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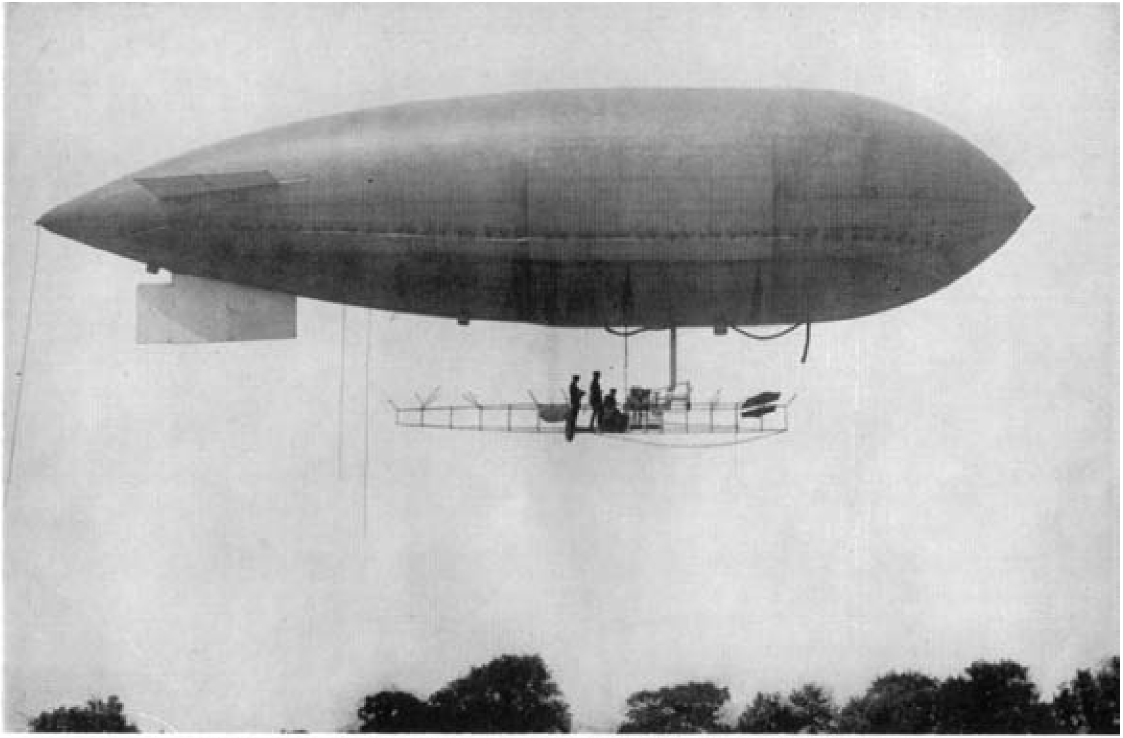


Photo 17.—H.M. Airship *Beta*. Captain P. W. L. Broke-Smith, R.E., at the helm.

THE HISTORY OF EARLY BRITISH MILITARY AERONAUTICS

(*Concluded*)

By BRIGADIER P. W. L. BROKE-SMITH, C.I.E., D.S.O., O.B.E.

CHAPTER V

THE BALLOON SCHOOL AFTER SEPARATION FROM THE FACTORY. 1909–1911

Separation of factory from military side—H.M.A. *Beta*—H.M.A. *Gamma*—Airship incidentals—Decision to form Air Battalion—Departure of Colonel Capper—Clement Bayard and Lebaudy airships—Airship flight by Mr. Haldane—The first army aeroplanes—Provision of aircraft—Successful airship wireless experiments.

IN October, 1909, the British Government decided to separate "instruction" from "construction." The Balloon Factory was placed under independent civilian management directly responsible to the Master General of the Ordnance. Mr. Mervyn O'Gorman, a consulting engineer, was appointed Factory Superintendent, the Commandant Balloon School ceased to be Factory Superintendent and the military Assistant Superintendent was replaced by a civilian. Mr. Haldane, the Secretary of State for War, announced that thorough scientific investigation was to precede the development of military flying and provision of aircraft for war on a large scale.

The era now commenced of great expansion of the Factory, with greatly increased funds, and with facilities which hitherto had been sadly lacking. The Factory was to investigate and experiment in the design of aircraft and their components in collaboration with the National Physical Laboratory, in which a special new department for aeronautical research had been formed. Whilst in the long run, the concentration of the Factory upon research as its chief function was indisputably fruitful, the immediate effects of this policy and the divorce of the military side from the Factory were prejudicial to the air training of the Balloon School and its successor the Air Battalion, which were very dependent upon the Factory for the issue and major overhaul or repair of aircraft.

At the time of the separation Colonel Capper had in hand the reconstruction of the second experimental airship (as *Beta*), increasing the length of the envelope by 20 ft., and the capacity to 33,000 cu. ft., and installing a 35-h.p. Green engine (the first successful all-British aero engine). He had also in hand a third experimental airship (*Gamma*). This was of non-rigid type, similar to *Beta*, but larger. It was equipped with an 80–100-h.p. Green engine, was fitted with swivelling propellers to facilitate ascents and landings (the first practical example of this appliance), and had a French

Astra cotton and rubber envelope of 72,000 cu. ft. capacity. The envelope was of the stream-line shape now developed for non-rigid airships, to which *Baby* was being converted, but somewhat longer in proportion to its diameter. Goldbeater's skin was excellent for ordinary balloons, and was to give wonderfully good service in *Beta*, but with the construction of *Gamma* it was superseded for airship envelopes by rubber-proofed fabric. It was difficult to attach an airship framework to goldbeater's skin, and the manufacture of airship envelopes of the material was expensive and troublesome, and took a long time.

H.M.A. *Gamma* was launched in February, 1910. She could carry a crew of five, and achieved a speed of 32 m.p.h. after modifications including the replacement of the original bulbous tail fins by stabilizing planes. The swivelling propellers were a marked success; they greatly facilitated rising from or descending into restricted areas, and the conservation of ballast and gas. After a number of flights, in August she was rip-deflated and docked for repair and further improvement. A ripping panel had been fitted in the envelope to facilitate rapid deflation; this feature was not practicable in goldbeater's skin balloons. The envelope was inferior in gas-retaining capacity to goldbeater's skin in good condition, but it was of the best material obtainable at the time.

H.M.A. *Beta* appeared in May, 1910. She carried a crew of three and fuel for five hours' run; after adjustments she eventually attained a speed of 32 m.p.h. On 3rd/4th June, Colonel Capper, accompanied by Mr. T. J. Ridge, the Assistant Superintendent of the Factory, who was also an officer of the London Balloon Coy., R.E. (T), and Lieutenant C. M. Waterlow, R.E., took her on a night run to London and back; this was the first night flight. During the rest of the summer *Beta* was in almost perpetual commission, with one reinflation. Her constant flights included another journey to London in July, in charge of Lieutenant Broke-Smith (who had been recalled from India to succeed Captain King as Instructor and acting Adjutant), and voyages in August and again in September to and during the manœuvres, over Hampshire, Wiltshire, Dorset, and Somerset as far as the Bristol Channel. During the manœuvres over a thousand miles were covered, and the airship spent several nights moored in the open, under the lee of trees or in quarries (an advantage of the small airship). The successful reconnaissance reports which were rendered showed the value of aerial reconnaissance from power-driven aircraft. The old ballooning gas train, drawn by a traction engine, provided a mobile base for the airship.

There were many adventures in the days of the early Army airships, but there were no serious accidents and there was no loss of life. Engine breakdowns were not unusual, and other failures occurred, such as the propeller chains snapping, the elevators jamming, valves sticking, or fittings coming adrift owing to the vibration. Very frequently the defects were remedied in the air, whilst the airship drifted free ; this sometimes necessitated one of the crew crawling out along the frame or on to an outrigger to effect adjustments. If repairs could not be achieved in the air, the airship was landed, and assistance was obtained from Farnborough, the field base, or a ground party which followed the airship by road. A folding grapnel, as used in balloons, was carried. With this, choosing a sheltered spot protected from the wind, emergency landings (whether on account of a breakdown or with deliberate intent) could be effected without the assistance of a landing party, the grapnel being hooked up in a hedge or tree. The technique of emergency landings became a matter of routine.

