Russia.

The voice of the Army is heard in *Grand Party*, by Lieut.-Colonel Graham Brooks, whose early experiences of the training of a 2nd-line Territorial artillery unit read strangely like those of 1914; service in France and Belgium and the retreat to Dunkirk are well described. David Masters relates in *With Pennants Flying* deeds of the Royal Armoured Corps in France and Africa; the Stationery Office has published *Combined Operations* which, while not an exclusively Army affair, is largely concerned with the formation, training, and exploits of the Commandos.

Another Stationery Office publication which should command wide interest is *U.S. Army*, the official biennial report, July, 1941–June, 1943. It is a most comprehensive survey and includes an account of operations with the necessary maps and charts. We have nothing like it.

The Dominions have yet to write their stories, but Donald Cowie in *War for Britain* has provided a brief survey of their part in the war during the first year. Other early books are *Canada comes to England* by Gordon Beckles; *Anzacs in Battle*, by Tahu Hole, an Australian journalist who writes of his compatriots in Libya, Greece, Crete, and Syria and is unhappily very wrong in his forecast of events in Malaya and at Singapore; and J. S. M. Simpson's

South African Fights, which explains South African problems and deals with the notorious Mr. Pirow.

Before considering any particular theatre of war, attention may be drawn to that rather stormy petrel the "anti-Imperialist," Wendell L. Willkie, who in *One World* has recorded the events of his 49 days' flying trip, visiting Egypt, the Middle East, Russia, and China. It is a stimulating account—a best seller in the U.S.A.—for he met all the leading personalities; his impression was that this is a small world and tells us that "world-wide thinking" is essential. Another American who has flown far and wide, though not perhaps with such lofty ideals, is David Woodward, a correspondent who visited North Africa, Syria, Malta, Chungking, the North-West Frontier of India, and Dakar; his *Front Line and Front Page* is entertaining and includes some outspoken criticism.

Malta has a little literature of its own. The first complete account of what has been called the "siege" is *Malta G.C.*, by Ian Hay, good but containing some inaccuracies. *Tattered Battlements*, by a "Fighter-Pilot," pays a well deserved tribute to all arms and services and to civilians of all nationalities, who co-operated so well with the R.A.F.; *Spitfires over Malta*, covering the period March to July, 1942, is by two pilot officers, P. Brennan, an Australian, and R. Hesselyn, a New Zealander, who took part in the operations, the volume being edited by H. Bateson; *Malta Magnificent* is by Francis Gerard, "Information Officer" during the critical period; and "Bartimeus" has written a pamphlet entitled *Malta Invicta*.

The North African eye-witnesses have spared no pains to provide us with impressions of the fighting, but first mention may be made of *The Tiger Strikes* published in Calcutta by the Public Relations Directorate (India); it is an admirable account of the campaigns in Africa and the Middle East of the 4th and 5th Indian Divisions, written by Lieut.-Colonel Hingston, I.A., and provided with excellent maps and illustrations. Alan Moorehead has produced another good volume, *The End in Africa*, which gives a workmanlike survey of the last campaign, some vivid impressions of the confusion of modern warfare, and an appreciation of our difficulties with the French. In *One Continent Redeemed* Guy Ramsey, who unfortunately did not see the later phases of the Tunisian campaign, explains to his American compatriots why General Eisenhower accepted Darlan; *The Battle is the Pay-off*, by Ralph Ingersoll, an American editor, describes the taking of a hill in Tunisia by U.S. troops and offers some shrewd comments on modern war; *Jordan's Tunis Diary* reveals the frank untempered judgment of the said Jordan (Philip) who pays a tribute to the British soldier and condemns the Allied political arrangements as "shameful and degrading"; *Tunisian Battle*, by J. D'Arcy Dawson, has the purpose of showing how the U.S. forces and our own First Army became inured to war. Alexander Clifford in *Three Against Rommel* describes the course of events from El Alamein onwards, whilst Howard Marshall's *Over to Tunis*, a rather B.B.C. title, is confined to that theatre; both volumes contain a deal of good descriptive writing. *Tunis Expedition*, by Darryl F. Zanuck, has an interest of its own; the author, an eminent film producer who, in the words of Damon Runyon has "gone military for the duration" was on the U.S. signals staff, his business being to take photographs. As may be imagined the illustrations are good.

Containing more varied fare *Every Man to His Post* is a collection by Alan A. Michie of personal narratives of "unknown warriors": a New Zealander in Crete; a bomber crew cast away in a dinghy; commando adventures in Libya. Cecil Beaton, the well-known photographer, was lent to the Air Ministry by M.O.I. to take pictures, and the attractive results are seen in a small volume called *Near East*. Another picture book, which also contains an interesting narrative, is *Red Moon Rising*, by George Rodger, photographer of the American magazine *Life*, who went to Burma to take pictures of the campaign and shared the hazards of the withdrawal.

Iraq has found a chronicler in Somerset de Chair whose expensive and attractive volume *The Golden Carpet*, published by the Golden Cockerel Press, describes the adventures of General Kingstone's column which marched from the Mediterranean and occupied Baghdad. The author was Intelligence officer to the force and in a sequel, *The Silver Crescent*, he tells the story of the advance from Baghdad on Palmyra (Syria) when the column, lacking air support, was "pinned down" in the desert by French bombers, he himself being severely wounded.

The development of the war in the Pacific provides the theme for many American correspondents who have gained their experience by land and sea and air. In *They Call it the Pacific* Clark Lee tells of his many personal escapes during his journeyings from the Phillipines to Guadalcanal, and emphasises the unpreparedness of the U.S.A.; *Queens Die Proudly*, by W. L. White, is the story of 35 American "Fortresses" in the opening phases of the war when they were vastly outnumbered and fell back from bases in the Phillipines to others in Java, one composite machine eventually reaching Australia; *Guadalcanal Diary* (published in New York) is by Richard Tregaskis, who was with the first landing of the U.S. Marines, an easy affair it seems, for the Japanese were taken by surprise, although there was plenty of hard fighting later; *Into the Valley*, by John Hersey, describes the U.S. Marines in action on Guadalcanal and has illustrations by an officer of the corps; *Queen of the Flat Tops* is a tale by Stanley Johnston of the aircraft carrier *Lexington* in action up to the time when she was sunk during the Battle of the Coral Sea; and the operations of all three services are racily described by Ira Wolfert in *Battle of the Solomons*, published in Boston. Captain Ted W. Lawson, who lost a leg in what was for long a rather mysterious venture, tells his story of the bombing of the Japanese capital in *Thirty Seconds Over Tokyo*; he piloted one of the sixteen Mitchells from the carrier *Hornet*. *How the Japanese Army Fights*, a "Penguin" book, consists of interesting contributions from members of the U.S. Army and shows how rigorous is the Japanese soldier's training for war. Ian Morrison's *The War Against Japan* expresses the fear that the British and Americans are not fully alive to the importance of the struggle in the Far East.

Of Japan herself something may be learned from Frederick Moore's *With Japan's Leaders*, the American author having been the first adviser on international affairs to the Japanese Foreign Office before serving at the Washington Embassy; he thinks that Japan would have preferred the U.S.A. to keep out of the war. In *Tokyo Record*, Otto D. Tolischus, correspondent of the *New York Times* who was imprisoned in Japan, largely ascribes her aggressive policy to the ambition of Matsuoka, the Foreign Minister.

The Home Guard has inspired many to write training manuals, some good, some not so good, and some which might well be spared. Hugh Slater, a purveyor of rather muddled military history, supplies some practical hints in *Home Guard for Victory*; Charles Graves, with *The Home Guard of Britain*, provides a history of the movement to which is added the records of certain units contributed by their officers. Another "Home" book, one of unique interest, is A. G. Street's *Hitler's Whistle*, an interesting view of war-time life and work in the English countryside.

AIRFIELDS IN WAR

By Colonel E. St. G. Kirke, D.S.O.

1. Paramount Importance of Air Power

EVEN the most case-hardened sceptics are no longer in any doubt as to the paramount importance of the air arm in war and of the necessity for an air umbrella whether operations are being conducted by land or sea.

Among the most striking examples of air power in this war were the wrecking of the American battle fleet at Pearl Harbour, which altered the whole strategic position in the Pacific; the sinking of the *Prince of Wales* and *Repulse* by Japanese aircraft off Malaya, which enabled them to land troops for the invasion of that country without let or hindrance by us, ending in the fall of Singapore; and the battle for Midway Island which was decided entirely by aircraft without the main battle fleets coming within fifty miles of each other. When the Japanese had lost four out of five of their aircraft-carriers by bombing from the air they realized that their chances of victory had vanished, and turned tail for home.

Similarly we have had many bitter lessons as to the comparative helplessness of an Army which is subjected to uninterrupted attack from the air, but have now got into the position where we can reverse the picture.

The operations in Tunisia were conducted primarily to enable our east-bound convoys to pass down the Mediterranean under the protection of fighter aircraft based on the North African coast. Several thousand miles of the sea route to India and the Far East have been saved by the successful conclusion of that campaign.

To give complete fighter protection, airfields are necessary every 100 miles, since a fighter's range is limited by the length of time which it can stay in the air. This at present is about two hours at cruising speed, but less than half that time when the engine is at full throttle.

Airfields are to aircraft what harbours are to ships, with this difference, that harbours can be more widely spaced, because the endurance and range of a ship at sea are much greater than those of a fighter in the air.

The primary object of airfields is to enable fighters to take off, land, be filled up with petrol, oxygen, and ammunition, while enabling their pilots to rest. For this reason runways will, in the first instance, be required for fighters (which are much lighter than bombers) and runways need not be either so long or so strongly made as they have to be for bombers.

In Tunisia it was found that runways of 1,200 yards by 50 yards wide sufficed in the first instance, and that any landing ground was better than none. Later, the width of improved surface was much increased to allow of several aircraft taking off at the same time, instead of in succession, because the dust of the first aircraft taking off on a fifty yard width sometimes did not settle for ten minutes, and a squadron took over an hour to get into the air.

2. Responsibilities

The R.A.F. will decide, in consultation with the C.-in-C. of the Army, where aerodromes are required, and will state the type of aircraft for which the airfield is wanted, while the Army provide engineer services in theatres of operations overseas. In this connection, Army H.Q. must be placed where it is possible to make a landing ground ; the advent of the air arm has made this the primary consideration.

The closest liaison must be maintained between the Army and the R.A.F., and in the Libyan campaign the G.O.C. Eighth Army and the A.O.C. lived side by side. In Tunisia the Chief Engineer of the First Army had a Wing Commander of the R.A.F. attached to his D.C.E. (Air) ; there was also a representative of the R.A.F. with each Airfield Construction Group. All these R.A.F. officers were pilots and not members of the ground staff, as flying experience was considered essential.

It will be the duty of the R.E. staff to point out the possible engineering disadvantages of sites which may be tactically the most suitable, and about which, apart from these disadvantages, there would be no question.

3. Selection of Site

The following decisions must be made before a search is made for sites :—

(*a*) The area in which the airfield is wanted.
(*b*) The kind of aircraft for which the aerodrome is required.
(*c*) Number and direction of runways.
(*d*) Whether night flying will be required.
(*e*) Establishment of the R.A.F. Unit, including aircraft, personnel and vehicles.
(*f*) The scale of ground defence and the numbers available.
(*g*) The length of time for which the airfield is likely to be required.
(*h*) The time of year for which the airfield is required.

(*e*) and (f) are qualified by the fact that the best available sites must usually be considered regardless of strengths for which required.

Intelligence reports as to the meteorological conditions which may be expected are obviously of the utmost importance when considering (*c*)—as regards the prevailing wind, (*g*)—as regards the nature of surface, and (*h*)—as regards the rainfall to be expected.

The following points are important :—

(*a*) Desirability of flat area on high ground.
(*b*) Accessibility of communications.
(*c*) Absence of flying obstructions.
(*d*) Water supply.
(*e*) Possibilities of accommodation.

If maps are not available the preliminary work can be done by air reconnaissance from 2,000 ft. in the first instance, and a closer inspection of any site which appears promising, can then be made from a lower height. Such sites will be marked by the pilot on air photos, or compass sketches and visited later by a joint R.A.F. and Army ground reconnaissance party.

Stereoscopic air photographs are invaluable : they show the nature of the ground, and the nature and extent of the vegetation. In many countries, such as the N.W. Frontier of India, where food is a constant and pressing anxiety to the inhabitants, the amount of water available for the construction of airfields and other purposes is exactly indicated by air photographs which show clearly all patches of cultivation. The size of these patches is limited only by the amount of water available to irrigate them.

4. Soils

Much will depend upon the nature of the soil if wet weather is anticipated, for a soil which is perfectly fit in its natural state to form a landing ground in dry weather may, and generally does, very quickly become a morass after rain, and, as such, quite unusable ; in fact, *gravelly or sandy soils are the only ones which form much hope of being used in their natural state in wet weather*, unless there is thick enough vegetation to form a mat.

Black cotton soil, which occurs in many places throughout the world, is the worst of all soils under changes of weather conditions. When it dries after rain it leaves cracks which may be 2 ft. wide and several feet deep. It should never be used if it can possibly be avoided.

The silt deposited by great rivers, and similar soils, which are so common in the East and Africa, form satisfactory landing grounds *so long as they remain dry*, and during the Abyssinian campaign no work had to be done to form landing grounds, other than the clearing of camel-thorn and low scrub, which could be done in a few hours.

During the Tunisian campaign, on the other hand, our aircraft were to a great extent grounded by mud, whereas the enemy had the use of permanent airfields built during peace. (From the meteorological point of view no worse time of year could have been chosen for this campaign, as the heaviest rainfall in Tunisia occurs between October and March. Strategically, of course, the campaign was perfectly timed.) Sommerfeld Track runways proved to be useless as an antidote to mud ; they quickly disappeared. (*See also Sec.* 12.)

Grass landing grounds can be used in moderately wet weather by the lighter types of aircraft, but may be dangerous through causing the aircraft to skid when brakes are applied to bring them to rest. Aircraft have been known to turn through a complete half-circle under such conditions and their pilots have only prevented them from skidding tail first into some obstruction at the end of the airfield by opening full throttle. (Steel runways are often of great value by enabling grass and other forms of vegetation to be used in wet weather. They prevent skidding and the creation of ruts.)

The bearing capacity of soils is important if they are to be used in their natural state, or as a foundation for surfacing materials, and a simple test can be made with a circular table about three feet in diameter having three legs, nine inches long, each with a cross section of one square inch. This table can be loaded with known weights, such as bags of cement, until it sinks suddenly, or continues to settle. The load per leg causing the sinkage gives the pressure in pounds per square inch which the soil will *not* stand, and should be divided by a factor of two, to give the load which may be applied to the soil under the runway.

Charts can readily be made which enable the thickness of bituminous runways to be calculated, and they can equally be applied to concrete and similar surfaces. (See page opposite.)

In the case of *sand*, its suitability can be decided by running a utility van shod with " sand tyres " over it and measuring the depth of track made. If the imprint is one inch deep, the van should be run at 20 m.p.h. and declutched :—Then, if it runs for at least 100 yards before stopping, the surface is safe, but if it stops within this distance the R.E. should not accept responsibility, but consult the R.A.F. The average of two runs in opposite directions should be taken if the wind is strong enough to affect the result.