For some time there were no reliable compasses, and installations of instruments generally were perforce elementary. Sometimes the drifting airship would get lost in clouds or fog. On one occasion *Beta* just dodged the spire of Salisbury cathedral in a fog, when, after a breakdown during which she drifted, her engine had been restarted, and she was resuming her journey, proceeding at a low level in order to feel the way. On the first night run (as in free balloon practice) the map and gauges had to be read with the aid of an accumulator-fed lamp hung from the balloon and a pocket lamp ; direction was maintained by the railway which was observable when lighted trains passed, and by observation of the river Thames and the lights of London when the metropolis was approached. Night flying was regarded as one of the principal functions of airships, whose war rôles were distant reconnaissance and bombing, as they were particularly vulnerable by day. But the practice of night flying had to be limited until the march of time permitted of the necessary navigation instruments being provided.

Amusing incidents were not without occurrence. On one occasion, on a run from Farnborough to Salisbury Plain, near Andover the airship passed over a cricket match in progress. The batsman was so occupied in gazing up at the airship, which the bowler had not noticed, that he was bowled out middle stump. On another occasion, which perhaps might not have been quite so amusing, the returning airship, short of lift and ballast, was caught in a down current over the grounds of St. Michael's Abbey in the Empress Eugénie's estate at Farnborough. Petrol cans had to be hastily jettisoned, and a can just missed one of a group of monks who were strolling in the grounds absorbed in their breviaries. The Prior gracefully accepted the subsequently tendered apologies.

Owing to the growth in practicability and in general esteem of the aeroplane, as well as of the airship, in October, 1910, the War Office announced that it had been decided to commence the expansion of the air branch of the Army, by reconstituting the Balloon School, definitely to include flying in heavier-than-air machines as well as the operation of airships and of balloons and kites, and to take in officers of all arms. The objective was the formation of a small body of expert air officers and men, from which personnel for air units could be drawn in due course.

The employment in the air branch of officers of other arms than the R.E. was no new thing. Many officers not of the Corps, who were interested in ballooning had been so employed in the past, from Colonel Templer onwards; until aeroplanes arrived there was, however, not unnaturally, no general demand for air employment, and the handling of balloons had been left to the R.E. Similar circumstances had obtained in other armies.

It has been a well-known characteristic of the British nation to be dilatory in taking up new developments,* although it generally makes up for lost time in the end. The British Government still considered it desirable to proceed cautiously, pending decisions as to the best types of aircraft for military use. The design and performance of aeroplanes improved from month to month, and what was up-to-date to-day would be obsolete to-morrow. The policy was to go slow in the acquisition of aeroplanes, and to gain experience as to the nature and scope of the air units and equipment suitable and necessary for war before purchasing aeroplanes on a large scale, organizing in detail and expanding appreciably. The Air Battalion, which was formed six months later in reconstitution of the Balloon School, with a few additional officers and men and a prospective reserve of officer-pilots, was a transitory training and experimental unit; it was obvious that the full development of the air arm would mean a separate corps or service. This was the intermediate step.

At this stage Colonel Capper was replaced as Commandant Balloon School by Brevet Major Sir Alexander Bannerman, Bart., R.E. Colonel Capper, who had been a Brevet Colonel since January, 1906, had completed the regulation period as substantive Lieut.-Colonel, and the post was not considered to be sufficiently important for a substantive Colonel. This was unfortunate, in view of the promise which the future of the air held and since Colonel Capper was an air expert of world-wide reputation.

Since the previous year two large French airships of successful types, the semi-rigid Lebaudy and the non-rigid Clement Bayard, had been expected. The former was being purchased for £25,000 from a fund raised by the *Morning Post*, and the latter was under

* As had occurred over forty years before, when the introduction of military ballooning was delayed.

option for purchase under arrangements made by the Parliamentary Aerial Defence Committe, which had been formed to endeavour to bring the British Government up to the mark in respect of aerial development. The War Office were prepared to take these airships over provided that they fulfilled stipulated conditions of performance. These conditions included an air speed of not less than 32 m.p.h., the airship to be anchorable in the open in winds up to 20 m.p.h., a ceiling of 6,000 ft. with a crew of six, wireless, and fuel for three hours at full speed, and the airship, fully equipped, to cover a triangular course of 300 miles in not more than fourteen hours.

The arrival of these airships was retarded, owing, in the case of the Lebaudy, to constructional delays and the simultaneous supply of airships to the French Government, and, in the case of the Clement Bayard, to the acquisition by Russia of its predecessor at the time of the original negotiations, subsequent mishaps during test flights, and eventual detention in France for the army manœuvres. Colonel Capper made a flight in the Clement Bayard in August, 1910.

During October, 1910, both airships arrived in England. First came the Clement Bayard, which, one Sunday morning, the 16th October, taking advantage of a favourable wind, made the voyage, unheralded before the start, to Wormwood Scrubs, where a shed provided by the *Daily Mail* had been awaiting her for a year. This airship had a balloon capacity of 227,500 cu. ft., and two 120-h.p. engines ; on the voyage over she showed a speed, in a light following wind, of 33 m.p.h. Ten days later the Lebaudy, for which the new Army airship shed at Farnborough, built to be large enough to accommodate her, had been cleared, followed the Clement Bayard, with Sir Alexander Bannerman on board. She was of 353,000 cu. ft. capacity (the largest airship of the kind yet built), carried a crew of nine, and was equipped with two 135-h.p. engines arranged so that either or both could drive the two propellers. On the crossing from France, in which she was guided by captive balloons on the coast at St. Valery-en-Caux and Brighton, and escorted over the Channel by a British destroyer, she attained a speed of 36 m.p.h. against a light head-wind.

The Clement Bayard was far from being in new condition ; her envelope was leaking badly and required replacement. The makers had originally wanted £25,000 for her. The War Office, under pressure of public opinion, eventually offered £12,500. A further sum of £5,500 was contributed by the Parliamentary Aerial Defence Committee, and the airship became British Government property. She was deflated and dismantled, and was removed to the Balloon Factory at Farnborough. She was unlikely to be able to pass the tests demanded for an efficient army airship ; it was ultimately decided that she was not worth rehabilitating, and she never reappeared.

When, upon arrival, the Lebaudy was being docked in the shed at Farnborough, the Air Battalion officer in charge of the landing party of 160 Guardsmen and Sappers noticed as the balloon approached the entrance that the opening was a little too low, and halted the landing party whilst he inspected the fore and aft trim and arranged if necessary for the whole envelope to be pulled down towards the airship car and the ground. A big crowd of soldiers and civilians from far and near had collected, Lord Roberts and seven general officers were there, and the excitement at the arrival of the large airship was intense. An enthusiastic spectator, believed to be an officer of high rank in uniform, shouted to the landing party to go on, which they did. The envelope, impinging upon the top of the doorway, was punctured, and the airship collapsed on the ground and was damaged. It transpired that the over-all height of the airship was 10 ft. greater than the makers had specified. The height of the shed was subsequently increased by 15 ft.

These two events were a disappointing beginning to the charge of the new Commandant, Sir Alexander Bannerman, who had only just assumed office. But worse was to come.

The collapse of the Lebaudy airship left room in the single airship shed then available (the original small airship shed had long since been appropriated for other purposes in the Factory) for the inflation of *Beta*. This airship, except during a further overhaul which took from mid-November to mid-January, was in action up to March, 1911.

In November, 1910, the Secretary of State for War, Mr. Haldane, visited Farnborough, and was taken for a flight in *Beta* by Captain Broke-Smith. This much interested Mr. Haldane ; he claimed to be the first War Minister to fly in an airship. Mr. Haldane arrived in his tall hat, an unsuitable headgear for a voyage in an open-frame airship, and was persuaded to exchange it for a civilian mechanic's cap.

In this month also, the first flying of a British Army aeroplane (apart from the experiments with the Cody and Dunne machines before they were discarded in 1909) was carried out by Lieutenant R. A. Cammell, R.E., of the Balloon School. The aeroplane was a Bleriot XII monoplane fitted with a 60 h.p. E.N.V. engine, and in this machine, few examples of which were made, the engine with the pilot and passenger was carried under the wings. Lieutenant Cammell had practised flying at the Blériot works in France the previous June. After unsatisfactory trial flights at Larkhill, on Salisbury Plain, where a Government hangar had been erected, Lieutenant Cammell was flying the aeroplane, which had acquired the nickname of " the man killer," to Farnborough for overhaul, when engine failure caused a forced landing *en route*. The machine was brought into the Balloon Factory, where, in pursuance of the Factory researches, it was " reconstructed " to a new design, using its engine but little else. This was a " tail-first " experimental biplane, the S.E.1.,* which came to grief, the type thereafter being abandoned. The designation S.E. was continued later for a successful tractor biplane type (the " Scouting Experimental ").

An original pattern " tail-first," catapult-started, Wright biplane had earlier been presented by the Hon. C. S. Rolls, an expert amateur balloonist and a pioneer aviator, who had close associations with members of the Balloon School. He arranged to demonstrate its operation, and teach Lieutenant Broke-Smith to fly it at Farnborough. Before he could find time to do this, Mr. Rolls was killed at the Bournemouth aviation meeting in July, 1910, the tail of the modified Wright machine which he was flying collapsing in a steep dive in a gymkhana event. The aeroplane presented to the Army, which had become warped and obsolete, was eventually written off.

Meanwhile, the construction of another Army airship, designed to be of performance suitable for war in speed, range, altitude capacity, and equipment, had been commenced in the Balloon Factory in 1910. This was the *Delta*, which was originally designed as a semi-rigid with a 160,000 cu. ft. silk balloon, but was eventually completed in the autumn of 1912 as a non-rigid with a 175,000 cu. ft. rubber-proofed fabric balloon.

Two aeroplanes of French make (the French were in advance in aeroplane construction, largely owing to Government encouragement), a 50-h.p. Gnome engined, Henry Farman pusher biplane and a 50-h.p. Gnome Paulhan, a similar type, but of novel unorthodox construction, including continuous W boxed spars in the wings, elevator, and tail, were ordered by the War Office. The Factory acquired for experimental purposes a Farman type biplane designed and constructed by Mr. G. de Havilland,† who was now employed there, and a 60-h.p. Wolseley-engined, Voisin pusher biplane presented by the Duke of Westminster. The de Havilland machine,

* Aeroplanes were then classified, under a system devised by the Balloon Factory, in three categories based upon the fundamental types, and labelled accordingly.

The categories were :—

(i) *S type.*—" Tail first " machines, i.e., with the only subsidiary lifting surfaces in front of the main planes, called after M. Santos Dumont's miniature " Demoiselle " machine of 1906, and to which category the original Wright machines also belonged.

(ii) *F type.*—Pusher machines with elevator in front (eventually suppressed in favour of tail elevators alone) and tail supporting surfaces ; named after Henry Farman, who was the most successful early exponent of the type, which he developed from the Voisin " box-kite " biplane of 1907.

(iii) *B type.*—Tractor machines with all subsidiary surfaces and controls in rear, the prototype of which was the Blériot monoplane, which Louis Blériot developed from 1907, crossing the Channel in July, 1909.

The second prefix, " E," denoted an experimental version of the fundamental type devised in the Balloon Factory.

† Later Sir Geoffrey de Havilland, C.B.E.

after reconstruction with front elevator removed, was in July, 1911, to appear as F.E.2, the forerunner of the pusher fighter biplanes with a machine gun in the bow. The Voisin was "reconstructed," providing the engine for the B.E.1. tractor biplane which appeared in January, 1912, the original of the successful B.E. type.

The Farman and the Paulhan (ordered under the piecemeal trial policy), being quite inadequate for the forthcoming influx of officers to be trained, upon the personal representation of the Commandant in the highest quarters, six Bristol Farman type biplanes, including two to provide reserves and replacements, were ordered. The standard engine for these machines was the 50-h.p. Gnome, but eventually two were ordered to be fitted with 60-h.p. Renault engines. The light rotary Gnome had for some time been the most generally successful type, but it was difficult to maintain, and the stationary air-cooled Renault was achieving considerable success. The Bristols were reliable machines of proved type, easy to fly, and of British manufacture (at that time there were few established British aeroplane constructors) ; and they were especially suitable for the initial training in flying and reconnaissance of recently qualified pilots, or the tuition of new pilots. They also had the advantage that the makers, the British and Colonial Aeroplane Company,* had established a flying school and workshops adjacent to the Army sheds at Larkhill, on Salisbury Plain, which had been selected as the best centre for Army flying development. Here two Government hangars were under construction, to supplement the one already built ; these were all that were sanctioned at this stage.

The aerodrome facilities at Farnborough were limited and inconvenient, and would remain so until funds were provided for the clearance and levelling of the ground between Farnborough and Cove Commons and the level expanse of Laffans Plain. Farnborough was, therefore, in the first instance to be a minor aeroplane station, for headquarters and local use as required, and as the necessary second station for early training in cross country flying between two points.

The Bristols were to be followed by faster machines (which at that stage were mostly of foreign manufacture) for trial and for the further training of pilots, as their proficiency increased, and as the development and performance of speedier types should lead to their selection.

The Farman biplane arrived at the end of 1910. Captain C. J. Burke, Royal Irish Regiment, who had learnt to fly Farmans in France, was attached to the Balloon School in advance of the formation of the Air Battalion, and commenced flying the aeroplane in January, 1911, at Farnborough. Captain J. D. B. Fulton, R.A.,

* Subsequently named the Bristol Aeroplane Company.

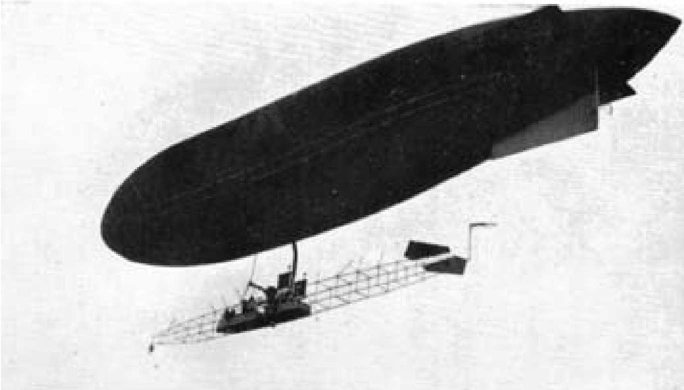


Photo 18.—H.M. Airship *Gamma*.

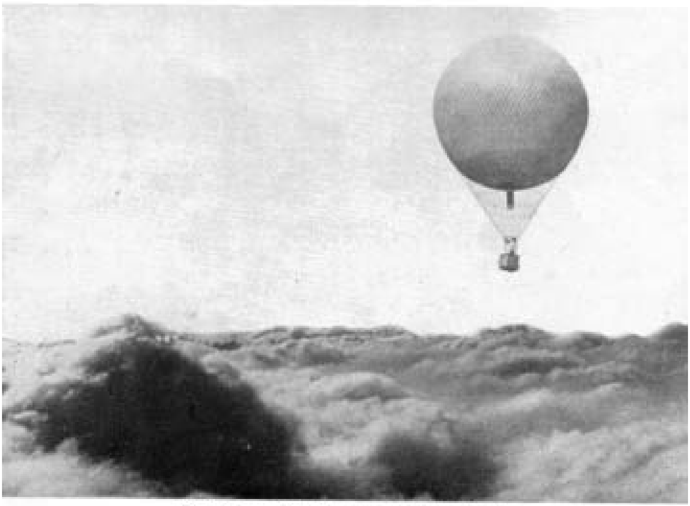


Photo 19.—Free balloon above the clouds.

Photo 20.—Bleriot XII Monoplane, 1910. Lieutenant R. A. Cammell, R.E., with ground party.

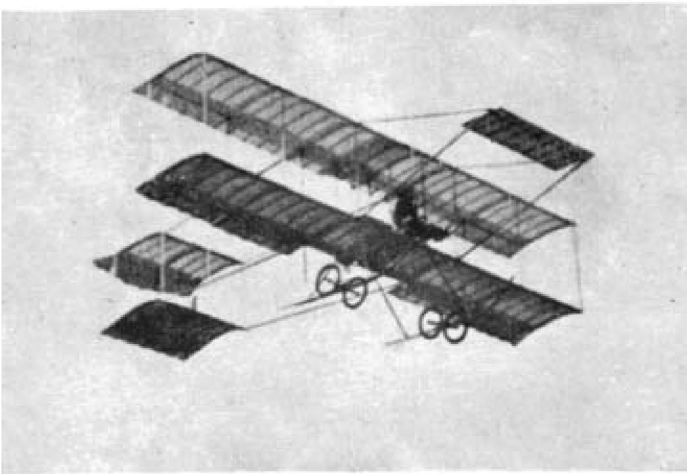


Photo 21.—Henry Farman Biplane, piloted by Captain C. J. Burke.