Sand which is too soft for runways when dry may often be so hardened by water as to be quite usable. Thus the sea shore may be quite impossible to use above high water mark, but quite hard enough, where it has been wetted by the tide, to form a good runway. Again, sand may be laid upon

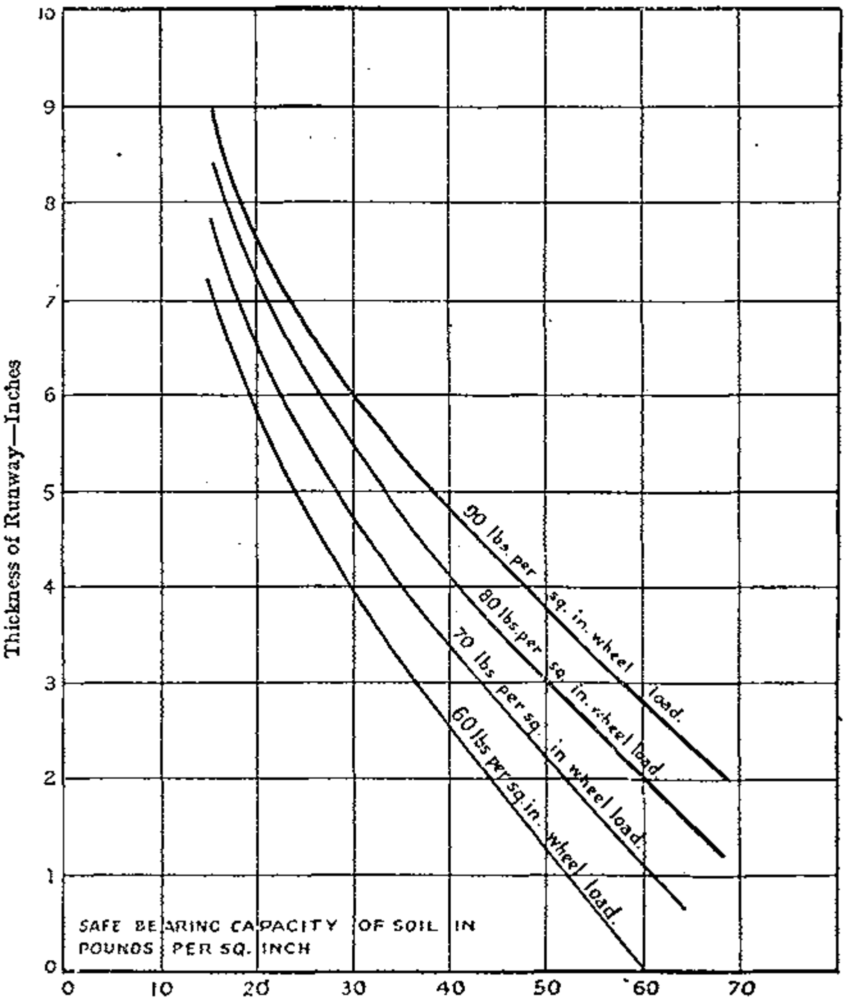


Chart giving thickness of Bituminous Runways

mud in sufficient quantities to dry it up and make it usable in wet weather, even without steel mats.

Smoothness of surface. As a rough guide it may be assumed that if an ordinary four-wheeled saloon car can be driven over the surface at 30 m.p.h., without damage, the surface is suitable for aircraft.

As regards general evenness, no rules can be laid down, and the R.A.F. should be asked to say whether they are satisfied with the ground as it exists.

5. Drainage

This may well prove to be an over-riding factor in selecting the site for an airfield, and depends on four factors :—

(*a*) The amount of rainfall.
(*b*) The run-off on the surface—governed by the slope of the ground.

(*c*) The porosity of the soil.
(*d*) The rate of evaporation—depending upon the temperature and humidity of the air.

As regards (*b*), the best site is one which has a steady slope in one direction, preferably across the runway. If the slope is along the runway, water channels are sure to be scoured out, and the surface rendered unsafe.

A convex site is good so far as drainage is concerned, but, by limiting vision, may create difficulties for operational control and night flying.

A concave site is bad because water will lie in the centre after rain unless the ground is sufficiently porous to soak it up.

If waterproof runways can be constructed during dry weather, sub-soil drainage may not be necessary: the runways will keep the water from softening the ground underneath them if side drains are made deep enough to prevent capillarity. The maximum gradients laid down by the Air Ministry are 1/80 in a longitudinal direction and 1/40 across the airfield.

The drainage of a permanent airfield is a serious undertaking and it is unlikely that full scale drainage could be provided under the conditions of mobile warfare. When such drainage has to be put in ordinary methods of land drainage applicable to the neighbourhood should be used, and full use made of local knowledge.

6. Effect of Altitude and Temperature

As altitude increases from sea level the air gets lighter, has less supporting power, and reduces the pull of the propeller. The result is that a runway has to be longer in proportion to the altitude.

Similarly, hot air is not so efficient from the flying point of view as cold air, and an addition to the normal length of runways in temperate climates may have to be given in the tropics or sub-tropics. India lays down 7 per cent increase per 1,000 ft. of altitude, to allow for temperature and barometric pressure.

This factor of heat is particularly troublesome in Iraq, where average shade temperatures vary from 40°F. in winter to over 125°F. in summer. Guidance on this point must be sought from the R.A.F.

7. Obstructions to Flying

These may be natural, such as hills; or man-made, such as electric pylons and buildings. The general rule is that there should be no obstruction to flying within a horizontal angle of 15 degrees splayed out at each end of the 200-yard wide cleared strip (in the centre of which each runway is made) unless it is lower than a vertical slope of 1 in 50 from the end of the strip. Obstructions which infringe these limits must be removed.

In practice, hills are the only form of obstruction which it may be uneconomical to move, though the diversion of electric power-lines, etc., may not be easy under active service conditions.

8. Communications and Dust

There is always a great deal of traffic up to and around an airfield, particularly when the form of runway adopted involves the fetching of large quantities of materials. If good communications do not exist, it may mean that the country surrounding the airfield gets so badly cut up as to create a very difficult dust problem.

In one instance in North Africa it was found that whereas the average number of dust storms over a period of a year before the arrival of aircraft was only five, the number counted after the establishment of an airfield was over fifty in the year.

In a 10 m.p.h. wind, dust reduces visibility to under one mile, and in a 35 m.p.h. wind will completely blot out the sun even at midday.

It may be better to pave access and service roads, taxi-ing tracks, standings (where aircraft "rev. up") and dispersal lanes, before paving the central half or two-thirds of the runways where the evil of dust is less pronounced than at the ends.

(The problem of making airfields where no communications exist is dealt with in Section 13.)

9. Detailed Reconnaissance Report

When the site has been selected after due consideration of the factors outlined above, a detailed reconnaissance report should be made under the following headings :—

(*a*) *General suitability of site* :—	
(i) Extent	
(ii) Levels and slopes	
(iii) Soil	If information can be obtained a note as to sub-soil also should be included.
(iv) Drainage	
(v) Condition of surface—	Whether undulating or largely filled with holes, ditches or mounds.
(vi) Air approaches	
(*b*) *Accommodation* :—	
(i) Personnel	
(ii) Aircraft	Note possibilities for dispersal.
(*c*) *Communications* :—	
(i) Waterborne	Note proximity of canals, navigable rivers, etc., and means for handling cargoes.
(ii) Rail	Note most convenient railhead, length of platforms and sidings, cranes and other details.
(iii) Road	At least one good road, or one that can be made good, is essential.
(iv) Telephone, telegraph.	Existing lines should be noted.
(*d*) *Supply* :—	
(i) Water	Note what facilities exist or can be made for supplying both personnel and aircraft and also for constructional work.
(ii) Materials	Note possibilities of obtaining stone, sand, gravel, etc. If not required for construction, they may be needed for repairs after enemy attack.

The report should also contain notes as to the possibility of extending the site, and should state in what manner extensions could be made, with an estimate of the work involved.

Each item of the reconnaissance report is to contain an estimate of the work required to bring that item into usable condition, and any feature which the reconnoitring officer considers of importance, if not mentioned above, is to be included under a general remarks heading.

The final selection of the site will be made by H.Q., Royal Air Force, on the information contained in the engineer's report and the pilot's report.

When the site has been definitely selected a further series of air photographs, consisting of lines of oblique overlaps on the proposed runways, should be taken from about 2,000 ft., and a mosaic prepared on a scale of 1 in 10,000 to include the landing ground and the country within a mile of the perimeter.

The plan will show all the work which is required, and the approval of H.Q., R.A.F., should be obtained to make sure that requirements are properly met, and in particular, that the direction of runways suits the prevailing wind.

Normally in war, however, work will start immediately on mutual oral approval of R.A.F. and R.E. officers on the spot.

10. Protection

The protection of an airfield against attack involves questions of camouflage, dispersal, ground defence, and defence from the air.

Camouflage. It is almost impossible to deceive the camera carried by hostile reconnaissance aircraft, but it will suffice if the airfield is not readily picked out from a distance of five miles at a height of 6,000 ft., because the bomber takes time after reconnoitring the airfield to open his doors and straighten up on to the target before releasing his bombs.

There should be no well-defined natural landmarks (such as the bend of a river) or an artificial object (such as the Marble Arch in Libya) in the vicinity of an airfield.

The runways on an airfield will be most difficult to conceal owing to their length, but this does not necessarily apply to natural landing grounds.

A camouflage officer should always be asked to advise as to the best method of dealing with each particular problem, because there are many ways of making airfields blend with the surrounding country, *e.g.*, spray-painting the runways, burning strips to represent hedges, patches to represent trees; spraying with tar or oil, or sprinkling with black cinders and other suitable substances.

Dispersal. The most practical way of protecting aircraft from bombing attacks is to disperse them so as to minimize the effect of each explosion, and the same principle is applied generally to R.A.F. installations and transport.

Targets on the ground, including aircraft, are mostly betrayed by their shadows and dispersal enables these shadows more easily to fall on and be absorbed by the shadows of trees, woods, and buildings.

Although woods offer excellent cover from the air they can easily be set alight in dry weather by incendiary bombs, and aircraft concealed therein can be destroyed by the enemy, with the minimum of trouble. Apart from this, woods near an airfield form an obvious target, particularly if there is little sign of aircraft, dumps, etc., elsewhere.

The extent of the dispersal in each case must be decided primarily by the R.A.F., but may also be wrapt up in the scheme of perimeter defence and defence against airborne or parachute troops.

Fighters are usually dispersed towards the leeward end of runways so as to be ready for taking off at short notice, but bombers can be dispersed up to a mile away and all round the airfield if topographical and tactical considerations allow.

Ground defence. Aircraft on the ground can be protected to a certain extent against blast by traverses, but these take a long time to construct and are not easy to hide. The guiding principle in this and other forms of concealment is that there are no straight lines in nature, and that if such appear on air photographs they proclaim the handiwork of man. In general, airfields are likely to form the primary objective for all kinds of attack from both air and land, and their defence will form an important item in the main plan of operations.

11. Accommodation

Accommodation at an airfield depends entirely upon the period for which its occupation is expected and the climatic conditions prevailing at the time.

In the case of rapidly moving warfare, there may be time for little more than slit trenches, constructed by the R.A.F. to protect the personnel from air attack, and such shelter as circumstances demand, *e.g.*, tents. Camp structures and water supply should receive early attention.

When accommodation is provided it will be on Army scales, in addition to which there are requirements peculiar to the R.A.F. such as Operations Rooms, shelters for duty pilots, medical posts, and spare gun crews; repair hangars, "blister" hangars, petrol and oil installations; parachute and other stores. In this connection the R.A.F. supply all structures whose entrances are 18 ft. high, or more, to the R.E. for erection.

12. Steel Surfaces for Runways

Where soil is not sufficiently strong by itself to support aircraft it can be strengthened by the laying of steel mats. The lightest of these is the Sommerfeld track, made up in Standard units 25 yards long by 10′ 7″ wide. Enough of this track to form a runway 52 yards wide and 1,000 yards long weighs 225 tons.

It can be laid on grass or on sites which have been roughly levelled and are urgently required for operational use. Ground preparation should be confined to site clearing, *i.e.*, the felling of hedges and trees, the filling in of ditches (with suitable provision for allowing the water to pass down the original channel) and minor levelling of ridges and depressions.

This netting will unfortunately not enable the ground to be used if it gets thoroughly wet, as it merely gets driven into the mud and ceases to be of practical value. Some sort of herbage is essential for it to be laid upon in wet weather. Sometimes rushes, sand, etc., may meet the case but in Tunisia neither this nor any other form of steel mat was successful, because wet mud got to the surface and completely blinded the pilots of all but the first aircraft when taking off or landing.

In short, no steel runway will overcome mud, unless the mud can be kept from rising by an almost unlimited number of tarpaulins, or overlaid with a sufficient depth of sand to soak up the moisture and consolidate the surface.

13. Advanced Landing Grounds

As stated above, experience in this war has shown that fighter airfields sited well forward are essential to an army fighting against a first-class enemy.

These advanced landing grounds may be required in places not served by roads, such as high plateaux, frozen lakes, or airfields on islands—in the Pacific, for example.

If such airfields are to be made quickly and *if speed is vital*, labour, mechanical equipment and stores must be carried by air. Specially trained airborne engineers are also required for the purpose, and they can, to a great extent, be dropped by parachute.

The work involved in one of these rapidly made fighter airfields can be divided into two phases :—

PHASE I
- (i) Levelling and marking of landing strips, 1,200 yards long by 50 yards wide.
- (ii) Clearance of approaches.
- (iii) Consolidation of soft spots.

PHASE II
- (i) Laying runways or parts of runways with metal track.
- (ii) Making taxi tracks and possible dispersed aircraft standings.
- (iii) Light Anti-aircraft defence.
- (iv) Provision for R.A.F. personnel servicing and maintenance stores.

The above form the minimum requirements of a fighter airfield, such as can be made through the agency of air transport.

Type of Aircraft required. Gliders can carry all the equipment needed. They are cheap to fly, readily available, can crash land without serious injury, and can easily be moved out of the way by hand. Their range is, however, limited and a long runway is required for their take-off. The Germans have greatly developed the use of gliders for carrying freight, and have a large type provided with auxiliary engines to assist in their navigation.

Equipment.—Machinery and stores which are to be carried by air must be as light as is practicable, and cover all reasonable requirements. The dimensions of such equipment must also be co-ordinated with the dimensions of the cabins (or holds) of the freighter aircraft and gliders which are to be used.

Engineer plant must be able to start work as soon as possible after being landed, and it should be so designed as to be capable of rapid assembly, if it has to be taken apart for loading.

In general, it is much easier to get equipment into gliders than into freighter aircraft, because the floors of the former are little more than a foot from the ground, their doors are at the end instead of at the side, and small ramps can readily be carried or improvised. Freighters on the other hand stand much higher off the ground, and have to be side-loaded ; this entails time and trouble in turning equipment through ninety degrees before it can be passed into the hold.

All inanimate objects loaded into gliders or freighters must be *securely lashed in position*, under the guidance of the R.A.F., to ensure that the centre of gravity conforms to flying requirements, and that no shifting of the cargo during flight can lead to disaster.

14. MORE PERMANENT AIRFIELDS

Although in the first instance it may suffice to make landing grounds for the lighter types of aircraft, it is almost certain that they will be ultimately required for the heavier types, if only for purposes of supply, except in countries which are well provided with surfaced roads.

As one of the most important features of warfare is the adequacy of transport, airborne transport will almost certainly be used sooner or later. In the

Libyan campaign practically all the immediate requirements of the R.A.F. after the advance from El Alamein were met by air transport, which enabled airfields to be seized behind Rommel's army so that fighters could operate from bases quite close to the front.

Soil-stabilization and mix-in-place.—The only forms of semi-permanent runway which afford any prospect of being made in a short time are those which are made from mixing the natural surface of the ground with some bituminous binding material or cement, because the only material which has to be brought to site is the binder itself. Granular soils are the most suitable for this process, but ordinary agricultural soils have been successfully treated under favourable conditions.

For instance, a perimeter track has been made on an airfield in England from a soil-stabilized sub-base surfaced with two inches of tarmacadam, but the addition of the tarmacadam surface precluded the possibility of the work being done at short notice owing to the quantities of material which had to be taken to site.

Mix-in-place work pre-supposes the existence of the necessary machinery to carry it out, as although such work can be done by hand this would take far too long and would present a perfect bombing target to the enemy. The machinery required includes bull-dozers, blade-graders, scrapers, scarifiers, disc-harrows or other apparatus which will enable the soil and the bitumen binder to be turned over together twenty or thirty times to form an intimate mix.

Runways made from concrete or similar substances require the aggregate to be brought to site, involving the provision and transport of enormous quantities of material. This type of construction is therefore not suitable for mobile warfare except for heavy bombers, the distance of whose airfields from the front line is not so important as in the case of fighters.