Photo 22.—Lieutenant R. A. Cammell's Bleriot XXI Monoplane, 1911.

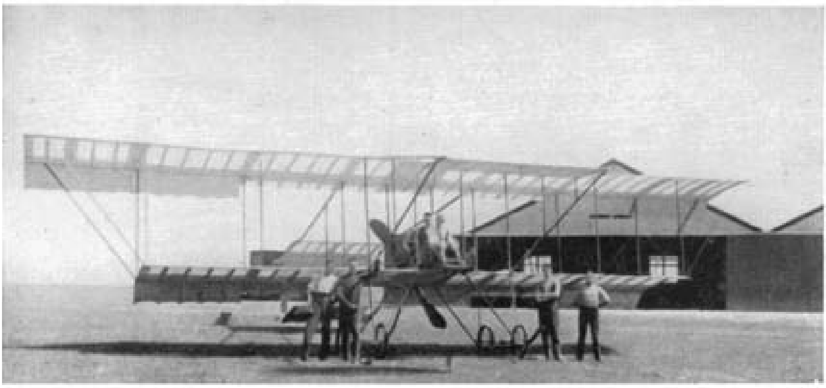
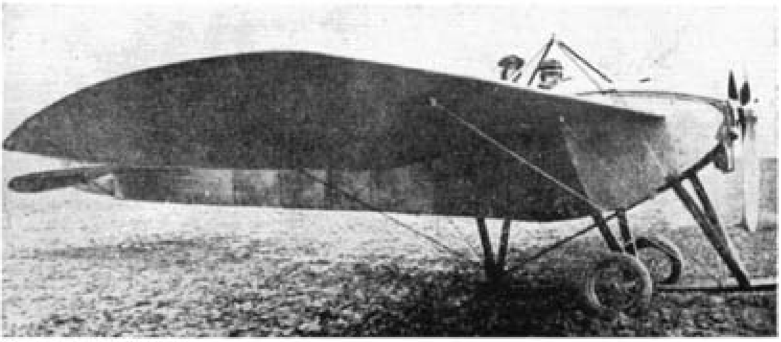


Photo 23.—Bristol Biplane. Crew Lieutenant B. H. Barrington-Kennett and Lieutenant H. R. P. Reynolds, R.E.



(*By courtesy of "Flight"*)

Photo 24.—Nieuport Monoplane. Pilot Lieutenant B. H. Barrington-Kennett with Staff Sergeant Wilson, R.E., as passenger.

Photo 25.—"The Old and the New"—Air Battalion horses on Salisbury Plain come to the rescue of a civilian aeroplane lorry.

who had his own 25 h.p. Anzani-engined Blériot monoplane at Larkhill, was similarly selected for attachment, and in January, 1911, was sent to the Paulhan works at Buc, where he tested and accepted the aeroplane ordered by the War Office ; this machine, however, did not become available, after examination in the Balloon Factory, until May.

Experiments in the production of aircraft wireless apparatus were revived at the end of 1909 by Captain H. P. T. Lefroy, R.E. (who had been appointed O.C. Wireless Experimental Section, R.E.), so far as the pressure of work due to the development of ground wireless sets for the Army permitted. Trials from balloons were resumed in 1910, and on 27th and 28th January, 1911, the first successful airship wireless tests were made. During voyages of *Beta*, that of 28th January being to Portsmouth and back via Andover, piloted by Lieutenant Waterlow, signals were transmitted continuously ; signals were also received, but at this stage only when the engine was stopped. In February, 1911, messages were transmitted from and received in *Beta* up to a range of thirty miles.

CHAPTER VI

THE AIR BATTALION APRIL, 1911, TO MAY, 1912

Formation of Air Battalion—Air Battalion Reserve—Lack of aircraft—Destruction of Lebaudy Airship—Aeroplane Company on Salisbury Plain—Airship, etc., Company at Farnborough—Air Battalion aeroplanes—Flying training—Mortimer Singer Cup Competition—Daily Mail Circuit of Britain—Airship training—Balloons and kites—Preparations for autumn manœuvres—Aeroplane tenders—Aeroplane Company's flight to Cambridge—First Army flying fatality—Further air activities at Farnborough and Larkhill—Airship mooring mast—Aircraft wireless developments—Eclipse of monoplanes—Decision to form Royal Flying Corps—Formation of Royal Flying Corps.

ON 1st April, 1911, the Balloon School was reorganized as the Air Battalion, with an establishment of fourteen officers and 176 other ranks, including six officers of other corps, and the final phase of the responsibilities of the Royal Engineers for military aeronautics began. The Air Battalion, which, as mentioned in the last chapter, had the specific duty of training officers and men in the handling of all forms of aircraft and providing a small body of expert airmen from which air units for war could be formed, was destined to have a brief existence. A few months after its birth the formation of a fully organized separate air arm was decided, but during its short and eventful life all ranks made the most of the opportunities available, military flying training was started, and a foundation was provided for the future air service.

To provide the specialized technical staff necessary for the maintenance and operation of aircraft engines and machinery, a cadre of six military mechanists, who had mostly to be specially recruited, was included in the establishment ; they were so valuable that the authorized number was shortly increased to twelve, but the full strength was never achieved owing to recruiting difficulties. The internal organization provided for headquarters and two nucleus companies, one for airships with balloons and kites, and one for aeroplanes. The total establishment in N.C.Os. and men was only twenty-seven more than that of the Balloon School, and for the handling of any large airship the personnel would always have to be supplemented by infantry landing parties, attached and trained as circumstances allowed.

The inauguration of the Air Battalion was followed some months later by the institution, to facilitate expansion, of an Air Battalion Reserve. This was to comprise up to one hundred officers who had obtained pilots' certificates at the civil flying schools which were rapidly springing up ; they were to be called up in due course for further training. Officers of all arms who had qualified at civil flying schools and were accepted for the Air Battalion or the reserve were paid a grant of £75 (an amount which, incidentally, did not cover all expenses). Simultaneously with the formation of the Air Battalion the Balloon Factory, which had been known as H.M. Balloon Factory for some years, was renamed H.M. Aircraft Factory.

When the Air Battalion was started no aeroplanes or airships were in commission, and facilities for workshop practice in the maintenance and overhaul of aircraft and their engines, which the Air Battalion, unequipped with workshops, did not possess, could not be provided by the Aircraft Factory in the conditions resulting from the separation of the military side from the factory in 1909. Some of the additional officers who had joined, therefore, had at first to be employed in practising map reading and air reconnaissance from captive and free balloons, and all concerned counted the days until power driven aircraft should be available for the flying aspirants. Actually, the Army Order constituting the Air Battalion laid down that the initial air training of all officers on joining was to include ballooning and kiting—a provision which was obviously impracticable for inclusion in the general curriculum.

The Lebaudy airship was still under repair in the airship shed after its accident upon arrival six months before, and the airships *Beta* and *Gamma* were under overhaul. The Farman biplane was under repair in the factory after a recent accident, and the Paulhan biplane had not been issued. Owing to ordering and constructional delays none of the six Bristol biplanes (four of which had been intended to be available by April, 1911) was ready.

Early in May the Lebaudy airship was relaunched, in charge of her French crew, after rehabilitation under the supervision of representatives of her manufacturers. Apparently she was out of adjustment, in this her first flight after being rerigged. On descending after a short test flight the airship missed her landing, and she eventually collapsed, with engines running, on a house across the main London road adjoining Farnborough Common, after uprooting with her trailing ropes the line of telegraph wires along the road, and a number of trees. She crossed the landing ground at such a speed that it was impossible for the landing party of Sappers and Guardsmen, run as they might, to catch the landing ropes. A fire was fortunately avoided, and no one was hurt. The envelope was so badly torn that the gas escaped upwards at once, and a Sapper with Mr. McWade of the Aircraft Factory, who had been the Balloon Factory works superintendent in the time of Colonel Templer and Colonel Capper, rushed forward and turned off the petrol. The wife of the officer occupying the house, who was upstairs dressing for dinner, had the fright of her life when she saw through her window the large airship advancing upon the house. The airship was badly broken up, and it was decided that she was not worth rebuilding. So finally ended the expectations which had been entertained of acquiring two full-sized airships of proved performance in the shape of the Clement Bayard and the Lebaudy. The next day the new Paulhan biplane was damaged when Captain Fulton was landing it after a test flight before taking it over from the Aircraft Factory, and it ceased to be available for army training. Nearly a year later it emerged from the factory transformed as B.E.3, one of the tractor biplanes for which the Aircraft Factory was responsible, but little of the original machine except the engine had survived. Although it achieved considerable flying successes, the Paulhan design was disappointing, and it was discontinued by its maker after a short life.