(A very good idea of the quantities of material required for a permanent airfield will be found in an article entitled "Airfield construction during the invasion battle," published in *The R.E. Journal* of March, 1943).

15. Repair and Maintenance of Airfields

Airfields may be put out of action by aerial bombing, or as the result of deliberate demolition. In either event, to make the airfield usable the aim should be to get a landing lane freed from obstructions as soon as possible.

If the damage has been caused by aerial bombing, a reconnaissance aircraft should be flown over to see where a landing lane can most easily be re-established, facing into the wind blowing at the time. This reconnaissance should be done in the presence of engineers so that no time is wasted in getting work started. Ranging rods or flags to mark the centre line of the landing lane should be set out, preferably by the R.A.F.

The filling of craters follows the recognized method of filling shell holes and can best be done by mechanical means.

The requirements are :—

(*a*) Remove loose lumps of earth and ruptured soil until a firm bottom is established.

(*b*) Fill with alternate one foot layers of earth and hard material, ending with hard material on the surface. Earth and sandbags can be used as hard material for filling.

(*c*) Ram each layer.

(*d*) Restore any damaged drains (allowing a few inches for subsequent settlement), or if this is impractical lay a line of hard core to connect the broken ends of the drain.

(e) Roll with a ten-ton or heavier roller and fill any settlement with hard material, not earth. If possible a three-inch surface of tar or bitumen macadam should be added. The filling is bound to go on settling for some time after repair and will need careful maintenance to keep it fit for use.

Machinery and Tools for repair.—It will seldom be possible to have the necessary apparatus available at each airfield owing to the supply position, and for this reason central depots will generally be established where plant, etc., can be stored ready for an emergency, to serve airfields within a radius of 20 miles. Mechanical earth-movers such as bull-dozers, dumpers, blade-graders, scrapers, power-driven rammers, will all speed the work and call must be made on all the personnel within reach, of every service or arm, to make good the damage as soon as possible by all available means.

After a raid the runways must be examined to see if camouflets have been formed. These can be detected by slight upheavals in the ground, cracks, smell of explosive and blackening round the hole. They may contain carbon monoxide and there is always the possibility of their falling in, particularly in wet weather.

A method of repairing hard-surfaced runways which have started to break up or develop weak spots has recently been perfected, and is now being widely used in England. This is the "Colcrete" process, which consists in grouting up the weak spots from underneath with a specially dense grout. The grout is made from exactly measured quantities of cement, sand and water, which are mixed together in a high-speed centrifugal machine and pumped underneath the damaged area until the surface is restored. This process is far quicker than breaking up the old surface and relaying it with fresh concrete, or other material; gets over difficulties of joining the new and old surfaces; and produces much stronger results.

16. Destruction of Airfields

Circumstances may arise under which airfields have to be put out of action. This is done by displacing as much earth on the runways in as many places as possible with the time and explosives available, and in such positions that the filling of a few craters would not make the runways fit for use.

A simple way of doing this is to use earth augers, with the idea of exploding camouflets, and, as a rough guide, two pounds of ammonal for each running yard of runway or taxi track are required. Unsurfaced airfields can readily be put out of action by ploughing them up, and this method was much used by the Germans when they were being bundled out of North Africa.

The destruction of runways by bombing cannot normally produce good results even with ten times the amount of explosives used for demolition on the ground, and the Germans never put any airfield in England out of use for long, even when they had most of the sky to themselves.

It may be possible to put airfields out of action by diverting or pumping water from whatever source, over them, and if craters have been made beforehand the effect of the water will be enhanced.

Pipe-pushing method.—Explosives can be introduced beneath runways by placing them in pipes and pushing the latter underneath them from the clear ground at the sides. Details of this procedure is given in "Field Engineering Pamphlet," No. 11, just issued. Normally this is a specialist's job, carried out by Tunnelling Companies.

Concrete runways can be destroyed by a strong rooter drawn by a D.6 or larger tractor, moving at a speed of half a mile per hour. Alternatively, concrete and other hard surface runways can be destroyed by explosive charges, which need only be large enough to upset the level of the surface and so prevent aircraft using it until it has been pulled up and relaid.

Booby traps can be laid within the demolition area with the object of blowing up hostile working parties and lowering their morale sufficiently to slow up the repair programme.

In all cases of deliberate demolition, the consent of the R.A.F. must be obtained as to the amount of work to be done, the time available, and the form of demolition employed, particularly if they propose to use the airfield up to the last moment. If time permit, the demolition plan should be put on paper so as to make sure that the best possible use has been made of the explosives and labour available.

17. Conclusion

A fitting conclusion to this article may be found in the words of a senior R.E. officer writing from one of the battle-fronts:—

"The big lesson I am learning here is the magnitude and urgency of the airfield problem. . ."

"We can never have enough mechanical equipment, the demands are enormous. . . ."

"Everything we do is limited by the transport problem. . ."

"I feel that all C.R.E.'s Works must be taught to understand that the maintenance of airfields and immediate repair work after air attack is their primary commitment in theatres of operations."

A FABLE

ONCE upon a time there was a Man who Drank Heavily. And Often. And he went into his Club for luncheon. And as he waited to be served he saw upon the menu the words:—

"Soused Herring (1) .. .. .. 1/6."

And he pondered deeply. For he knew well from past experience that it cost him about twenty shillings to get soused. And he weighed two hundred pounds. But in the case of a twopenny herring the same operation would appear to cost one shilling and fourpence. Yet the herring weighed but four ounces. Then indeed did he reason with himself in saying:—"Whereas it costs me one penny farthing per pound to get soused, it costs the lowly herring five shillings and fourpence per pound to achieve the same condition."

Obviously the moral of this is that it is cheaper to do things for yourself than to have them done for you.

J.C.T.W.

R.E. WORK FOR MECHANIZATION IN THE ARMY

PART I

PRIOR TO AUGUST, 1914

(Extract from unpublished Corps History)

Compiled from the Work of various Authors

NOTE :—*The R.E. Journal* has previously published extracts from *Corps History* dealing with (1) The mechanization of R.E. units (2) The R.E. and the Tank Corps.

PROGRESS of mechanization in the Army has been mainly dependent upon mechanical progress in the world. In war, and in preparing for it, armies are dependent upon the talents, progress and resources of the nations to which they belong. Armies apply the inventions of peace, adapting them from commercial use to the purposes of war. From time immemorial : Shipping, Roads, Vehicles, Animal Transport have been diverted and adapted from civilian use to the needs of war. Likewise in more modern times : Railways, Telegraphs, Mechanical Transport, Aviation and numerous other facilities produced by science have been made to serve armies. The more inventive and scientific the people of a country are, the better equipped by science will its army be when it has had time to adapt and to apply this knowledge to its requirements.

But the balance of credit between the civilian and the military professions is by no means all in favour of the former. In the preparation for war in time of peace the War Department takes up inventions at a very crude and embryonic stage, finances and aids the inventor in experiments and demonstrations, and places orders with civilian manufacturers without which their ideas would never have been launched upon commercial practice. Military men were among the inventors and researchers. In war, money is found lavishly for research and experiment, risks are taken by service personnel and by civilian scientists which would never be countenanced in peace. Large orders are placed by the War Department. The moment a new or better type appears in war former types are ruthlessly scrapped in favour of the latest. An invention runs through several editions, each better than the last, in a short period of war, whereas in peace the same progress would not be made within a generation. Of this, aviation is an outstanding example. Had there been no great war we should not have reached the present stage of development of flight within 50 years from 1914. Some may see no disadvantage in such delay but none will deny the acceleration due to war.

Consequently in describing the mechanization of the Army and the work done for it by the R.E. we must begin with a compressed synopsis of progress in the civilian mechanical world.

Civilians and soldiers had to wait for the development of the internal combustion engine before they could transport themselves, and their goods, on roads upon an economic and satisfactory basis. Soldiers had to wait for high tensile steel and light alloys for the multi-wheel drive, or the tracked vehicle, or better still the large low pressure pneumatic tyre, before they could obtain sufficient facility in travelling across country to justify scrapping their animal transport. The most important milestones in mechanical progress were the steam tractor, the motor car, the cross-country wheel, the petrol tractor, and the motor bicycle.

In 1789 Watt was granted a patent for a steam engine with a separate condenser.
In 1801 Trevithick produced his steam road locomotive, the father of all mechanical road vehicles.
From 1826-1831 Sir G. Gurney manufactured and ran steam coaches between Gloucester and Cheltenham.
In 1829 Robert Stevenson built the first practical locomotive engine, "The Rocket," the father of English locomotives.
In 1845 Thompson invented and patented the pneumatic tyre.
In 1857 Messrs. Fowler of Leeds made the first traction engine.
From 1857-1860 Boydell's traction engines in use in civil life aroused a good deal of interest in the War Department, and they were used commercially in India.
In 1865 was passed the act of Parliament which paralysed progress in mechanical transport on the road by enacting that every mechanical vehicle travelling by road should be preceded by a man walking in front carrying a red flag. It was not until 1896 that this act was repealed and motor transport was emancipated by the passing of the "Locomotives on Highways Act."
In 1865 the bicycle was invented.
From 1870-1874 Lieutenant Crompton of the K.R.R.C. (later Colonel Crompton, R.E., T.A., persuaded the Indian Government to allow him to purchase and run five rubber-tyred traction engines in the service of the Indian Post Office.
In 1884 the earliest Daimler motor car engine was made. This was the real beginning of the high speed motor car, lorry, motor boat and aero engine of to-day, but not till 1895 did Levasser in France make a practical success of these engines.
In 1893 the Diesel engine patent appears, followed in 1897 by Diesel's first engine which led to the high speed compression ignition engines fitted to commercial vehicles since about 1930.
From 1896-1900 as a result of the repeal of the "Red Flag Act" there was intensive development of the pleasure motor car and the commercial motor lorry, which placed the motor industry on a sound commercial basis and on the path of continuous progress.
In 1898 the Royal Automobile Club arranged trials of motor vehicles.
In 1902 the following was the condition of progress of Commercial M.T. in England :—
Heavy steam transport very well developed and plentiful;
Steam lorries in their infancy;
Petrol lorries in their early experimental stage;
Light tractors practically unknown.

Between 1902 and 1914 further evolution of mechanical vehicles, in civil life, can perhaps best be followed in the ensuing description of the progress of mechanization in the Army from the early days up to August, 1914. The part played therein by the Royal Engineers will of course receive special attention. As this progress in the Army unfolds, its dependence upon progress in the civilian mechanical world, see the foregoing synopsis, will become obvious, and the way in which the War Office and the men of the Army helped mechanical progress in general.

Military Engineers, from the very beginning of their existence in ancient warfare, established their profession by using mechanical means to multiply the power of men and animals, while at the same time making a saving in the number of men or animals required to produce a given effort. As progress in the mechanical world developed, the Royal Engineers were continually trying to adapt available machines and mechanical devices to their work in war and in peace. There emerged from these efforts certain vehicles which were of great value to the Army as a whole.

Thus in describing the progress of mechanization in the Army, so far as it concerns this history, we begin by describing the efforts of the R.E. to obtain mechanical plant and vehicles for use in their normal work, from which various types of vehicles for the Army as a whole developed. Next we come to the handing over by the R.E. to other branches of the Army the running and the maintenance of the vehicles, which those branches required, and the further development of their progress, leaving the R.E. still pursuing the development of mechanical plant and vehicles required for their own work in peace and war.

The first record we have of a Royal Engineers Officer pursuing this line of thought is of Captain Savery, R.E., in 1696 patenting a machine for raising water; an invention still in use to-day as the pulsometer pump.

In 1833 we find Colonel C. W. Pasley, Commandant of the R.E. Establishment at Chatham, a member of the Committee reporting upon Gurney's experiment in running steam coaches on the road.

In 1868 and 1869 the R.E. in their desire to use mechanical plant, mainly for water supply, and to bring this plant near the site by a mechanical vehicle travelling on the road, decided to purchase from Messrs. Aveling & Porter of Rochester a traction engine which was described as "Steam Sapper No. 1" and was used at Chatham.

It was named "The Prince Arthur" after the Duke of Connaught, who had recently received his first commission in the R.E.

In 1871 Major-General J. Lintorn Simmons (late R.E.), while Governor of the R.M.A., Woolwich, was appointed President of a War Office Committee to enquire into the respective merits of various traction engines.

We have already noted that it was in this year (1871) and up to 1875 that Lieutenant Crompton, K.R.R.C., was running traction engines in India. Although he started Army life in the K.R.R.C., we like to claim this very distinguished mechanical and electrical engineer as a Royal Engineer because, as related elsewhere, he was first a Volunteer and later a Territorial R.E., the first Commanding Officer, and ultimately the Hon. Colonel, of that splendid unit the London Electrical Engineers, R.E.

In 1871 also Steam Sapper No. 2 was purchased for use at Chatham. It was employed on manœuvres that year, and must have proved the value of mechanical transport for the Army, because in the same year five more similar machines were ordered for the R.E. Two of these, driven and maintained by R.E., were employed drawing heavy guns at Shoeburyness.

In 1873 we sent an expedition under the command of Sir Garnet Wolseley to Ashanti on the West Coast of Africa.

The C.R.E. of this expedition was the mechanically-minded Major R. Home, R.E., at that time Secretary of the R.E. Committee at the War Office. He included a steam sapper and a saw bench among the plant that he took with him to West Africa. It was landed at Cape Coast Castle in pieces.

In 1873 and for very many years afterwards there was not a mile of road in West Africa outside the coast towns, so it was hardly the best terrain for British mechanical transport to make its debut in war. It is not surprising to read that the steam sapper did not leave the town of Cape Coast Castle but was very useful there sawing timber.

In 1877 steam sappers were used in the siege operations at Chatham, and demonstrated their utility in bringing siege trains from the base to Artillery parks and stores from depots. The transport of heavy guns by mechanical traction continued to be a constant subject of investigation by War Office Committees on which the R.E. played a very important part, with the R.A., in research and experiments.

In 1883 a very notable man, Colonel Templer, began a long association with the Corps. At that time he was a Major in the Volunteers (7th Battalion, K.R.R.C.) and an enthusiast on ballooning for military purposes. He was also a mechanical engineer. He was authorised to establish a balloon and hydrogen factory at Chatham, and directed the attention of the War Office to the value of Fowler traction engines. In 1898 the balloon party was transferred to Aldershot. The Balloon Company was a Royal Engineer Unit working in collaboration with the Superintendent of the factory. We shall continue to hear of Colonel Templer.

For many years, certainly as far back as 1883 and probably earlier, a limited number of R.E. Officers were sent singly or in pairs to Civilian Engineering or Manufacturing Firms for a course of training in their workshops.

From 1883 onwards the R.E. Submarine mining service had a workshop at every port where they were established.

In 1884 the workshops of the S.M.E. Chatham became a separate branch of that instructional Establishment, which indicates the increasing importance attached to mechanical work in the Army. The R.E. "other ranks," who since 1870 had received their mechanical instruction in Woolwich Arsenal, henceforth obtained it at Chatham.

From 1871 until the South African War in 1899 steam transport was employed almost exclusively in schools and depots, and in connection with Colonel Templer's balloon factory, in fact in station work, but on several occasions also proved useful on Army manœuvres, notably in Berkshire in 1893 when 8 steam sappers and 3 hired traction engines were fully employed. Every year from 1895 to 1898 saw steam traction engines on manœuvres, their driving and maintenance being entirely in R.E. hands.

From 1870 onwards we find continuous record of the work of the R.E. Committee (the parent of the R.E. and Signals Board) in the research testing and purchasing of mechanical vehicles and plant.

In 1886 a new branch was established at the War Office under the Inspector-General of Fortifications and Works, the officer in charge of which was until 1917 known by the curious title of "Inspector of Iron Structures." Fortunately he never limited himself to inspecting such structures, but conceived it to be his duty not only to arrange mechanical and structural contracts connected with Army works, but also to co-operate in many branches of research especially for the mechanization of R.E. Units and the provision of mechanical transport for the Army, in which this official has always played a very important part, collaborating with the R.E. Committee which later became the R.E. Board.