When the first pair of new Bristol biplanes was reported as approaching completion, in the middle of May, a detachment of officers and other ranks detailed for flying was sent to Larkhill. This detachment was designated No. 2 (Aeroplane) Company, and was placed under the command of the senior officer, Captain J. D. B. Fulton, R.A. Captain Burke joined the party with the Farman, flying from Farnborough. Later, Captain E. M. Maitland, Essex Regiment, took over the command of No. 1 (Airship, etc.) Company at Farnborough, after qualifying as an airship pilot. Captain Maitland was an expert amateur balloonist, who had made many long free balloon runs, and had decided to devote himself to airships after an accident, when he was practising flying in his own aeroplane in 1910, had caused such damage to his legs that it was inadvisable for him to go in for flying.*

Owing to the accidents which were common in those days, the frequent engine overhauls necessary, and delays in supply of new machines, the number of effective aeroplanes in hand at any time during the existence of the Air Battalion never exceeded nine and the normal maximum during 1911 was four or five. Two of the Bristols were handed over by the makers' Larkhill establishment in May, two in July and two in August. These and the Farman were supplemented by a new 70-h.p. Gnome engined Blériot XXI monoplane, in which the pilot and passenger sat side by side, and an old reconstructed Howard Wright Farman type biplane. The former had been ordered, at his own expense, by Lieutenant Cammell when the Army Blériot which he had been flying was written off, and was flown by him, after taking delivery in May, 1911, at Hendon, to Larkhill, reporting at headquarters at Farnborough *en route*. The latter was purchased by the War Office from Captain Maitland ; it had but a short further life. Three promising new types were ordered, a 60-h.p. Renault Bréguet tractor biplane (the first all-metal frame aeroplane), a 50-h.p. Gnome Nieuport monoplane, and a 60-h.p. Anzani Deperdussin monoplane ; aeroplanes of these patterns subsequently took the first three places in the French military aeroplane competition in October. But these machines did not reach the Air Battalion until the end of the year. Their respective speeds were 55, 69 and 69 m.p.h., whilst Lieutenant Cammell's Blériot flew at 60 m.p.h.—an improvement on the speed of the pusher biplanes, which was about forty miles per hour.

The arrival of the Aeroplane Company on Salisbury Plain was followed by three months of progressive flying practice, tempered by availability of machines and weather conditions. Only the fastest aeroplanes could fly in strong winds, and flying was usually confined to the early morning and the evening, in order to avoid unstable air conditions. Cross country flying, away from the airfield, was developed, and many flights were made in the vicinity of Salisbury Plain and between Larkhill and Farnborough. Excursions further

* When all the additional officers had joined, the distribution was as follows :—

Commandant, Major Sir Alexander Bannerman, Bart, R.E. ; Adjutant, Capt. P. W. L. Broke-Smith, R.E. ; Experimental Officer, Capt. A. D. Carden, R.E. ; Quartermaster, Lieut. F. H. Kirby, V.C., R.E. ; *No. 1 (airship and balloon and kite) Company*, Capt. E. M. Maitland, Essex Regt. (O.C.), Lieut. C. M. Waterlow, R.E., Lieut. A. G. Fox, R.E. (replaced by 2nd Lieut. J. N. Fletcher, R.E. from January, 1912) ; *No. 2 (aeroplane) Company*, Capt. J. D. B. Fulton, R.A. (O.C.), Capt. C. J. Burke, R. Irish Regt. (O.C. Farnborough detachment from September, 1911), Lieut. D. G. Conner, R.A., Lieut. B. H. Barrington-Kennett, Grenadier Guards, Lieut. R. A. Cammell, R.E. (killed flying in September, 1911, and replaced by Lieut. Fox), Lieut. G. B. Hynes, R.A., Lieut. H. R. P. Reynolds, R.E. Several other officers were attached from time to time and one of these, Capt. H. R. M. Brooke-Popham, Oxfordshire and Buckinghamshire Light Infantry, was posted to the Air Battalion in March, 1912.

afield included flights to Oxford and other places in neighbouring counties, including the civil aerodromes at Brooklands and Hendon.

On the longer journeys the limitations of the aeroplanes necessitated intermediate landings. Aerodromes were few and far between, and a likely looking field had to be chosen when the engine or some part of the machine was giving trouble or nightfall was approaching. Two of the most enterprising young pilots, when held up *en route*, and not put up by newly made friends, would sleep in a cottage with a string tied to one of them hanging out of the window, which a villager, or their ground party corporal, if with them, was induced to pull at 2 or 3 a.m. to rouse them for an early start. Expenses had to be kept down, and on one occasion, to save the cost of lodgings, the corporal and his two men slept in an old cab near the landing place. Unfortunately the saving was rendered abortive, as one of them on waking up put a foot through a window of the cab, an accident for which ample compensation was demanded by the owner.

The elementary nature of the instruments available for the first airships has already been mentioned. Few of the aeroplanes in the early days, except Lieutenant Cammell's Blériot and others of the more advanced French types, had any instruments at all except an engine revolution counter. Until altimeters could be obtained, height had to be judged by an aneroid barometer, as used in balloons, tied on to the machine. Compasses were obtained from marine instrument makers and installed. The Experimental Officer, within whose province such work came, received much useful assistance in compass swinging from a Naval expert, Captain Chetwynd, R.N. A beginning was made with what was afterwards known as the Pitot Tube, for measuring air speed.

In July, 1911, Lieutenant Cammell with his Blériot, whilst competing for one of the two £500 prizes offered by Mr. Mortimer Singer for the longest flights with a passenger by Naval or Army pilots during the year ending 31st March, 1912, covered a distance of 110 miles (of which 100 counted for the competition). This was a notable achievement at that time. Lieutenant Cammell had no opportunity of bettering it before he was killed flying in September, and eventually Lieutenant Barrington-Kennett, flying the Army Nieuport, won the prize for an Army pilot with a flight of 249½ miles in February, 1912, making the current world record for a flight with a passenger. Lieutenant Cammell in his Blériot and Lieutenant Reynolds in a privately-owned Howard Wright biplane competed in the *Daily Mail* Circuit of Britain race in July, 1911. They had to retire on the second and third days respectively owing to engine failures which caused them to make forced landings when they had got as far as Wakefield and Harrogate, starting from Brooklands. They were well up in the race when they had to retire. Only four competitors out of twenty-seven completed the circuit ;

the fourth of these was Mr. Cody, who had a rough landing *en route*, but repaired his machine and completed the course.

Valuable assistance was given to the Aeroplane Company at Larkhill by the British and Colonial Aeroplane Company, the makers of the Bristol machines, and by Mr. G. B. Cockburn, who also had a hangar there. Mr. Cockburn, a philanthropic private aviator, to whose generosity and enthusiasm much was due, had previously gratuitously taught the first four Naval aeroplane pilots to fly at Eastchurch.

Meanwhile, the activities of the Airship Company were unfortunately much limited by lack of airships. After her last commission in the early part of 1911, *Beta* did not appear except at intervals, her longest commission being for four weeks in August and September. Her envelope, after long service and prolonged exposure to the weather, gave constant trouble and needed a thorough overhaul. *Gamma*, which had been under modification since the previous year, reappeared in July. After trials, in which her speed was found to have been increased to 34 m.p.h., early in August she was deflated for overhaul and alteration, in readiness for manœuvres.

The usual training in observation of artillery fire from balloons and kites was carried out at the heavy artillery practice camp at Lydd, but owing to the many demands on the small establishment of the Air Battalion it was possible to send only a small detachment, which was supplemented by R.A. personnel at the camp who had to be trained. This was hampering enough for ballooning, but was even more detrimental to kiting, as the safe and efficient operation of the kites demanded lengthy training and experience. Static aircraft remained useful for artillery observation pending the perfection of aeroplane wireless communication, although the eventual inability of balloons to keep the air in face of hostile aeroplanes and improved artillery was anticipated. The rapid development of power-driven aircraft was, however, causing an eclipse of interest in balloons and kites for observation purposes and made the maintenance of the necessary continuity of training impossible, so the use of the kites was gradually to die out. Owing to the advances in reliability and efficiency which kite balloons had by then achieved, they were introduced into the British service in the 1914–18 war.