Among the holders of this appointment were Colonel Inglis, Major English, Major Bate, Captain J. d'E. Johnstone. Other holders prior to August, 1914, whose names are prominent in work for Army mechanization were :—

1899-1905, Captain C. H. Nugent.		Staff Captains in this Office were :—
1905-1909, ,, T. H. Cochrane.		1902-1906, Captain R. K. Bagnall-Wild.
1909-1913, ,, A. G. Stevenson.		1906-1911, ,, D. Walcot.
1913-1917, ,, R. Oakes.		1911-1916, ,, A. L. C. Neame.

Thus the R.E. Committee, the I.I.S. and the Assistant Instructor at the S.M.E. Workshops, Chatham, were all working in close liaison, continually researching, experimenting, purchasing, testing and using numerous types of mechanical plant and vehicles, and adapting them to military purposes.

In 1897 a very important event was the purchase by the R.E. Committee of the Army's first steam lorry.

Major Nugent and Captain Bagnall-Wild were very prominent up to 1910 in numerous tests and trials in the contest between the Lorry Land Tractor, as the general purpose Army mechanical vehicle, and the ancient G. S. horsed wagon. From this contest the Lorry emerged the victor.

Captain Gaynor, R.E., who was Assistant Instructor in Workshops at the S.M.E. from 1893-1898, and in addition from 1895 R.E. adviser to the War Office on steam road transport, was very zealous in pursuing the cult of M.T. in the Army, and preaching and practising the doctrine. We find him on every committee and representing the War Office at every trial of M.T. It was a great misfortune that this promising and popular officer, after joining the Staff College, was killed in a riding accident. It seemed as if the horse was taking his revenge for Gaynor's constant efforts to eliminate him from the Army's transport.

His successor at the Chatham Workshops, Captain F. E. Harward, R.E. (unfortunately killed when sent to start motor transport in Somaliland) also did a great deal in mechanical research for the Army.

We have now reached an important milestone in Military Mechanization at the outbreak of the South African War, 1899-1902. Every war stimulates the development of the application of science to the art of destroying enemies, and stimulates science itself. The South African War was no exception. It was the first British war in which a serious attempt was made with some success to utilise mechanical transport, as we can hardly admit as a success Major Home's gallant attempt to take a steam sapper into West African jungle. Incidentally the name "Steam Sapper" disappeared in 1894, being replaced by "Traction Engine."

In this South African War Lieut.-Colonel E. P. C. Girouard, R.E., Director of Railways, caused 6" and 9.2" guns to be mounted on railway carriages. These guns firing from the railway came into action on several occasions. Many armoured trains, some of them commanded by R.E., and all of them containing R.E. detachments in their crews, well equipped with guns, machine guns, searchlights, and repair equipment, played a very important part in the operations under the general command of Major H. C. Nanton, R.E. Mobile field searchlights drawn by mechanical transport began their career in this war, manned by a very efficient detachment of the London Electrical Engineers under the redoubtable Colonel Crompton with Captain Lindsay Lloyd, R.E. as his Adjutant.

The abolition of the "Red Flag Act" in 1896 had been followed by a great spurt in the development of mechanical transport, and Colonel Templer had drawn the attention of the War Office to the value of the Fowler traction engines, which he was using at his balloon factory, specially built to his design. He was also a pioneer in experiments for rubber tyres.

He was appointed Director of Steam Road Transport in South Africa, with 45th Company, R.E., raised for the occasion, under the command of Captain

G. P. Scholfield, R.E., with one Subaltern, Lieutenant E. Barnardiston, R.E. Men with suitable trades were drafted into the Company, the strength of which was 100 Other Ranks. Three Civilian Engineers, Messrs. Walker, Borrell, and Maclaren, and a few civilian drivers also went with Captain Scholfield. The traction engines and trucks, spare parts and workshop equipment, reached South Africa at the end of 1899 and early in 1900, after a mishap to one shipload, sunk at Las Palmas, but whereas the traction engines were recovered from the wreck and did their work in South Africa, the horses in the same ship remained drowned.

In April, 1900, Lieutenant Harward, R.E., Instructor at S.M.E. Workshops, took charge of workshops and stores for steam road transport (S.R.T.) at Cape Town. In 1902 Lieutenant N. D. Conner from the I.I.S. office joined S.R.T. in South Africa.

In October, 1900, Colonel Templer being required at home to resume his work at the balloon factory, Captain Scholfield became Director S.R.T. in South Africa.

By June 1st, 1902, on the declaration of peace the small establishment for S.R.T. in South Africa had grown from its modest beginnings in 1899 to:—

10 Officers,	Steam Tractors, 46, of which 41
326 R.E. Other Ranks,	built by Fowler of Leeds.
156 Civilians,	
238 Natives.	Steam Lorries, 2.
Total 730.	Trucks, 250.

S.R.T. in South Africa was used almost entirely in Depots and Towns. It was sometimes allotted to columns but was rarely a success on such occasions, largely because the method of utilising it was not understood. It occasionally hauled heavy guns out of difficulties.

With the important exception of Colonel Templer, and his two Staff Officers, mechanical transport in the South African War was entirely run by the R.E. assisted by a civilian detachment. It was steam transport because steam was still supreme in the mechanical world. The infant petrol I.C. engine had issued a challenge and was developing fast, but was not yet sufficiently efficient to oust the long established steam engine.

But Captain R. S. Walker, R.E., "Long Walker" commanding the R.E. Searchlight Company, which had taken over from the London Electrical Engineers their mechanical transport and searchlights in South Africa, and also the experimental vehicles of the S.R.T. on their disbandment, had already introduced the petrol I.C. engined motor vehicle to war. He was the first to use such a vehicle in war and nearly paid for doing so with his life. He had his searchlights in a blockhouse line and decided to do his round of inspection at night by motor car. On arrival within sound of a blockhouse he was received with a furious fusilade. Leaving his motor car in a depression in the ground, he approached the blockhouse on foot and then on hands and knees, which was prudent as he was 6 ft. 6 inches in height. Having arrived close to the blockhouse, he took advantage of a lull in the firing to ask if they had not been warned by telephone that an officer was coming out by motor car. "Yes," was the reply, "but we didn't believe that."

The writer can testify that Captain R. S. Walker was in 1901 preaching that the petrol I.C. engine had solved the problem of Army transport and of flight in the air. He also reported officially that mobile searchlights should be carried on petrol driven vehicles, whose engines would generate the electricity but another 12 years elapsed before this came about. If Walker had not unfortunately been killed in France during the first world war he would undoubtedly have made a great name in the mechanical world.

The Subalterns of his small searchlight unit in South Africa deserve also to be recorded. They were :—

Lieut. D. S. Collins, R.E. (D.F.W., War Office, from 1935),
,, C. B. Harvey, R.E.
,, A. E. Davidson, R.E. (Director of Mechanization, War Office, from June, 1936),
,, W. H. E. Forsyth, R.E.

The achievements of mechanical transport in the South African War, modest though they were and limited by the existing development of mechanical vehicles, established the fact that mechanical transport for the Army in war and in peace had come to stay. The reports of Captain Gaynor, R.E., on its use on manœuvres in 1899, and Major G. P. Scholfield's report on S.R.T. in South Africa attracted the attention of the authorities at the War Office, with the result that in 1900 General Sir Richard Harrison (late R.E.), then Inspector General of Fortifications and Works at the War Office, wrote a minute proposing that a mechanical transport committee should be established at the War Office to study the question of M.T. in the Army and to develop its use. General Sir Evelyn Wood, the Q.M.G., strongly backed the proposal, and the "Mechanical Transport Committee" (M.T.C.) came into existence with an allotment of £4,000 for experiments.

This was the beginning of serious, sustained, and vigorous prosecution of the development of M.T. for the general use of the Army, coinciding as it did with the great spurt in progress of the civilian automobile world.

Hitherto the R.E. had been responsible for studying the progress of mechanical vehicles and plant, mainly with a view to helping them in their own work. Then in South Africa they demonstrated the utility of M.T. for the Army as a whole. Now the head of the R.E. Corps (the I.G.F.) had drawn the attention of the Army to this important subject, and created the M.T.C., the agency which caused mechanical transport to serve the whole Army. In this article we have naturally drawn attention to this work of the Corps, but we must not omit to mention that other officers of the Army had from early days been working on the same lines, notably Lieut.-Colonel Heyman, R.A., since the Gunners were interested in mechanical traction for guns and worked in collaboration with the R.E.; Colonel Templer also played a very important part in the introduction of M.T. to the Army.

With the formation of the M.T.C. in 1900 it was obvious that the time had come for the Army's transport corps, the A.S.C., to turn their attention to this subject. The M.T.C. was divided into three sub-committees: R.A., R.E., and A.S.C. The R.A. sub-committee was particularly concerned with gun haulage, the R.E. continued to examine how mechanization could be developed in their own Units, but at the same time were collaborating with R.A. and A.S.C., especially in research experiment and in training the A.S.C. personnel to assume their mechanical responsibilities. The A.S.C. sub-committee were occupied in developing the mechanical side of the Army's transport, but all three sub-committees worked in collaboration with the "M.T.C." A very important member was Lieut.-Colonel Holden, R.A.

The R.E. supplied the Secretary, Major Lindsay Lloyd—who since became a leading light in the automobile world. Lieut.-Colonel Crompton, now a big consulting engineer in London, was a member of the Committee. He was also President of the Institution of Automobile Engineers in 1906-1908. Major C. H. H. Nugent, R.E., was on all the sub-committees, and other R.E. Officers connected with the M.T. Committee were Colonel T. R. Main, Captain C. H. Prentice, Captain G. B. Roberts. The I.I.S. was *ex-officio* a member, and his office was the agency for much of its practical experiments and work. Captain Nugent, who was I.I.S. from 1899-1905, played a very important part in starting the work of the M.T.C. on the right lines. Captain Nugent was again prominent in connection with starting the M.T. of the Army in India during the first World War.

We find in the records that all the I.I.S.'s. and their Staff Captains (already named) were continuously doing good work on the M.T.C., and R. S. Walker, A. E. Davidson and F. R. P. O'Callaghan also gave valuable help. During 1903 Lieutenant A. E. Davidson underwent training in Messrs. Thorneycroft's workshops for M.T. manufacture, the first Officer to do this training with a motor manufacturing firm.

The successive Secretaries of the M.T.C. were:—

Major Lindsay Lloyd, R.E.	1900-1906.
Captain Bagnall-Wild, R.E.	1906-1909.
Captain A. E. Davidson, R.E.	1910-1914.

We have already said that the history of the M.T.C. is the history of progress from 1900 to 1914 (and later) in mechanization of the Army. The R.E. sub-committee of the M.T.C. was engaged not only on the question of mechanization of R.E. Units, but on the problem of the mechanization of the whole Army.

The mechanical vehicles used for transport of searchlights in South Africa led to enquiries whether mechanical traction could not be used by other R.E. Units. Since 1897 steam traction Engines had been used by the R.E. at Gibraltar. We will anticipate later history by recording here that in June, 1933, Lance-Corporal J. S. Barnett, R.E., was awarded the M.B.E. for his skill and courage in taking heavy and awkward loads up the steep slippery and narrow roads on the Rock (see full account in *The Sapper*, November, 1933).

Inspired by these examples the mechanical enthusiasts on the R.E. sub-committee of the M.T.C. in May, 1901, made the sweeping recommendation that steam tractors or steam lorries should be used by the following R.E. Units:—

Pontoon Troop, Telegraph Division, Balloon Section, Field Company, Field Park, Railway Company, Searchlight Unit,

and advocated the allotment of 80 to 90 lorries to each Army Corps for the use of the Engineers. Only the Field Troop, the Balloon Depot, and Survey Section were to retain horse transport.

We know now that this recommendation was much in advance of the existing state of development of mechanical transport, which was still tied to roads or hard ground. It was essential for the transport of the Telegraph Division (the forerunner of Signals) and the Field Company to be able to travel across country. Not till mechanical vehicles acquired cross-country capacity was it possible to completely mechanize Field Companies and Signal Units, as we shall see later. Nevertheless the Sub-Committee of 1901 were right in foreseeing the necessity for R.E. to have M.T. at their disposal for work in war.

They were right in proposing M.T. for pontoon trains and mobile searchlights. Skipping the continual efforts to search for solutions of the problem, when the R.E. went to war in 1914 they had a few traction engines at the S.M.E., a few Halford Stevens petrol electric searchlight lorries purchased in 1908 and onwards, whilst a smaller number of light M.T. vehicles and motor cycles were allotted to the Signal Units. Most fortunately, a special reserve of civilian motor cycle despatch riders for the Signals was formed in 1910 which proved invaluable in war.

Captain E. G. Wace, R.E., at the Military Training branch at the War Office organized and maintained this reserve. No provision had been made for mechanical traction of pontoons before 1914. In fact the motor transport at the disposal of the R.E. in August, 1914, was almost negligible. But the more important work done by the R.E., at Chatham and Aldershot, was to help the Transport Corps of the Army, the A.S.C., to take up their responsibility for M.T.

In 1902 as a result of the deliberations of the M.T.C. the War Office made a decision of paramount and far-reaching importance, that M.T. was Army transport and not confined to technical units. Therefore the A.S.C. must drive and maintain mechanical Army transport. Hitherto the A.S.C. had not been concerned in any way with this type of transport. They were organized and equipped entirely on the basis of animal transport, and naturally turned to the R.E. to start their new responsibilities. In 1902 one section of an M.T. Company A.S.C., was formed at Aldershot under R.E. tutelage. In 1903 and 1904 two complete M.T. Companies, A.S.C., were formed and trained for a year at Chatham, using the workshops there. Their technical instructor was Major M. R. Kennedy, R.E., and a certain number of R.E. Instructors and Other Ranks were transferred to the A.S.C.

In 1905 M.T. Units first appear in the establishment of the Army with steam traction engines. By 1910 the A.S.C. strength of personnel in M.T. was only 600. Experimental work was still being carried on by the I.I.S. at the War Office, pending the development of an A.S.C. technical nucleus formed at Aldershot. Not till 1909 were A.S.C. Officers sent for technical training to civilian workshops.

The transfer of Army M.T. from R.E. to A.S.C. was gradual, the A.S.C. taking over as the technical efficiency of their M.T. organization developed. In 1903 the R.E. were still running M.T. on manœuvres under Major Kennedy. The transfer of responsibility for Army M.T. from R.E. to A.S.C. was completed by 1910. Thus when the civilian mechanical transport engineers and personnel came pouring into the New Armies for war they were commissioned or enlisted in the A.S.C. and not in the R.E.

The War Office, on the initiation of the M.T.C., in 1901, 1903, and 1909 organized competitions and trials among civilian firms to obtain suitable types of vehicles, but they failed to produce the answer to the problem, and the same may be said of similar trials arranged by the Royal Flying Corps.

Just as the nation had bound itself by the " Red Flag Act " of Parliament from 1865 to 1896 not to develop mechanical transport, so the Army, on the strength of the best technical civilian advice, hampered its search for suitable vehicles by banning the use of petrol in war as being too inflammable and explosive to survive such risks. Not till 1912 was this ban removed, just in time to enable the Army to acquire some of the right types of mechanical vehicles with which to begin the War. In 1912 the first W.D. trials were held open to a speedy type of *petrol* lorry.

By good fortune the technical experts of the London General Omnibus Company evolved an omnibus, the chassis of which was not only the right answer to the Problem of London Transport, establishing the motor 'bus in an unchallenged position in that service, but also proved very useful in war for the carriage of troops and bulky loads such as hay.

In this account it is worthy of special note that the London General Omnibus Company was under the able management of Major Dumble, R.E., who retired from being Adjutant of the London Electrical Engineers in order to take up this post when the L.G.O. Company was in considerable difficulties owing to repeated failures to produce a satisfactory motor 'bus. Under Dumble's management, with Captain Fishbourne, R.E., as his assistant, the L.G.O. Company bought up all competing omnibus companies and acquired virtual monopoly of that type of transport service in London. Financially and as a transport service the Company had a rapid rise to assured and continuous success, which at the same time gave the Army one of the types of vehicle it was looking for. But it must be noted that there was yet no cross-country capacity in any available vehicles. The solid rubber tyre tied the M.T. to roads and hard ground.

In 1910 it was decided that the I.C. Lorry should be the vehicle for supply columns and Parks.

Thus we find that when war broke out in 1914 the 2nd Line Transport of the Army was entirely on a lorry basis except for a few steam tractor-drawn workshops, and the R.E., who had played a considerable part in bringing this about, had just handed over the complete control and running and maintenance and technical research of Motor Transport to the A.S.C.

In August, 1914, although the Army owned only 20 petrol-driven vehicles, nearly 1,000 vehicles, drawn from civilian sources were sent overseas with the B.E.F. The Army's M.T. were 3-ton and 30-cwt. lorries. But the resources of Great Britain in the manufacture of mechanical vehicles had not reached a stage of development sufficient to meet the demands of the rapidly expanding Army. It was from America that the bulk of these demands were met.

Gun Traction.

The R.A. Sub-Committee had meanwhile been busy with experiments for the mechanical traction of guns. The I.I.S. and other R.E. Officers were associated with this work on Committees and at practical trials.

Up till about 1910 guns in siege trains were hauled on travelling carriages by traction engines.

In 1877 the Secretary, R.E. Committee, reported on trials for gun traction by 8-ton and 6-ton steam sappers. Such reports and trials by R.E. continue to be recorded from time to time. We have already referred to occasional traction of guns by steam traction engines in the South African War. After this war R.A. and R.E. were busy at Lydd, Aldershot, and other places on experiments for mechanical traction of guns. The Hornsby chain tractor proved to be the most successful pre-war model as a result of trials in 1906 and 1907.

In 1902 a Volunteer Artillery battery, the 1st Newcastle-on-Tyne Volunteer Artillery, equipped with 4.7" guns, was supplied with hired Fowler steam traction engines and travelled fifty miles in one day. In 1908 engine draft for individual guns on their firing carriages attached to limbers was first introduced. By 1912 a Hornsby oil-driven tractor had successfully passed its trials. The purchase of Holt tractors from America was also recommended by the M.T.C., but the G.S. were doubtful whether heavy artillery would be required in the next war, which it was expected would be short and mobile. The technical branches of the Army had found the vehicles required, but Army policy was against their use.

We therefore began the first World War without a gun tractor, and had to resort to America for nearly all our requirements in gun tractors, although the French in 1913 had more than 100 four wheel drive tractors for heavy guns. The Austrians also had over 100 four wheel drive Daimler tractors.

Armoured Cars.

In 1896 Hiram Maxim produced a quadricycle carrying one of his machine guns, but the Army did not adopt it.

In 1898 Vickers and Maxim mounted Maxim guns in 14 H.P. Daimler motors, but they were not successful as there was not sufficient power.

Prior to the first World War the difficulty of carrying the necessary weight on the motor vehicles available prevented their adoption by the Army.

The War therefore started with no organized armoured car units.

MEMOIRS

BRIGADIER P. W. CLARK, C.B.E., D.S.O., M.C.

PERCY WILLIAM CLARK was born on 19th November, 1888, at Ash Cottage, Putney. He was the eldest son and third child of James and Elizabeth Clark, who had a family of six. His father was an artist whose early talent and passionate love of his work had brought him in the early '70s from the north of England to study in London and Paris. The family moved to Chelsea and it was in the atmosphere of the artists' community of the nineties and early part of this century that Clark spent his childhood and early youth.

It was a happy environment. The family of three boys and three girls were unusually fortunate in their upbringing. Sensible strictness tempered with affection and freedom ; discipline, balanced with understanding, and, above all, a fine sense of humour, made absence of ease and luxury almost unnoticeable. The father was an imaginative and sensitive artist, a man of great faith and courage. A prolific reader of good books, who retained the enthusiasm of a student to the end of his life which came at the age of eighty-four, only five weeks before the death of his son, Percy William. Clark's mother, who survives him, always remained in his memory as the patient, practical, and sympathetic lady whose whole life was centred on the care of her husband and his art, and the well being and education of her six children.

Their home in Chelsea was the scene of a vigorous family life pivoting round the artistic activities of the studio. It was a constant meeting place for numerous painters, sculptors, musicians, and writers. Those were the days when people entertained themselves—musical evenings, Christmas plays in the studio with audiences of artists and their families—men like the painters, S. St. G. Hare, T. B. Kennington, F. Marriott, Fred Brown, Alfred Drury the sculptor, Herbert Sharpe the musician, George Sturt and the then little-known Arnold Bennett.

Clark was educated at St. Mark's College School, Chelsea. After matriculating he took a London University Course of Engineering at the South Western Polytechnic, Chelsea, and was then articled to a consulting engineer —the late Mr. H. W. Ravenshaw, M.Inst.C.E., M.I.Mech.E. He became an enthusiastic Territorial, joining as a sapper the Man-Lifting Kite Section of the Royal Engineers (T.F.).

Clark inherited and developed the quality of initiative and the capacity to improvise—signs of quick intelligence. There was not a great deal of money to spare in those days and the enjoyment of sport, recreations, and hobbies was dependent on energetic enthusiasm and an imaginative outlook rather than an easy supply of pocket money. An ardent lover of country life, he would seize every opportunity to get away to the country on his bicycle or for long walking expeditions accompanied by his numerous friends. Fishing, boating and swimming—each held an attraction for him. He had a natural aptitude as a jumper and as a schoolboy, student and Territorial, invariably won the high jump. In 1908, Clark joined the Staff of Alfred Parsons at Newcastle-on-Tyne, and later Messrs. Williams and Robinsons at Rugby.

In September, 1914, Clark received a temporary commission in the Royal Engineers and, after a short period of training, was posted to the 20th Divisional Signal Company then in process of formation. His O.C. was Colonel—then Captain—F. J. M. Stratton, D.S.O., Professor of Mathematics and Astronomy

Brigadier Percy W Clark CBE DSO MC

at Caius College, Cambridge. Clark was in charge of the mounted section and, taking to horsemanship and horse management as a duck takes to water, soon turned out quite a respectable body of horsemen from his men, many of whom had never ridden before. Clark's wit, keen sense of humour, and real efficiency made a happy and contented team of the Company in the early days of training. In July, 1915, the Company went to France.

In 1916, Clark obtained command of the 61st Divisional Signal Company. He received the Military Cross for gallantry in action in June, 1917, and the D.S.O. in January, 1919. His Corps Commander writing of him says "A highly efficient officer with a thorough knowledge of his work. He has been daily in the Line superintending the Signal arrangements and the Division has never failed to be in touch when required. He is personally popular, possesses marked individuality, and throughout has never spared himself in the interest of the Division." In January, 1919, Clark was demobilized as a pivotal man but was recalled to the Army at the end of the year, and was selected for a permanent commission as Captain in 1921.

In 1922, Clark came home from India for the Supplementary Course and, after a spell as D.O. York, and Instructor at Chatham, was appointed Staff Captain Works at the War Office, where his advice and opinions were always listened to "with the respect due to his engineering ability and experience, and he was deservedly popular with seniors and juniors alike." From 1928-1931, he served with the Iraq Army finishing up as Inspector of Military Works at Baghdad. He received the North Kurdistan Medal and clasp, and the bar to the D.S.O.

From 1932-1937, Clark was D.C.R.E. Shoeburyness, which gave great scope to his civil and mechanical engineering experience and ability. Apart from his work on the experimental 15" gun emplacement, prior to its installation at Singapore, the rebuilding of one of the proof butts, and other work at Shoeburyness, the defence of the Ports of London were being remodelled. His C.R.E. writes of him. "He had a very clear and logical brain with a very sound knowledge of Engineering and Building construction. He could pick out the weak spots in any project and had a most receptive mind."

In 1934, Clark received a well deserved brevet of Lieut.-Colonel. On leaving Shoeburyness he served under the Air Ministry as C.E., Iraq.

He was promoted Colonel in 1938 with an antedate to 1936. The outbreak of the second world war found him Assistant Director of Works at the War Office.

On 4th September, Clark went with the Destroyer party to France to be Deputy Director of Works. Early in December he was appointed Chief Engineer Advanced Air Striking Force R.A.F., with the rank of Brigadier and Headquarters at Epernay. The work included the construction of 18 new aerodromes with access roads and accommodation and the enlargement and improvement of at least 10 others.

This great task with all its attendant problems was one after Clark's own heart. Hard frosts, coupled with the paucity of materials transport and plant, caused heartbreaking delays. Clark worked 12 to 16 hours a day siting the new aerodromes required, arranging the Staff, manpower, and materials, and dealing with the interminable administrative problems.

"Clark worked wholeheartedly to co-operate with the R.A.F. He was never disturbed by the bigger problems that came his way. He possessed a fine fighting spirit, and at the same time a charm of manner. He had a knack of handling the French diplomatically, but firmly. "His sense of humour provided a fund of ready wit in times of difficulty which brought respect and goodwill under adverse conditions. He was a leader of men and always gave personal interest to those under him, wherever the personal touch was required. He could also be ruthless to those who failed him."

By the 15th April, twelve new aerodromes had been levelled and sown down to grass and the landing areas of eight satellite aerodromes had been enlarged and improved. Other work was well advanced when on the 10th May active operations by the enemy commenced. Efforts were then concentrated on providing airfields from which the Advanced Air Striking Force could operate—These included maintenance and repair work on existing airfields including eight new aerodromes in the South Champagne area and the construction of three new airfields in the Vendome area. "During this period Clark had to work entirely on his own and make the most outstanding and, under the circumstances, remarkably successful efforts to meet the constantly changing situation. He was one of these people who, while making quite clear what his needs are, does not wait about but gets on with what resources he has; in that he was an ideal subordinate. He fought like a tiger for what he considered necessary, so there was no doubt as to the position —meanwhile one could be quite certain that he would organize and press on his work to the best of his power—He was completely loyal and understanding and was always ready to appreciate the claims of others. Whenever I had dealings with him he seemed to have landed into a job at which many men might quail—Clark never seemed to falter—He never lost his equanimity and brought quietly to bear on the problems a clear thinking incisive brain."

In June, 1940, Clark was promoted Brigadier and appointed Chief Engineer, British Troops in Northern Ireland. In December, 1940, he was awarded a C.B.E. for his services in France and appointed Chief Engineer Southern Command. On 15th February, 1943, he left his office after his customary hard day's work to go to his billet. Within half an hour of his arrival the great heart, which had never failed him, had stopped for ever.

This memoir is drawn from tributes of many associated with Clark—seniors, colleagues, and subordinates. The compiler who was associated with him in the last three years of his life, and learned to love and respect him, must add a few words of his own.

Clark had a natural aptitude for his profession, had been well grounded in its technique and had a rich and varied experience in the arts of both civil and military engineering. Skill and experience, however, are but the craftman's tools, and it was the character and dominating personality of the man, which enabled him to use these tools to such good effect. Simplicity and an eager search for the beautiful in nature and in the arts, and for the finer points of his brother men, were the keynotes of his character. Fierce in the pursuit of justice for his fellows, and to him subordinates were not just subordinates but always fellow men, and intensely loyal to his superiors, he assumed, unless the contrary was proved beyond question, the same qualities in those with whom he came in contact. And if all could not reach his high standards, his was a torch which pointed the right way and was eagerly followed. As a man, a soldier, and an engineer he was, and still is an inspiration to those who were fortunate enough to be associated with him.

One cannot close without a brief reference to his married life. Despite long absences on foreign service the background of his home was the dominating influence of the man as it had been of the child. He married in 1920, Dorothy, daughter of E. T. Foulger, Esq. He leaves two daughters—one an L.R.I.B.A., following the family tradition of applied art, one training at Guys Hospital, and two sons, one in the Corps and the other still at school.

R.A.B.

Brigadier Mansfield H Caldwell CBE

BRIGADIER M. R. CALDWELL, C.B.E.

Mansfield Richard Caldwell was born on the 6th February, 1899, and passed from Bedford into "The Shop" at the time of short War-Courses. He was commissioned into the Corps on 26th May, 1916, at the very early age of 17½ years. After six months at the S.M.E., he joined the 64th Field Coy. in France, but was back at Chatham in April, 1917, as Assistant Adjutant, 1st Reserve Battalion, when just eighteen, and showed at once tremendous keenness and energy. Setting a very high standard himself, he expected it from others and this, coupled with his youth and inexperience, produced an outward appearance of militarism, or "Prussianism," which resulted in the nickname of Hindenburg: given by an unknown sapper recruit.

Time and experience softened this militarism, whilst broadening his high ideals. The nickname was soon appropriately mellowed into "Hindy," which never left him.

August, 1918, found him back in France with the 76th Field Coy., with whom he stayed until the end of 1919, gaining a Mention in Despatches. After a short spell at Aldershot he joined the 3rd Sappers and Miners in Palestine, and returning with them to Kirkee in 1921 was appointed Adjutant. The serious illness of his mother called him home in September, 1921; fortunately she recovered, and on October 8th, as a junior Subaltern of twenty-two, he married Jean Charlotte, daughter of the late Lieut.-Colonel W. F. Everett, of Tenterden, Guyra, New South Wales. They were indeed "good companions" and to Mrs. Hindy is due much of the softening of the militarism and the steady development of his character.

Shortly after his marriage Hindy was posted to the 12th Field Coy. in Ireland, coming over with them to Aldershot in March, 1922, and was appointed Adjutant to the C.R.E. 1st Division, but in September, 1922, he joined No. 9 Supplementary Class for the post-war two year Chatham-Cambridge Course. This enabled him to make up the leeway lost in the abbreviated War-time Courses of 1916 and to play games to his heart's content. Those games most appealed to his vital character which demanded real physical and mental fitness and guts, and he soon made a name for himself on the Rugger field and in the Boxing ring. At the end of the Course Hindy returned to Aldershot and the 12th Field Coy., leaving in 1926 on promotion to Captain to become D.O.R.E. Wellington Lines; his first experience of Works Services. In November, 1927, he returned to the 1st Divisional Engineers again as Adjutant, a job he thoroughly enjoyed, giving to it his tremendous energy, enthusiasm, and efficiency, even so he had some to spare for hunting, and to work for the Staff College examination. He qualified twice, gaining a vacancy the second time. Two happy years, 1929 and 1930, were spent at Camberley where he made more friends and the name Hindy became well known to many outside the Corps. The late Brigadier W. Porter, C.B.E., was in the same year.

In November, 1931, he took up his first Staff appointment as Brigade Major to the Federated Malay States Volunteer Force, his good work being rewarded by a Brevet Majority, a few months before his substantive promotion in April, 1935, and his reversion to the Home Establishment.

After a year in the Training Bn. at Chatham Hindy went in May, 1936, as Chief Instructor at the "Shop," an excellent selection and one after his own heart. Here he brought unbounded enthusiasm, drive and a real gift for getting to know the Cadets; to many it was their first encounter with an Officer of such outstanding zeal. After his tour abroad it was evident that his character had matured; his tremendous enthusiasm, efficiency, and drive remained, but knowledge and experience had softened the intense militarism of his youth. There can be no doubt that Hindy's own character and example helped to mould that of many Cadets of his time. He attended every Rugger match and his encouragement from the touch line could be heard all over the field. He refereed all the more important Boxing contests and used positively to glow with approval when a particularly tough fight was put up. The Hindy's were both more than useful at Amateur Theatricals; and now at the "Shop" they contributed, in no small way, to the Staff Plays.

Shortly before the outbreak of this war, Hindy was sent to the D.M.T's Branch at the War Office as a G.S.O.II, although longing for a more active job in closer touch with troops; but in September, 1940, he was appointed C.R.E. of a Division. Here he remained, revelling in the work and doing a first class job, until promoted Substantive Lieut.-Colonel at the end of January, 1942. Then he was selected, much against his will, for the Air Ministry as G.S.O.I. to Maj.-General Liardet who was then building up the new R.A.F. Regiment. On March 19th to his intense delight and satisfaction he was appointed Chief Engineer, 5th Corps, with the rank of Brigadier. There began an association with Commander and Staff which lasted until his death. His keenness, ability, and drive were proved to the hilt under the acid test of war.