In August, 1911, preparations were well advanced for the September cavalry division and Army manœuvres in East Anglia, at which it was hoped to operate Army aeroplanes for the first time, together with an airship equipped with wireless. There were to be three aeroplanes on each side, and *Gamma*, with *Beta* as a stand-by in reserve at Farnborough, was to operate with one side or the other under the orders of the directing staff.

The preparations included arrangements for air bases in the manœuvre area, the attachment and preliminary training of observers, the provision of portable aeroplane hangars, the planning of appropriate aeroplane and airship and gas trains, the design and provision of mechanics' field tool sets, and arrangements for the attachment of mechanical transport from the Army Service Corps.

The establishment of the Air Battalion included no transport except the horsed balloon and kite vehicles and one motor-car. No other first-line mechanical transport (which was as yet almost unheard of for Army units) had been allowed. In connexion with the manœuvres, Sir Alexander Bannerman managed to get permission to purchase two powerful second-hand cars (out of a minimum of four which it was hoped to secure in this way), and to have them adapted for use as first-line aircraft service vehicles, fitted with wagonette bodies to carry men and tools etc., and equipped with double rear wheels. These were the prototype of the subsequent aeroplane tenders of the Royal Flying Corps, the suggested designation " tender " being adopted.

Unfortunately, in the event, the manœuvres were cancelled, ostensibly owing to the severe drought, but actually, according to Lord Haldane in his biography, due to the strained international situation. However, as a culmination to its summer training the Aeroplane Company was permitted to fly its machines to the manœuvre air bases at Hardwick, near Cambridge, and Thetford in Norfolk. Only two, Lieutenant Cammell's Blériot and one Bristol piloted by Lieutenant Barrington-Kennett, got to Hardwick unscathed, returning later to Larkhill ; the remainder came to grief *en route*, due to bad weather or engine troubles. Lieutenant Conner had two mounts ; crashing the first in a fog on the first day out, he fetched a reserve machine from Larkhill, but was no more fortunate in his second attempt. Two were written off, one after a descent upside down in which the pilot, Lieutenant Reynolds, miraculously escaped injury. In the first of a succession of somersaults which the aeroplane performed, upset by the currents and air pockets due to the thunderous atmospheric conditions, the aeroplane seat and a handbag fell to earth. The driver of a train on the Oxford–Cambridge line, which the flyers were following, reported at the next station that the aviator had fallen out of the aeroplane. The news spread, and the next day Lieutenant Reynolds on entering a house in the vicinity heard his demise being discussed. Thrown out of his open seat in the front of the machine, he had hung on to a stay between the planes, and thus landed without injury, jumping out at the last moment, although the machine was smashed up.

Shortly afterwards, on 17th September, Lieutenant Cammell was killed when a " tail first " Valkyrie monoplane which had been presented to the Army by the maker, crashed with him when he was taking it over at Hendon. The arrangement and operation of its controls were different from normal practice, and Lieutenant

Cammell apparently did not appreciate the difficulty of accustoming oneself to the novelty ; the result was that he side-slipped when making a sharp turn. This pattern of aeroplane had been successfully flown for some time ; it was, however, unstable, and the design was soon afterwards discontinued. Lieutenant Cammell's untimely death was a great loss to aviation and to the Service. He was one of the three Air Battalion officers who qualified as a pilot of balloons, kites, airships, and aeroplanes. He was, in his time, about the most expert and versatile of the Air Battalion pilots, and was one who devoted the whole of his energies to the science of the air and its military application. He was one of those who foresaw the value of gyroscopic stability control of aeroplanes, and invented a device to this end, which, however, he was unable to get taken up for consideration and development. He also made a special study of air photography and the evolution of bomb sights. The first Army aviator to be killed flying, a monument to his memory was erected in the R.E. lines at Aldershot. After his death, Lieutenant Cammell's Blériot was taken over as an Army machine.

A period of recuperation followed the Cambridge Odyssey, after which flying training was resumed. The aeroplane detachment at Farnborough was revived, under the command of Captain Burke. It was allotted three of the portable hangars which had been provided for the manœuvres, to replace the previous inconvenient stowage of aeroplanes in corners of the Lebaudy airship shed, which was the Air Battalion's only aircraft and workshops building at Farnborough. Starting with the original Henry Farman biplane, which was still flying after many reconstructions, by March, 1912, the strength had increased to three machines, the Farman, one of the remaining Bristol biplanes, and the B.E.1 Aircraft Factory-made tractor biplane, now fitted with a 60-h.p. Renault engine, which the Factory handed over at that time.

The Bréguet biplane and the Nieuport and Deperdussin monoplanes, which had been anxiously awaited since they were ordered in the previous summer, were received between November and January. A high performance British machine which had just appeared, the 50-h.p., 65-m.p.h., Gnome Bristol monoplane, was ordered in November, and this was received in February from the British and Colonial Aeroplane Company's establishment on Salisbury Plain. The three congested corrugated iron hangars at Larkhill were supplemented by an equal number of portable manœuvre hangars, but there was still inadequate space for workshops and stores pending the completion of four additional permanent sheds which had been sanctioned in the previous summer. The Army airmen had been living in tents alongside the flying ground, but with the approach of winter, accommodation was found for them in barracks at Bulford Camp, three miles away.

Airship operation was actively pursued by Captain Maitland and his company during the four weeks commission of *Beta* in August and September, followed by *Gamma* for a similar period. The flights included night cruises, to obtain further practice in this special function of airships. Both airships had to be deflated for overhaul in the Factory as their envelopes continued to give trouble, the constantly expected *Delta* was still not forthcoming, owing to difficulties experienced in her completion, and, in the event, no airship was again available until the following April. In February, 1912, a promising test was made of an experimental mooring mast for airships made in the Aircraft Factory, using an old elongated balloon. This device was the forerunner of the mooring masts which later enabled airships to ride out severe weather conditions moored in the open, and credit for its initiation can be largely attributed to Lieutenant Waterlow, who was a confirmed exponent of airships and, alone amongst the officers who served in the Air Battalion (with the exception of the Quartermaster who was not concerned), never piloted an aeroplane.

Wireless work in airships was continued by Captain Lefroy during 1911, and he undertook the manufacture of a set for the new airship *Delta*. In January, 1912, he made successful experiments over Salisbury Plain from the B.E.1 biplane, which was piloted by Mr. Geoffrey de Havilland, with a wireless set made by Mr. R. Widdington of the Aircraft Factory, and in April, before the end of the time of the Air Battalion, he had a set ready for test in an aeroplane, but the machine selected, the B.E.2, was not then ready for issue to the Air Battalion. Tests of the apparatus were eventually carried out with the R.F.C. in the latter part of May, with successful results which led to the subsequent achievements in this field.

In the early months of 1912 monoplanes fell into disrepute. There had been breakages of stay wires, and it was considered that they were unable to withstand the top pressure caused by steep diving, and had other weaknesses. As monoplanes were inherently more efficient and faster than biplanes, and had been achieving increasing success, three out of the four aeroplanes which the Commandant Air Battalion had been able to recommend for purchase for advanced flying practice and trial, in succession to the initial batch of essential instructional machines, were monoplanes. The use of monoplanes was banned pending technical inquiry ; this was unfortunate as monoplanes, including Lieutenant Cammell's Blériot, constituted about half the effective aeroplane strength and more were on order for the R.F.C. There was at the same time a ban on Blériots in France, where monoplanes had been initiated and most developed, owing to unexplained breakages ; confidence in them, however, was soon restored, and foreign nations continued to use and improve monoplanes—the exploits of the German

Fokkers in the early part of the 1914–18 war are a matter of history. The British ban was removed, but a renewed condemnation later in 1912, as a result of further accidents, was to cause an eclipse of monoplanes in the British service which lasted for many years.

We now approach the end of the story. In it little mention has been made of the work of the rank and file, who, as the officers were primarily the aeronauts and observers, had few chances of distinction. But the good services of the N.C.Os. and men in the air branch of the Corps, who handled all forms of aircraft, from balloons to aeroplanes in their turn, and without whom such successes as were achieved would have been impossible, must be given due recognition. From and before the time of Sapper Wright, who spent several hours in a balloon during the Red Sea littoral operations in 1885, they played their part not only on the ground but in the air when they were required to go up. A number of the N.C.Os. and men of the Air Battalion subsequently became airship or aeroplane pilots in the Royal Flying Corps. Due tribute must also be paid to the work of the civilian staff of the Balloon or Aircraft Factory, in relation to the Balloon units and the Air Battalion and for the advancement of aircraft design, a fuller account of which does not come within the scope of this history ; and particular mention must be made of the Factory mechanics who often acted as the flight engineers of the airships.

The international crisis in the late summer of 1911, after the German Emperor had shaken the mailed fist, demonstrating with a warship at Agadir in Morocco, revealed the imminent risk of a European war, and caused serious attention at last to be given to the development of the British air arm. At that time we could not have mobilized more than one or two small experimental airships with well-worn gasbags, and about four effective aeroplanes, mostly of training type. Other nations were well in advance. France had a considerable fleet of aeroplanes in being (put at 174) ; this was said to have been a factor in preserving peace at the time. Germany, which had originally not gone so far as France in the development of aeroplanes, owing to the success of her airships, notably the Zeppelins, had by now undertaken heavy expenditure upon the provision of aeroplanes for the German army. In its report, presented in August, 1911, the War Office Committee under the chairmanship of Lord Kitchener, which had been considering the future organization of the Royal Engineers, recommended that, as aviation had now emerged from the experimental stage, aeronautics should no longer be included in the functions of the Royal Engineers. Before the end of the year the British Government decided to go ahead with the organization of a separate air corps, fully equipped.

This resulted in the formation in April–May, 1912, of the Royal

Flying Corps, containing Naval* and Military wings, and the establishment of a Central Flying School at Upavon on Salisbury Plain. Initial requirements for the Military Wing and the Central Flying School alone were 131 aeroplanes, and 26 aeroplanes were ordered by the War Office by February, 1912. Airships of intermediate size (i.e., round about 160,000 cu. ft.) were considered to be still of military value, particularly for night and long distance flying, and the operation of airships was to be included in the duties of the Flying Corps.

From the last months in 1911 the staff of the Air Battalion was much occupied, in addition to maintaining training as far as was feasible with the aircraft available, in paving the way for the introduction of the R.F.C. This included allocation of personnel to the forthcoming units, advice to the War Office on aircraft and equipment, and the reception and training of additional officers. Ten officers of the Air Battalion Reserve, who had been selected for the R.F.C., were successively attached in the early months of 1912. Only one of these officers was intended for airships, but enough aeroplanes were not available for the others, and under War Office instructions some of them were given air experience in balloons and in the airship *Gamma* when that became available in April. On 13th May, 1912, the Royal Flying Corps (Military Wing) was officially inaugurated, and took over from the Air Battalion R.E., absorbing the bulk of the personnel. No. 1 (airship) Squadron R.F.C. was formed from No. 1 Company,† the first two aeroplane squadrons, Nos. 2 and 3, were formed from the Farnborough and Larkhill detachments of No. 2 Company, and the Flying Depot (the forerunner of aircraft parks) was started from Air Battalion headquarters, workshops and stores personnel.

The responsibilities of the Royal Engineers for air work, which, in discharge of their duty of pioneering new technical branches (other notable examples of which were submarine mining and military telegraphy), they had sponsored for thirty-four years—from balloons, through the infancy of flying machines, had ended. Flying machines were now considered to have reached a stage at which the air service was worthy of man's estate. Power-driven aircraft, the effective number of which could almost be counted upon the fingers of the two hands, were now to multiply and in due course be reckoned in thousands, of ever-increasing capability, whilst air personnel and equipment were to increase in proportion. Everything has to have its beginnings.

* The Naval Wing soon became the Royal Naval Air Service, and the designation "Military Wing" became obsolete.

† In 1914 all airship work became the prerogative of the Navy, and No. 1 Squadron was re-formed as an aeroplane squadron, most of the officers and some of the rank and file transferring to the Royal Naval Air Service.

THE INFLUENCE OF MECHANICAL HANDLING METHODS ON ENGINEER TACTICS AND TECHNIQUE IN THE FIELD

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INTRODUCTION

IN this article the application of the principle discussed in a previous paper on " The Mechanical Handling of Military Stores," published in the *R.E. Journal* for March, 1952, will be considered in detail in relation to the execution of engineer work in the field. An attempt will be made to show that the use of such material handling methods would lead to substantial savings in the labour, time and transport required for engineer tasks ; and that these savings would have a profound effect, not only on the total output from the available engineer resources, but also on the ability to carry out work at all in many of the tactical conditions likely to be encountered in future operations. In particular it will be suggested that, with the increasing scale of engineer work represented by the 75 to 100 per cent increase in potential stores tonnages compared with the last war, the economies which could be achieved by the introduction of co-ordinated mechanical handling methods would be the vital factor in balancing engineer resources against commitments.

It has been well realized in the development of " teeth " engineer equipments that no degree of efficiency in planning or organization can compensate for inadequate or out-of-date technical methods. As a result mechanical methods are now being applied to many engineering tasks formerly carried out by hand. It is not equally well realized, however, that the essential corollary to the development of such methods, which in essence lead to the mechanical consumption of stores, is the development of equally powerful and efficient means of handling, moving and deploying the vast tonnages of stores which follow in their train. It is also not generally realized that mechanical handling and mechanical transport are logical counterparts, together filling the gap which lies between the machines which make military stores and those which are being increasingly developed to use them. When this idea is accepted it will be considered just as ludicrous for mechanical handling methods to be confined to rearward areas as it would be for mechanical transport to be replaced by carrying parties at some arbitrary ideological boundary on the way to the front.

Some Important Contrasts Between Military and Civil Engineering Requirements

Before considering the detailed application of mechanical handling methods to engineering in the field it is necessary to establish some important contrasts between military and civil engineering requirements which have major repercussions on the subject.

1. The rate of incorporation of stores in engineering projects in the field is usually very much greater than in corresponding civilian ones. This is achieved by extensive prefabrication, as in military bridging and hutting, by the elimination of frills and finishes, by the general adoption of temporary standards, by the use of plant which may be uneconomic in civilian work, and by the effect of operational urgency. The result is that the tonnage flow of stores in relation to the man-hours required to incorporate them is high compared with civilian practice.

Military engineers must be prepared, therefore, not to follow civilian practice, but to lead it in the development of field mechanical handling methods.

2. In military engineering there are nearly always two rather conflicting problems, which, on the whole, the civil engineer manages to avoid :—

(*a*) That of maintaining the highest possible over-all efficiency in order to obtain the maximum total product from the available resources.

(*b*) That of being able to concentrate adequate resources for priority tasks, often at short notice. Such tasks may range from the building of a bridge in support of an assault to the reopening of a major port hit by an atom bomb.

It is clear that the development of mobile mechanical handling equipment of general application can go far towards reconciling the requirements of these two problems.

3. Handling effort can be reduced in two ways ; firstly by reducing the number of handling stages, and secondly by the introduction of mechanical handling methods. It must be remembered, however, that the reduction of handling effort is not the sole aim of any material handling scheme. Flexibility of stores deployment, and savings of transport, time and space are also important considerations. Generally, with manual handling, the available labour will only allow for stores to be handled in the minimum number of stages. Everything else has, therefore, to be sacrificed to this end. With mechanical handling, however, which gives man mastery over material, it is often better to introduce extra handling stages to gain other important advantages. This feature of mechanical handling can be observed in the civilian scene, but is not usually of major importance. In military engineering, however, as may be seen from

the examples discussed later in this article, it may become paramount. The military engineer must remember always that mechanical appliances are not merely a means of saving effort, but are also means of saving time, transport, space, blood and other fundamental resources with which he has to deal, and which it must be his aim to conserve.

Equipments and Methods Assumed to be Available

It is assumed in this paper that the techniques of parcel loading and palletization described in the previous article have been generally developed and are well understood, and that the proposed types of cranes and forklift trucks, together with suitable auxiliary devices are generally available.

The Field Engineer Regiment is taken as being organized on the present establishment, except that it has a scale of cranes and forklift trucks as suggested in the previous article. In brief this gives a mobile forklift truck and trailer (see Fig. 1) to each troop, and two similar equipments plus two 3-ton lorry-mounted cranes to each squadron headquarters.

In the Field Park Squadron there are four 7-ton bridging cranes in the plant troop and an appropriate number of 3-ton cranes and of forklift trucks in the other troops. Other engineer units have equivalent scales. Limited numbers of heavier cranes and forklift trucks, and of tracked equipments are available in the usual way as project stores. The full range of post-war equipments has been developed and is in use, though often in conjunction with interim equipment.