5th Corps H.Q., during that hard testing, and disappointing winter of 1942-43, was the only British Corps H.Q. in North Africa. The responsibility and the work were prodigious; but Hindy was at his best in such conditions. Untiring and always cheerful, he set all the Sappers in the Corps a wonderful example, never asking anyone to do a thing he was not prepared to do himself. He was particularly proud of the battle scars on his car. Three times his car was shot up under him by low-flying intruders and a road junction where one of these episodes occurred was known to all as Hindenburg Corner. All kinds of sapper work fell to his lot, airfields and landing grounds, a most difficult but vital job during those wet muddy months; mine clearance; Class 70 fords and bridges, built under service conditions. Hindy set out to make the Sappers in his Corps the best; but not regardless of his men's welfare, accommodation, employment, and training. His personality and character carried his officers and men with him, driving was never necessary.

His untimely death was the result of a tragic accident at Taranto, in Italy, on September 16th, 1943. Passing the station he saw a truck burning, and ran down collecting some men to push it away from the rest of the trucks on that line to prevent the fire spreading. No doubt he knew that it contained petrol and being therefore a dangerous job he stayed to help the men himself, as he always did in such circumstances. The truck exploded, and he was badly wounded and burnt.

Although everything possible was done in the Hospital to which he was taken, he died on 25th September, 1943, and was buried in its newly created small British Cemetery. The service was taken by Victor Pike (the old Irish International) who had been on the "Shop" Staff with him, and was attended by his General and all his friends from Corps Headquarters.

His Corps Commander writes:—

"He was liked by everyone and we had such jokes together always, just like a big family. He loved having his leg pulled and then came out with some answer to make us all laugh. He was happy here I do know and it will be many a long day before we get anyone who fits in half so well. Quite apart from all this he was really first class at his job.

"He used to flare up like a squib very quickly if something went wrong, and this was because he was so mad keen to get whatever was in hand pushed through and finished. During one of these spells he would often say pretty sharp things to his subordinates, not one of whom minded or bore him a pennyworth of malice at any time. In fact one of the things that surprised me most when he died was how many of the men said quite openly how very sorry they were that he had been knocked out; and this from an undemonstrative nation is a good chit.

"His enthusiasm and drive were infectious, he could sail in to a rather weary party working on a bridge or road and crash about amongst them urging them on, and the response was always forthcoming.

"We say goodbye temporarily to a great companion and a grand fighting soldier. He has done a great deal for the Corps and the C.B.E. he received was really well earned."

Apart from 5th Corps, Hindy saw the wider picture and gave a loyalty and service to those above him in the Engineer chain of Command which was deeply appreciated and will not be forgotten; personally I owe him a deep debt of gratitude. He most surely lived up to the motto of—Service not Self. The Chief Engineer, First Army, has written me:—

"I have known nobody who was more loyal to those with whom he served, more straightforward in all his dealings, or more devoid of any form of self interest. He bore the brunt of the responsibility for the engineer work during the Tunisian Campaign. It was largely due to his resourcefulness and unsparing efforts that such success was achieved. C.R.E's frequently told me how much they owed him and how easy he made their task. Brig. Hindy, as he was affectionately called by both officers and men, was one of the personalities of the Tunisian Campaign. I can never forget how much he did to contribute to the success of the campaign and towards the mutual support and close co-operation that existed between the sappers of the various formations in the First Army."

Hindy's passing at the early age of 44 robs the Corps of one of its truest members, who can be ill spared, and leaves a gap that can never be filled. His ideals were of the highest, he never spared himself in their attainment; at all times he was a foe to slackness; self seeking and self advancement were entirely foreign to him. By his life and example he has added to the honours of the Corps of Royal Engineers, which he loved and served so well.

He leaves three children, two sons and a daughter; the eldest son John, aged 19 has just passed into his father's Corps through the R.E. O.C.T.U. and is now a subaltern in an Armoured Divisional Engineers.

B.K.Y.

BOOK REVIEWS

(Most of the books reviewed may be seen in the R.E. Corps Library at Brompton Barracks, Chatham.)

SOLDIERS ALSO ASKED

Edited by the REV. RONALD SELBY WRIGHT, C.F.

(Published by the Oxford University Press 150 + x pages. Price 4s. 6d.)

THIS book consists of twenty-two questions frequently asked by troops, and their answers given by twenty-two different persons, of whom eighteen are clergymen.

The answers coming from twenty-two different sources naturally vary in their effectiveness. Some are undoubtedly convincing, and just what a genuine seeker after the truth needs. But in the opinion of the writer of this review many are unsatisfying. The reasons for this may be defined as follows :—

Many of the questions enter the realm of the spirit, far beyond all human knowledge, dealing with matters about which the only knowledge man can acquire is from such revelation as God may give. It is therefore disquieting to find but little attempt to base the answers on God's one revelation to man, *i.e.* His Book, the Bible, where His thoughts on all essential matters can be found. Unfortunately this is rarely quoted as the authority, and thus the foundation of faith is in danger of being undermined. In fact in at least one answer the authority and reliability of the Bible is deliberately attacked. Nothing could be more unfortunate. Another reason for the inadequacy of some of the answers, is that they do not appear to be based on personal experience, which men now value far above abstruse reasoning.

In the answer to what happens—" If I am shot " it is unfortunate that so much space is devoted to the " findings " of Spiritualism. The answer as given may stimulate interest in this evil thing, categorically forbidden in both Old and New Testaments.

Space does not permit further detailed criticism but the above may suffice to show why the writer of the review finds much of the book disappointing and unsatisfying.

W.G.S.D.

THIS WAR AGAINST JAPAN

BY IAN MORRISON

(Faber & Faber Ltd. A most informative little book, 119 pp. and 64 photographs. Price 7/6.)

Mr. Morrison in a few well-written pages states very clearly some problems arising out of the present conflict in the Far East, and suggests possible solutions. This publication is fully justified ; it supplies a crying want, and should make all who read it realize that this War is global. The defeat of Germany and the destruction of Hitlerism are not enough.

Part I.—In his search for the causes and the true nature of the war. the author traces the origin and development of the Japanese, from the dawn of history until their belated but too rapid Westernisation of the last fifty years. He shows very fairly how the intercourse between Europe and Asia through the ages has affected the national character of the race, and arrives at the following conclusions :—

The Japanese are not individualists like the Chinese, they are emotional rather than intellectual, inspired with a belief in their own uniqueness and with a genius for exploitation—they are idealists, and typically totalitarian.

Part II.—Begins with a review of the progress of the war against Japan, unfortunately only as far as April, 1943, and a second edition would be very welcome. The factors enabling Japan to achieve her early successes are clearly set out, as also the reasons for the swing of the pendulum. The fighting in Papua is dealt with fully and is convincingly illustrated by the photographs in the Addendum. A well-earned tribute is paid to the natives ; and proof is given that white troops, e.g., the A.I.F. and the American Marines, when properly trained and hardened, fight as dourly as the Japanese and with more intelligence.

The author then asks—" How is Japan to be defeated ? " He foresees this as no light task, and he tackles the problem boldly : criticism of his suggestions is however disarmed by the extreme modesty with which they are put forward. They include a warning with which few will disagree. The War in the Pacific is a struggle for airfields and there is no short cut to victory. The Leaders of Japan are prepared for Germany's collapse, but count on war weariness among the Western nations for a compromise peace. " A Compromise peace in Asia," writes Mr. Morrison, " means another war ten years later."

Part III.—Deals with Post-war reconstruction, and is speculative rather than didactic. The Author's speculations, however are based on knowledge and judgment. Japan's own programme, for the new order in Asia, is clearly unacceptable. On the other hand the Allies have not yet formulated theirs. The problem to be solved is very fairly stated.

T.F.

TO-DAY AND TO-MORROW
THE TESTING PERIOD OF THE WHITE RACE

By J. H. Curle

(Methuen & Co., 10th Edition, 1935. Price 7s.)

This book, which has run through ten editions, was last issued in 1935. The author deals briefly with vast problems, such as the characters of the various stocks of the human race ; their relations with each other and the effects of mixing ; the rise and decline of the different elements ; and the problems of sex as affecting population. He touches upon some difficult philosophical problems, and sums up his views on the ultimate effects of evolution on humanity, particularly as affecting the white portion of our race.

The author has travelled widely and has gathered much of his material from his own personal observation. In his journeys he has scrutinized the social and racial characteristics of the people amongst whom he journeyed with a philosophic eye. He is much perturbed by the cruelty of animate nature, both human and non-human, and by nature's appalling waste of life through over-production. But he looks upon man as the trustee for the whole process. " By no reckoning can he turn this Nature-made world into elysium ; but he can do ever so much more for it than he yet realises."

He is also, rightly, exercised about the perpetuation of the unfit in modern States, such as England, and indeed this is a consideration of the utmost importance for the future. But we must not equate fitness with social status, as some people are inclined to do. We must take account of nurture as well as nature, and we should contrive a social system which will be favourable for good breeding. In the words of Dr. Julian Huxley we should study social environment " as an indispensable ally " of eugenics.

C.F. A-C.

RENDEZVOUS WITH ROMMEL

By Richard Macmillan

(Jarrolds Publishers, Ltd. Price 7s. 6d.)

This is one of the best descriptions of the campaigns in North Africa compiled by a war correspondent. Mr. Macmillan fortunately was present at many of the principal scenes of action, during the two years from December, 1940, that he scoured the desert for news, and luckily escaped unharmed. The chief interest of the narrative lies in the periodic summary by the author of his opinion on the causes of our victories and set-backs. He ascribes our success from El Alamein onwards chiefly to the improved morale of our troops consequent on General Montgomery assuming command of the 8th Army. The book is in fact a tribute to the strategy, will-power, personality, and leadership of the general, and contains but few references to the C.-in-C., General Alexander, who dictated the strategy, and bore the ultimate responsibility for the success or failure of the operations.

Other reasons given for our successes in the autumn of 1942 were that we had at last learned at heavy cost not to pit tank against tank in combat, but to let our guns deal with the enemy's armour. Moreover we had acquired the necessary troops and material, notably 400 Sherman tanks and sufficient heavy guns to overpower the enemy's defences. Further Rommel had let slip his last chance of reaching Cairo by not pushing on to the Nile in July, 1942, before we had time to reorganize and receive reinforcements.

The book deals not only with our victorious advance to Tunis, but also gives a summary of General Wavell's campaigns, with appreciative and well-merited chapters on the co-operation of the Royal Navy and R.A.F. throughout the operations.

Anecdotes abound, and among many items of interest is the account of Marshal Balbo being shot down accidentally by the A.A. guns of the cruiser *San Giorgio* in June, 1940, when he was returning in his plane to Tobruk, whilst an R.A.F. raid was in progress.

No maps, other than a poor photo of the battlefield of El Alamein, are provided, which makes it difficult to follow the troops in their moves to and fro across the N. African desert.

C.G.F.

ENGINEERING MATERIALS

By A. W. Judge

(Sir Isaac Pitman & Sons. Vol. I 25s. Vol. II 30s.
With diagrams and plates).

Those who have studied the construction of high speed petrol and oil engines for use in automobiles, aircraft and motor boats, will probably be familiar with Mr. Judge's earlier works such as *Automobile and Aircraft Engines*. The present series may perhaps be best described as a compendium of information on the various properties of those materials likely to be found in such types of engines. Some of the materials which the constructional engineer uses in his bridges, girder work, etc., are touched upon, tabulated and described, but these volumes will appeal primarily to those interested in engines, rather than in static structures. They are essentially storehouses of information in a digestible form, rather than research reports.

The books are not the author's first venture into this subject as they are revised versions of a book published in 1920. They form a very compact and useful guide to the many features that the engine user or designer wishes to know about the many materials available for engine work. Metallurgy, heat treatment, effect of various alloys, best machining methods, weldability, and other features are described briefly, but clearly. In such a small work on this wide subject, it must not be expected that every facet of desired knowledge has been explored. Further reference to larger works may be required under certain headings, possibly because the author's brief, but graphic account, has whetted the reader's appetite for more. The books are fully illustrated by clear diagrams, graphs and photographs, and though the older generations of readers may not care to see so many of these supplied by trading firms—who better could supply the information?

Part 1 dealing with Ferrous Metals starts with a description of the structure of this class of material, and the methods and characteristics of microphotographic examination of the iron and steel alloys dealt with in succeeding chapters. The *raison d'etre*, and best uses for various alloy steels are dealt with fully, and their particular abilities to resist such factors as high temperatures or corrosion. The final tables of mechanical and physical properties of the various grades of iron and steel should prove very useful.

Part 2 Non-ferrous and organic materials covers alloys of copper such as brasses and bronzes, of aluminium under the heading of light alloys, and of nickel. It also demonstrates that other substances such as rubber, ferodo, and plastics, must be dealt with on the basis of engineering materials subject to known laws, and treated by appropriate calculations on the same lines as ferrous materials. The aluminium alloys are likely to come into even greater general use once the war demands for aircraft drop, as the world's potential production of aluminium has been so greatly increased.

A.E.D.

TANKS

By A. H. Franks

(Sir Isaac Pitman & Sons. Price 1/-)

This is one of the series of Pitman's Pocket handbooks, and contains in its 36 pages and numerous illustrations much information on tanks, both British and foreign. It starts with an interesting description of how tanks are made, from the raw material to the finished product. Then follow chapters on British, American, Russian, German, Italian, and Japanese tanks, giving details of their dimensions, armament, speed and general characteristics. Tanks are continually improving, and though this booklet was only published in 1943 the latest models are not always included. This is especially the case as regards foreign tanks, a notable omission being the German 63-ton Tiger tank. Readers will however find details of all our well-known types, *i.e.* Crusaders, Matildas, Churchills, and Valentines. The latter has been used with great success in the African campaign, and is apparently the British tank most favoured by the Russians.

The author on page 31 is wrong in imputing to Lord Kitchener a lack of foresight regarding the possibilities of tank warfare. Sir George Arthur in his recent memoirs pointed out that Lord Kitchener of set purpose showed little interest in the tank at the demonstration in February, 1916, in Hatfield Park, so as to put the many onlookers, who much to his disgust were attending the trials, off the scent. In this he was successful, as the Germans never realized the value of this weapon until it was too late.

Lord Kitchener was so impressed with its somewhat modest performance that on the journey back to London he told Sir George Arthur he intended to order straightway a hundred of them. It is to Lord Kitchener and not to Mr. Lloyd George that the credit is due for supplying the Army with tanks in the last war.

C.G.F.

THE CONQUEST OF NORTH AFRICA

Prepared from Official Records and First-Hand Reports (Burke Publishing Co., Ltd. 78 pp., with maps, charts and illustrations. Price 2s.).

It is to be hoped that the somewhat tall writing in its Introductory Chapter will not ride readers off this chronicle of our North African campaigns; for it is a reliable and an extremely interesting chronicle. It gives a very good account of events up to the clearance of Tripolitania, and a not so good account of the subsequent conquest of Tunisia. We may, in fact, hazard a guess that the last four chapters have been prepared more from " First-Hand Reports " than from " Official Records."

The description of the swinging pendulum of advance and retreat, actuated in turn by Graziani, Wavell, Rommel, Auchinleck, Rommel again, and finally Montgomery, could hardly be better done and it is illustrated by a well-drawn frontispiece. The value of *speed* in desert operations is emphasized; the administrative corps receive the tribute they deserve; and the development of whole-hearted co-operation between Sea, Land, and Air Forces is well brought out. There is an excellent résumé of the decisive results of Wavell's victorious campaign, and a convincing justification of the diversion of a part of our scanty strength to Greece and Crete. The successful tactics of first Auchinleck and then Montgomery at Alamein are clearly described; and there is a list of the British Units engaged in the " Battle of Egypt," on p. 37, which will interest many readers.

After a chapter on " The Allied Landings in North Africa," the chronicle proceeds to describe the operations in Tunisia which resulted in the complete expulsion of the Axis therefrom. This, as indicated above, is the least successful part of the book. It is written in the style and language which characterize " our special correspondent " rather than the historian; and, although it tells a good story, it tells it in the wrong way for military readers. There is a lack of proportion and more than a suspicion of " copy " suggestive of head-lines.

Still, this little book is a good two shillings' worth.

T.F.

CONCRETE AND CEMENT

(Extract from *Building Science Abstracts*, Vol. XVI, No. 6.)

416. On the influence of the nature of the fine aggregate on the properties of Portland cement concrete: A Steopoe: *Materialele de Constructie*, 1942, 2 (April/May), 45-59; *Zement*, 1942, 31 (29/30), 322.

In concrete mixes prepared in the proportions 1 : 6 with Portland cement or Ferrari cement (see *B.S.A.*, 1935, No. 1267) the aggregate of particle sizes up to 1 mm. was replaced by trass or by powdered calcium carbonate to the amount of 20 per cent of the cement content. Determinations of bending and compressive strength and of shrinkage after 7, 28, 56 and 112 days led to the following conclusions: The proportion of mixing water required for a given consistence was higher when trass replaced fine sand but it was lower when calcium carbonate was used. The volumetric weight of the concrete was reduced somewhat by the use of the admixtures. Shrinkage increased especially when trass was added. Bending strength remained unchanged but compressive strength increased particularly when trass was used with Portland cement. When the proportion of the admixture replacing fine sand was increased to 50 per cent of the cement content, the compressive strength again increased. The most marked effect was obtained with Portland cement as binder and trass as admixture.

MAGAZINES

THE ENGINEERING JOURNAL

(Published monthly by *The Engineering Institute of Canada*)

THE September, 1943, number begins with an article, appropriate to an Engineers' war, showing the general need for statistical analysis of inspection results. A typical example is the comparison of two types of tank track pins :— One hundred and sixty-eight type "A" pins, and a like number of type "B" pins were tested in the tracks of a tank under the same proving conditions. Five "A" pins failed and ten "B." At first sight it might seem that type "A" was definitely superior, but an examination of these results, by statistical methods, shows that the true mathematical probability of "A" pins being superior to "B" pins is only 1/5 ; or in betting parlance 4 to 1 against any superiority of the "A" type over the "B" type. From this and other examples the writer arrives naturally at his conclusion that :—

Unaided human judgment is frequently biased or in error. In handling large numbers of observations, some use should be made of the Science of Statistics to aid in judging the relationships between test data and variation of observations.

The article on the new Shand Dam, near Fergus, Ontario, contains a valuable account of the soil investigations and testing procedure necessary before designs and contract documents for the construction could be put in hand.

The Position of Manufacturing is a well-argued presentation of the possible fields for private enterprise in industry after the war, with the conclusion that the ideal solution many well be :—free enterprise for industry, but socialism for all essential and useful services, the latter to provide a much larger share of employment than in the past.

The October, 1943, number contains a valuable record of the three-day meeting at Toronto of the American Society of Mechanical Engineers and the Engineering Institute of Canada. At the inaugural luncheon, Brigadier-General E. E. MacMorland, Head of the Maintenance Division, Ordnance Department, U.S. Army, described the organization, in that service, which provides for the maintenance of weapons of all kinds in the field.

In the Production Engineering Session, Mr. L. E. Carr, British Ministry of Supply Mission, Washington, spoke on the "Comparison of Rivetting, Casting and Welding Tank Hulls" with a view to their ability to stand punishment; the replacement of rivetting by welding in light tanks, and the recent developments in cast steel hulls for larger tanks.

Next day, Mr. H. J. Carmichael, Co-ordinator of Production Development of Munitions and Supply, Ottawa, spoke on :—Canada's War Production. This year, 50% more machine guns and small arms were produced than last, and production of munitions is approaching its peak. The country has undergone a transformation which would have taken a quarter of a century under normal conditions : a wartime industrial revolution. Mr. C. B. Stenning, of the Joint War Production Committee, speaking on the "Conservation of Materials," took for his text :—"Stretching our Resources." Mr. C. E. Wilson, of the War Production Board, Washington, sounded a note of warning : The hardest and costliest part of the job lies ahead. No news from the fronts, however cheering, can lighten the Engineers' responsibilities, since "The Pace of the War is set by Production."

The October number also contains an instructive article on Modern Timber Engineering, which stresses the growing importance of timber in the structural field of recent years due to : The development of new methods of timber fabrication, e.g., spaced columns, split-ring connectors for joints, glued laminated structures, etc., the more general appreciation of the possibilities of timber, and the difficulty in obtaining steel and other materials.

Those interested in water power schemes of moderate dimensions will find an excellent detailed account of a 65,000 h.p. hydro-electric station in Ontario in "DeCew Falls Development."

H.M.F.

EMPIRE SURVEY REVIEW

October, 1943.—A large part of this number is taken up by Sir Gerald Lenox-Conyngham's memoir of Sir Sidney Burrard ; this is on the same lines as the notice which appeared in the December number of *The R.E. Journal*, but is fuller.

A. J. Morley contributes a discussion on precision of triangulation in relation to length of side, arriving at the conclusion that the greatest accuracy is obtained by the use of sides of 25 to 30 miles in length, which accords with the opinion of other observers.

There are two short notes by A. V. Lawes :—

(*a*) A simple and practical method of calibrating prismatic compasses, when these have to be dealt with in quantity.

(*b*) Sag correction in catenary taping, being some criticisms on an article by H. F. Rainsford in *E.S.R.*, vi, 45.

Brigadier Richards pays great tribute to the value of accurate survey methods during operations in West Africa in 1939 ; The help given consisted mainly of the production, with speed and accuracy, of maps made from air photos. He admits that he started with some prejudice against Surveyors in the field.

H.L.P.J. "Instructions for the Survey of First Order Precise Traverses" gives a list of closed circuits with their misclosures, showing that the accuracy obtained is equal to that of primary triangulation ; a result which, as he says, will surprise many geodetic surveyors.

A notice deals with a discussion by W. D. Lambert, of the U.S. C. & G.S., on the determination of the distance between two widely separated points on the earth's surface. This somewhat complicated problem has been dealt with by Clarke and others, but Lambert has devised formulæ which give more simply and directly a result which is approximate, but probably accurate enough for all practical purposes.

Details are given of the qualifications required for the Canadian D.T.S. (Dominion Topographical Surveyor) Certificate, for which a very high standard of professional knowledge is necessary.

In the correspondence, Brigadier Winterbotham raises an interesting point in connection with the length of the metre used by Clarke.

E.M.J.

THE GEOGRAPHICAL JOURNAL

August, 1943.—C. P. Fitzgerald contributes an interesting account of a journey in Northern Yunnan, illustrated by some beautiful photographs. W. J. Berry discusses the capacity of the United States to support population, comparing various parts of the States with other parts of the world having similar conditions of climate, surface, etc. His conclusion is that the U.S.A. could support four times its present population. His critics hold that the author's comparisons, though of interest, are fallacious in many respects.

Agnes Horsfield writes an account of a journey to Kilwa, a group of cells or hermitages, built of squared stones in the S.E. of Transjordan. This includes a short summary of "Transjordanien" by Hans Rhotert, the leader of the last German-Africa expedition in this region, including an account of most skilful rock drawings of dromedaries (believed to be the earliest known), ibex, and other animals.

September, 1943.—Mr. Kaare Rodahl gives an excellent illustrated account of the Swedish-Norwegian Expedition to N.E. Greenland in 1939-40, whose objects were glaciological, biological, and meteorological. Mr. Rodahl's opinion is that, owing to contact with white men, the Eskimo's diet is changing, consequently he is becoming less suited to Arctic conditions ; which means the destruction of the race.

P. A. Talbot reviews : *The Realm of a Rain Queen*, by J. D. Krige (a nephew of Field-Marshal Smuts) and his wife, a book on the Lovedu tribe, who live in the N.E. Transvaal, and holds that it gives a truer insight into the Negro mind than any other known work.

E.M.J.

JOURNAL OF THE UNITED SERVICE INSTITUTION OF INDIA

July, 1943.—*In Civil Government under Invasion Conditions*, the Governor, Sir R. Dorman-Smith states the difficulties with which he, in Burma, had to grapple and refutes the criticisms which have been levelled by irresponsible persons at him and the ministers. One problem was the repatriation of some half-million Indians, who naturally wanted to return home; this was successfully carried out. The conduct of the ministers, mostly of course Burmese, was apparently all that could be desired. A very instructive article.

The work of St. Dunstan's is being carried on at Dehra Dun by Major Sir Clutha Mackenzie, blinded in the last Great War, who, in *What's a little Handicap?* tells the story of how it can be successfully and cheerfully overcome.

Naturally, Auspex's article in the last number of the *Journal* (reviewed in the December *Pickaxe*) on pre-war training, comes in for many criticisms. The fullest is mainly a brilliant defence of the pre-war attitude to and aptitude for, games and sport.

A Tour in the Chin Hills is a chatty tale, full of amusing anecdotes. Chin levies are giving a splendid account of themselves, and many Japs have fallen victims to their ambushes, in which the local obstacle, *panjis*, play a great part; these are sharp bamboo stakes, planted in the ground at an uncomfortable angle.

What manner of people are they? is an illuminating description of the Japanese, by one who has lived among them for many years. He predicts no easy victory; they will fight to the bitter end.

Air Photographs and Interpretation in War sums up the subject admirably and there are good illustrations. The mapping of the coast of Burma, where mangrove swamps change in shape and position every year, is done from the air. Night photos show up detail almost as day; there are now photo interpretation units in all theatres of war.

Eavesdropping—the spelling error is intentional—treats, in the form of a talk among I.Os. and N.C.Os. of the education of women. It is apparently a reprint from *Current Affairs* published by the Directorate of Welfare and Amenities.

The Fourth Indian Division is a narrative, all too brief, of the exploits of that formation. The magnificent spirit which has carried it through is all the more remarkable in that nearly the whole of the personnel has been renewed, many units have gone and been replaced, there have been three divisional commanders, and an entire brigade was captured in Tobruk.

Keep him guessing, in other words mystify the Jap, has valuable hints, one of which is to be very sparing of wire, as it gives away the position and is easily cut by enemy night patrols. Booby traps and mines are the most potent form of obstacle.

F.C.M.

THE INDIAN FORESTER

September, 1943

Nature's Silviculture
compares natural methods of growth of tree-covered areas with the system arranged and practised by the Forester. One statement must not pass unchallenged, even by a layman, namely that " Nature's remedy " (for acidity of the soil due to over-accumulation of fallen leaves) is " to make fire by the rubbing of tree branches under the action of continuous strong winds." This phenomenon must be extremely rare, hardly warranting a place in the economy of forest life.

Drought in relation to forestry
gives a useful list of trees, native to or domiciled in India, grouped according to their powers of resistance to drought. The sacred *Pipal* (*Ficus religiosa*) is one of the best resisters. The list is a useful one for anyone to consult who is about to plant trees in the drier parts of India. The more common timber trees are however not mentioned, with the exception of *Sal*, which is rather tender to drought.

F.C.M.

THE MILITARY ENGINEER

(Published by the Society of American Engineers)

(*September*, 1943)

Visual Training Aids for Engineers. By Lieut.-Col. W. Whipple.

Visual training aids are of special value to give realism when experienced officers and proficient instructors are not available. Engineer training films are produced jointly by the Signal Corps and the Corps of Engineers, and their production need considerable numbers of men and training facilities. British training films have used American troops, but the British manner of speech is distracting and often unintelligible to the average American soldier, and sometimes (at the wrong times) it is amusing, although it is admitted that the narration is extremely well done.

A limited number of Engineer film strips have been in use for some time, and are suitable for small audiences. Having no sound track nor motion, they are inferior to training films, but are cheaper, more portable, and easier to produce.

The newest major development in visual training aids is the graphic portfolio; *i.e.* a series of charts, illustrating progressive instruction in a single subject. Its main advantage is that it can be used out of doors; disadvantages are cost, weight, and bulk.

Pierced Steel Landing Mats for Aeroplane Runways. A well-illustrated article by G. G. Greulich.

Experiments with various types have been made in America, and a landing mat has been finally evolved which appears to give very satisfactory results. The mat consists of a series of low carbon soft steel sheets, each 10 ft. long and 15 inches wide. Each plank is perforated with large circular holes (2⅝in. diameter) at 4 inch centres, and is ribbed (ribs 5 inches apart). The planks weigh about 65 lbs. each, a little over 5lbs. per square foot. They are one-piece stampings with integrally formed interlocking and fastening devices along both edges.

The purpose of the holes is: To reduce weight, to provide skid resistance for large plane tyres, and to allow rain water to drain through evenly over the whole surface. The fastening devices are so arranged that any individual plank can be taken out and reassembled without disturbing the others.

Airborne Engineers. By Captain S. A. Derry.

It was not till the summer of 1940 that the United States started the training and equipping of airborne units, but there are now three types of engineers concerned, namely:—

(1) *Aviation Engineers*—Construction organizations with very heavy equipment, they are not airborne, but may be attached to an airborne division. Their primary function is to organize and construct areodromes and air bases.

(2) *Airborne Engineers*—Combat engineers assigned as part of an airborne division. Their primary function is to build landing grounds and disable enemy landing grounds. Their unit is a battalion, composed of a parachute company and two glider companies. The parachute company is fitted out with flame throwers and demolition equipment. Parachute engineers serve as assault troops for reducing enemy fortifications and obstacles. The glider companies are equipped with heavier tools than the parachute company. Their mission includes the improvement and clearing of glider landing grounds and works of a similar nature.

(3) *Aviation Engineers Airborne* may or may not be attached to an airborne division. They are assigned the special mission of repairing and maintaining airfields inaccessible to regular aviation engineer battalions.

A description is given of the parachute training conducted at Fort Benning, Georgia, which appears to be pretty strenuous.

Such advances have been made during the past three years that it is impossible to predict how great an influence airborne engineers may have in this and future wars. The capture of Fort Eben Emael and the fall of Crete are outstanding examples of what they can accomplish.

(*October*, 1943)

It's a Strange Country. By Colonel H. Carruth.

The writer describes a short trip that he made in February, 1943, through North Africa. In the course of his journey he came into contact with officers of the Royal Engineers, for whom he expresses high regard.

On the whole he found the roads good, though few in number, but they needed renewal. He did not like the French bridges, which were not strong enough to carry the heavy army loads. Gangs of Arabs, under N.C.Os. of the Royal Engineers, were employed on road maintenance in the forward area, but the principal effort was to make alternate river crossings to by-pass the French bridges.

The British had also erected a number of steel bridges, and a point that struck the writer was :

The way they were classified and numbered to indicate their load capacity, and all types of army vehicles were marked with corresponding numbers to show their fully loaded weight.

Emergency Housing in the South Pacific. By Colonel B. Parker.

To avoid importation of building materials, advantage was taken of local materials and labour in the South and South-West Pacific theatres to build warehouses, offices, messes, etc. The materials being native-grown thatch, bamboo, coconut logs, poles cut from jungle trees, flexible cane, coral or gravel and sand. Buildings to be occupied by personnel require fly or mosquito netting—an article of import. A layer of poultry netting over the thatch lengthens its life by preventing wind lifting.

The framework of the huts was made of logs ; the rafters of poles or bamboo. Roof and side-walls were of thatch ; the latter being made up in 6 ft. by 2 ft. panels. Buildings occupied by personnel had wooden floors ; warehouse floors were of packed gravel or coral.

The following were found to be convenient standard dimensions :—

Large warehouse with centre columns :	40 ft. by 100 ft.
Warehouse without centre columns :	20 ft. by 100 ft.
Office Buildings, Mess Halls, etc. :	24 ft. by 50 ft.

The total cost of construction of one warehouse did not exceed 30 dollars. The buildings are expected to last three years.

Nomad River Crossings

Major P. Serenko (Soviet Army) describes methods used by the Russians for crossing a river on the Soviet-German front.

The Germans had established a strong point in a salient formed by a deep elbow of the river. From this point they had an excellent view of the Russian positions on the opposite bank. They illuminated the river at night and kept it under fire. The fire, however, always decreased in intensity during the hour before dawn, so this was the time selected for the crossing.

Attempts were made to construct rafts of metal barrels, but these were found unsuitable, as they lost buoyancy when punctured by rifle bullets. Wooden rafts were then tried, but they became waterlogged in a very short time. It was finally decided to use row-boats and ferry boats. A hundred of these were collected, and a portion of them was used in the preliminary attack, which completely surprised the Germans, and enabled the Russians to secure 700 metres of enemy river bank with a depth of one kilometre. This was sufficient to organize a permanent crossing.

In spite of German counter-attacks, artillery and mortar fire, and attacks by aircraft, the Russians succeeded in maintaining the crossing. To effect this, the Russians changed the positions of their ferries and bridges. Bridges that had been damaged by aircraft were repaired and left in their original position as dummies. Sham crossings were organized that were not used for troops. In order to attract attention to them the Engineers pulled empty boats backwards and forwards for days on end.

A.S.H.

REVUE MILITAIRE SUISSE

July, 1943

Une semaine à 4,000 metres

Lt. Roch concludes his account of a week on the top of the Bieshorn in igloos. The detachment, after constructing its quarters, did practically nothing but eat and sleep. Exertion was exhaustion.

Was there any fighting efficiency at that altitude? The author says "yes." Men who have to make a hasty ascent from a low level to such a height are unfit for fighting exertion, but after a night's rest in a shelter, they are in a fitter state than their opponents could be. That is all that can be said for it. There could not be opposing forces on the same knife edge. Those already established there have the pull.

The treatment of sick and wounded at such a height is practically impossible. Whatever the case he must be sent down.

It seems that with an enemy post on such a mountain top the only thing is to shell him off it.

Barrages de Mines

A review of recent articles in the Spanish military press. Minefields on the battlefield now almost dominate the tactical situation. Thanks to the continual laying of minefields, "The Germans, alongside their Italian comrades, had successfully conducted one of the most glorious [*sic*] retreats in history, ceaselessly harassed by the British Eighth Army."

Mines can be laid offensively or defensively. They have only come into importance with the appearance of modern tanks. They are now made in enormous quantities; they have been gathered up in almost astronomical numbers from the battlefield, having failed in their object; for every mine lifted innocuously is a mine wasted.

The article gives general information on types—mechanical, electric, chemical or electro-magnetic. Indulgence in too many improvised types leads to a waste of time and material; but the type has to be constantly changed in order to deceive the adversary.

Commentaires sur la guerre actuelle

At the time of writing, July 20th, the commentator was uncertain whether the Allied invasion of Sicily was intended to be a prelude to an invasion of the continent or to provide air and naval bases for the better security of the Mediterranean.

The success of the Allies in rapidly surmounting the first critical stage of the invasion was due to the prior neutralization of the Axis airfields in Sicily and in the Italian peninsula. It was noteworthy that the Axis had been unable to hinder the convoys; and that their submarines had not attacked the supply ships in any strength.

On the Russian front, the Germans began their summer campaign by a large-scale assault on the Kursk salient, attacking it from the north-west as well as from the south. Some 30 German divisions, half of them armoured, were employed. It was uncertain whether this offensive had for its object a shortening of the German line, or the forestalling of a Russian blow. It did not appear to be on the scale of a real general offensive.

August, 1943

Réflections sur la Campagne de France. By MAJOR E. BAUER

As in 1914, the French were totally unprepared for the magnitude of the great swing of the overwhelming German right arm through Belgium and the Ardennes.

First and foremost, Major Bauer blames the French High Command for imposing a desperately rash manœuvre on General Billotte's Northern Army Group, and giving him a totally inadequate proportion of the forces with which to carry it out. Gamelin's Staff calculated that the principal mass of the German armies launched against France comprised 125 divisions; Billotte was given 38 divisions (including the B.E.F.). The Dutch Army of 9 divisions and the Belgium Army of 22 (including 2 Cavalry) made the paper total up to 69, with reinforcements amounting to another 7 divisions available two days after Z day.

General Evan's 1st Armoured Division was scarcely fully organized by the 10th May.

The contrast on the German side was staggering. In place of a heterogeneous force contributed by four separate nations, two of which had only just made up their minds to join the Allies, Hitler had an overwhelming mass of divisions under one control and of one mind. Out of 110 infantry divisions which the Allies calculated were disposed on the Western Front, 86 began the great attack on the 10th May in the two Army Groups of von Bock and von Runstedt, preceded by a tidal wave of 10 panzer divisions, and covered in the air by thousands of machines of the 2nd and 3rd Air Fleets of von Kesselring and Sperrle.

The penalties of unpreparedness were about to be paid in full.

The Germans, with complete knowledge of the French dispositions and intentions, were able to concentrate their best troops between Treves and Wesel, leaving the defence of their left flank to the troops of the Siegfried Line.

The blind faith of the French in their Maginot Line, which stopped half-way along their total frontier, had paralysed their dispositions, and even the eight months of "phoney war" had not produced any realistic sense of the danger in the north. But it was not only due to faulty dispositions that the German avalanche was so successful. Failure to realize what strength the Germans were building up in the years preceding the war, and failure to stop it in its infancy; failure in fact, to insure against the dread recurrence ofa German war, was the cause of the disaster in France and of all the catastrophic ruin which followed.

The break-through on the Meuse was made by von Runstedt's Army Group, composed of 7 armoured divisions and 3 motorized divisions. It was covered on its southern flank by the 14th (Motorized) Corps, which was relieved successively by the 16th Army and the 12th Army, as the invading host surged on.

The Allied armies had no chance; but they should not have had to face such a situation. (*To be continued.*)

Commentaires sur la guerre actuelle

Covers the events from the fall of Mussolini to the opening of the Russian offensive against Kharkoff and Briansk, in July and August.

The surprising suddenness of Mussolini's fall and the disappearance in one night of the Fascist régime mark a decisive turning point in the war. Germany affected to believe that the fall of Mussolini was a purely Italian affair; but Hitler's subsequent rescue of the Duce showed how sorely he felt the blow. The Italian people did not want to enter the war; but they could not get rid of the Fascist yoke. It was the German domination in Italy itself, Hitler's growing demands for more Italian sacrifices and the fear of the Allied air raids, which brought about Mussolini's fall. That the war in Italy did not cease came as a further shock to the Italian people.

Badoglio's problem was how to get back the Italian divisions scattered in France and the Balkans. The Germans were too quick for the Allies; they seized control half-way down the peninsula, instead of withdrawing to the north, thus ensuring the disarming of all the Italian divisions north of Naples, and securing time to organize a delaying strategy.

W.H.K.

INFANTRY JOURNAL

Published by the U.S. Infantry Association
October, 1943

Action on Attu. By Lieut.-Colonel R. G. Amery.

In the American attack on Attu Island, the Japanese proved to be very tough customers. Their tactics differed considerably from those they had adopted against the Americans in the Malayan and South Pacific jungles. There is no cover in the Aleutians and Kuriles except defilade ; it is only during the short summer from July to September that the tundra grows high enough to hide a creeping man.

As a rule the Japanese fought stubbornly for the ridges. Their previously prepared semi-permanent fieldworks were sited on their upper slopes, and they held on tenaciously to every sniper's hole and gun-pit.

What the Americans wanted in this type of warfare were : (*a*) dogs to nose out Japanese lying low in their fox-holes, (*b*) one or two 37-mm. guns fitted with telescopic sights, rather than mortars, which were not too effective in snow or poor visibility, (*c*) a light sturdy radio for reconnaissance patrols and mortar observers.

Bunker Busting. By Captain R. M. White

In the coastal regions of New Guinea and most Pacific islands the ground surface is only two or three feet above sea level. This precluded the digging of ordinary dug-outs and trenches, and led the Japanese to adopt the bunker, *i.e.* a dug-out built above the surface of the ground.

Bunkers fall into two general classifications : large heavily bolstered bunkers located in more or less open ground, and smaller less heavily bolstered bunkers located in thick jungles, where direct laying by artillery, or precision bombing, is impossible.

The foundation for all bunkers is a trench varying in length from twelve to forty feet, and in width from six to ten feet, as deep as the water level permits. From the trench foundation log columns and beams, usually palm, are erected. Log revetment walls are then added. A ceiling course is superimposed, usually two or three layers of logs. The sides are then reinforced by steel drums or ammunition boxes filled with sand, and the whole structure is covered with earth. The entire mound is finally camouflaged with fast-growing vegetation, which covers it almost overnight.

To deal with these bunkers, the Americans organized special bunker-busting teams, divided into two parts. The mission of one was to neutralize sniper and ground fire, while the second blasted out the bunker.

Water Supply. By Groff Conklin.

An interesting article based on the experience gained by the Corps of Engineers in the Tunisian Desert campaign.

It had been estimated that the average water requirements for an up-to-date field army, with full motorized equipment and a complement of about 250,000 men, would be from five to eight million gallons of water a day, depending on the theatre, the type of units attached, climatic conditions, and many other factors. In practice this estimate proved to be very near the mark.

The type of water-bottle issued to the troops is the result of much painstaking research. The earlier bottles were made of aluminium : latterly, plastics have been used. To-day, two highly perfected types of plastic water-bottle are in production : a rigid and a collapsible type.

Each soldier carries a packet of tiny chloromine tablets, and puts two to four in his water-bottle when making use of an unpurified source.

Every field army is supplied with two standard pumping and purification units : (1) the portable unit—issued to engineer combat battalions, (2) the larger mobile unit—a standard issue to all water supply battalions attached to field armies. Portable units will produce about 20,000 gallons, mobile units upwards of 100,000 gallons a day. Chlorine is usually employed for purifying water.

A.S.H.

AN COSANTÓIR

(Published under the auspices of the Eire Army Authorities.)

September, 1943.—A translation from the German (via America) of the experiences of a small "Reconnaissance" detachment in the vicinity of Liége in May, 1940, gives a good example of intelligent and determined leadership of a small body under conditions giving wide scope to the initiative of a Junior Commander.

One article is in Erse, on "Hand-to-hand" fighting. It deplores the general impression in Eire that "in-fighting" has lost its importance and suggests that the Armies now at war clearly hold the opposite view and devote much time and trouble to special training in this line. A strong plea is made to restore bayonet fighting to its old honoured place in Military competitions. A few hints on murderous forms of attack and counter-attack in "unarmed combat" are illustrated by effective sketches.

An article condensed from the Soviet War News on "How we train our Soldiers" emphasises the importance of a stern and just Commander who will educate his men to display intelligent initiative in the carrying out of all orders, within the limits set by a high sense of discipline. The Officer must set a high standard himself in all matters, be patient and thorough in his teaching methods—slow to punish and that only after attempts to influence and persuade have failed—quick and generous in praise to encourage the triers. There is no task more noble than to train soldiers for the Motherland. The word "soldier" is an honourable one.

An article "Look out, we're surrounded," stresses the importance of being trained to expect this unpleasant event as only a normal "incident" in the modern battle, and having no special importance in itself. It raises only the problem whether to fight on where you are or when and how to disengage.

Reconnaissance Tactics in the Kuban Fens, reprinted from the Soviet War News, is a short survey of warfare in an "impossible" country of high reeds, swamps, streams and occasional islets or tongues of firm ground.

October, 1943.—Starts with an article on "O'Donnell Abu" and his ambush of a British force in the Curlew Mts. in August, 1539; this indirectly resulted in the loss of the whole campaign in which Essex was attempting to reduce Ulster and caused him (quite literally) to lose his head.

Some "Notes on Leadership" by a Colonel of the U.S. Army stresses again how the best laid plans of the greatest general must depend ultimately for success on the initiative, skill and fighting spirit of the most junior leaders.

"An Intelligence Officer in action"—original contribution—tells, in the form of a narrative of events during the first few hours of an imaginary sea-borne invasion, the sort of work, a Bn. I.O. might expect to have to do.

"The Development of Combat Intelligence" is a serious and interesting study of the work of the G.S.O. Int. at Div. H.Q. level. An excerpt from a Japanese Training Manual is quoted, showing that they rate the U.S. Army pretty low in this branch—and the writer suggests that Pearl Harbour shows how right they were. He brings out how the first step in an appreciation of the situation must be the estimate of the "capabilities" of the enemy—what we call "Courses open to the enemy"—and how the Intelligence Plans must be based on this.

The Italian General Douhet put foward a theory some 20 years ago that, in future wars the role of the Army and Navy would be to "hold" the homeland safe while the Air Force systematically bombed the enemy into submission. First his Aerodromes are destroyed, giving a large measure of Air superiority; then his communications are wrecked and then his centres of production, population, etc. The article discusses the success of a modified form of this theory as applied by the Germans in their attacks on Poland, Holland, etc., its failure in the "battle of Britain" and the lessons to be learnt from the Tunisian and Sicilian Campaigns.

D.ff.M.

TRANSACTIONS OF THE INSTITUTION OF CIVIL ENGINEERS OF IRELAND, NOVEMBER, 1942—MAY, 1943, VOL. LXIX

The Volume includes the President's address, and five papers read at various meetings. It is noticeable that the first two of the latter are concerned with the problem of Ireland's shortage of fuel, both coal and petrol. A paper by C. A. Waller deals with Peat Production, another by Professor Hogan concerns "Producer Gas for I.C. Engines." Of more direct interest to R.E. is an article by P. J. McCarthy on "Water Purification in small schemes" in which the author deals with schemes providing not more than 200,000 gallons a day. It covers in a general way types of filter, settling tanks, use of chemicals, etc., and, owing to war conditions, has to assume difficulty in getting the chemicals and materials the engineer would like; a state of affairs which is of normal occurrence to the R.E. Of special interest is, however, the inaugural address of the President, Mr. T. J. Monaghan, B.Sc., in which he deals with the ultimate aims and purposes of the C.E., though he christens it "enlarging the Engineer's sphere of influence." A reviewer of such an address can in limited space hardly do better than extract a series of nuggets either original to the President or quoted by him. These might well be taken as mottoes for a tear-off calendar for the R. as well as the C.E. "The scope of the C.E. in its broad and true sense remains co-extensive with the cosmos itself, whose powers it is his business to evoke and employ for the comfort, improvement and civilisation of our race." (R. Mallett, F.R.S. 1866).

"I am of opinion that the most honourable calling is to serve the public and be useful to the many." (Montaigne.)

"Special attention might be devoted to clear and accurate expression in speech and writing." (Prof. Walsh, Presidential address I. of C.E. of I. 1941.)

"The outstanding problem that confronts humanity to-day is to plot the course that man must follow if hope is not to perish from the earth, and to strive to follow that course. This is a task that demands the utmost efforts by all men of good will and the exercise by them, in patient persistent co-operation of all the varied talents they possess." (President.)

Such extracts indicate a humanistic and realist approach to the job of the Engineer which deserves careful study by all in the profession.

R.P.P-W.

CORRESPONDENCE

THE ROYAL ENGINEERS IN EGYPT AND THE SUDAN*

Crabble Court, Dover.

To the Editor, *The Royal Engineers Journal*.

DEAR SIR,

Since reading the article by Lieut.-Colonel Sandes in the last issue of *The Royal Engineers Journal* I have been wondering how many of the present generation in the Corps have read his excellent book *The Royal Engineers in Egypt and the Sudan*, published by the Institution in 1937? I think that this volume should find a place in the Library of every standing Mess of the Corps and should be read by all officers, not only as military history—and there is plenty of instruction in the accounts of the campaigns—not only as a record of the brilliant achievements of officers and other ranks of the Corps, but to give them some idea of the wonderful diversity of tasks that may be set to our officers on service, whether in civilised or savage countries or even in Germany and Japan.

Yours faithfully, F. E. G. SKEY.

*May be obtained from the Secretary's office, at 6 shillings per copy, post free, to all members and Associate Members of the Institution.

SPECIAL NOTICE

The fact that goods, made of raw materials in short supply owing to war conditions, are advertised in this magazine should not be taken as an indication that they are necessarily available for export.