Primary planning is based on operations in Europe, but consideration has to be given at all times to operations in other theatres.

Characteristics of the Main Equipments

Before considering the uses of the equipments mentioned above, it is necessary to establish their main characteristics. This presents some difficulty, in that the forklift trucks which have come under study are current commercial machines, and military models developed from them would have improved characteristics, which it is rather hard to assess in advance of experience. It can be said, however, that the machines illustrated, or ones which are being, or could be, immediately developed from them have, or could have, characteristics similar to the ones described below.

1. *The 2-ton mobile forklift truck or "humper"* (Figs. 1–5)

Though called a forklift truck in deference to civilian practice, this machine would be better described as a "mechanical humper." Its functions are to lift and lower, and fetch and carry. It is basically a wheeled tractor about six feet wide and ten feet long, weighing about three tons. In final form it would have a road speed of almost twenty miles per hour. It turns in a radius of 12 ft. and has a good cross country performance, which could be much improved in later models.

For field engineering purposes is has three main fittings, which would always accompany it. Any one of these can be replaced by another in two or three minutes.

(*a*) *The Shovel* (see Fig. 2).—This is a robust scoop of 1 cu. yd. capacity, which combines the functions of a shovel, a bricklayer's hod and a wheel barrow. The shovel can be used to lift a weight of 3,000 lb. from ground level to 9 ft. and can be dumped from any desired height by a trip line worked either from the ground or by the machine operator. The shovel would be used for loading tippers with hardcore, sand or gravel, for handling concrete aggregate or mixed concrete, for removing spoil from excavations, for carrying tools, barbed wire, pickets, mines, and many other types of stores. The shovel could not be used for digging in hard ground. In digging conditions beyond the scope of the tractor the shovel would be loaded by a bulldozer pushing material into it, or by the shovel being offered up against a working face and material being dragged down into it by hand.

(*b*) *The Jib* (see Fig. 3).—This is a simple, robust 5-ft. jib, along which a hook can be moved by hand; 4,000 lb. can be lifted to a height of 11 ft. with the hook 18 in. from the carrier face, 2,000 lb. can be lifted to the same height with the hook at the end of the jib, i.e., at 5 ft. from the carrier face.

(*c*) *The Forks* (see Figs. 4 and 5).—These are normal 3 ft. long forks on which loads of 2 tons at 18 in. from the carrier face can be lifted to a height of 9 ft.

It should be noted that all three fittings work on a mast which can be tilted backwards 10 deg. and forward 3 deg. by hydraulic power. This tilting action, coupled with the movement of the machine and the lifting and lowering of the mast, allows loads to be positioned with surprising accuracy, an important consideration, for example, when an engine is lowered into position, or when a bridging load has to be accurately placed.

Any competent M.T. driver could learn to operate a "humper" in a few hours.

The machine illustrated in Figs. 1–5 is an early form of the 2-ton cross-country forklift truck, made by Mathew Brothers of Wallington, Surrey. Illustrations are not yet available for the latest model.

2. *The 3-ton stores and plant trailer* (Fig. 1)

Matched with the "humper" would be a single axle trailer of 3-ton capacity, designed to carry the humper or other items of plant of similar dimensions and weight (e.g., concrete mixers, compressors, winches, etc.) at normal convoy speeds behind a combat G.S. 3-

tonner. The trailer is also intended for towing by the "humper" itself, or by a bulldozer, or by any other convenient vehicle. The "humper" towing the trailer loaded with tools, stores, fuel and a small working party would be capable of moving long distances over reasonable roads at an average speed of 10–12 m.p.h.

3. *3-ton and 7-ton lorry mounted cranes*

The 3-ton lorry mounted crane in the Field Squadron would weigh about ten tons, have a 20-ft. jib and be somewhat similar to the Coles Mk. VI, Series 2. This machine is reasonably small and inconspicuous and is capable of maintaining normal convoy speeds.

The 7-ton lorry mounted crane, the bridging crane, Coles model 96404, weighs 22 tons and has a 30-ft. jib. It is rather large and conspicuous, and can maintain only plant convoy speeds. With its large capacity and special control system it has a magnificent working performance. It can be operated either fully mobile, or with outrigger jacks in position to give increased capacity.

The performances of the two machines are compared below :—

Radius feet	3-ton crane	7-ton crane	
	Mobile	Mobile	Jacked
8	3 tons	7 tons	7 tons
11	2 tons	5 tons	7 tons
15	1½ tons	3½ tons	6 tons
20	1 ton	2½ tons	4½ tons
25	—	1¾ tons	3½ tons
30	—	1¼ tons	2½ tons

From the above it can be seen that the 3-ton crane, though capable of handling 1½-ton parcels adequately for normal loading and unloading, is rather limited in its capacity for laying out such parcels on a site of work. Owing to limitations of outreach the 3-ton crane cannot handle 3-ton unit loads. With the 7-ton crane, however, all normal parcels can be handled freely, the majority at almost maximum radius, even when the crane is fully mobile. 3-ton unit loads can be handled comfortably. The length of the jib gives adequate coverage of the working area for pile driving, placing pontoons in the water, etc.

The cranes could be used for operating Priestman, dumping, single rope grabs of the following characteristics (see Fig. 8) :—

Capacity of grab, cu. ft. heaped/struck	Weight of grab (cwt.)	Total weight (cwt.)	Safe operating radius		
			3-ton crane	7-ton crane	
			Mobile	Mobile	Jacked
10/8	14	24	12 ft. 6 in.	28 ft. 6 in.	Any
21/17	19½	40½	—	18 ft. 6 in.	28 ft. 6 in.

Based on struck capacities and a $1\frac{1}{2}$-minute operating cycle, it would take 15 minutes to load a 3-cu. yd. tipper using the smaller grab and 15 minutes using the larger one. Fitting the grabs to the cranes involves the re-reeving of the tackle. A skilled operator could fit a grab in about twenty minutes.

4. *2-ton tracked forklift truck*

The only commercial prototype which can in any way be related to this machine at present is the Stockport Manufacturing Co. (1950) Ltd., "Roughrider," Mk. I. This machine is illustrated at Fig. 6 and gives a very good idea of how a 2-ton military machine would look. The Roughrider is only a 1,000-lb. capacity machine, but a 4,000-lb. version has reached the design stage. The Roughrider weighs about 6,000 pounds, has a maximum speed of 8 m.p.h., a ground clearance of 12 in. and a track pressure of under 10 lb./sq. in. It is powered by a standard 22 b.h.p., o.h.v., Austin industrial engine. It is an interesting answer to a school of thought which a couple of years ago was stating that the development of tracked forklift trucks was impracticable.

An important feature of this machine is the special hydraulic clamp device with which it can be fitted in place of forks, and which is particularly suitable for the picking up of packing cases, barrels, and parcels of boxed stores, such as rations or ammunition.

There is no difficulty, therefore, in postulating the development for military purposes in the near future of a 2-ton tracked humper. Such a machine would probably be heavier, slower, and more expensive than the wheeled machine, but would be capable of operating in the same terrain as any tractor on "crawler-tracks."

It is of little value at present to discuss theoretically the relative degrees of cross country performance obtainable in wheeled and tracked forklift trucks, but it is important that commercial prototypes, which have been produced to show what can be done with really large diameter wheels and with tracks, should be tested against each other to establish practical data on this subject.

5. *Miscellaneous characteristics*

A point which must be remembered when comparing the relative performances of cranes and forklift trucks is that safety men are needed to limit the swing of a load suspended from a jib, but that they can be dispensed with for loads carried in a shovel or on forks. In cross country going, however, a suspended load cannot slip off the machine, whereas arrangements may well have to be made for lashing loads carried on forks.

The main advantages of forklift trucks lie in their low cost, simplicity and ease of operation. Their main disadvantages generally follow from the fact that they have to reach the point at which the load has to be picked up or deposited, whereas a crane can make use of its jib.

All mechanical handling plant requires a certain amount of light in which to operate. This can be provided either by local lighting or, if this is not permissible, by the use of movement light from distant searchlights. In these circumstances the slowing up of work would be comparable with that of manual work. Loading and other times given in this paper are estimated for daylight.

Tactical Bridging

In order to illustrate the application of mechanical handling methods in tactical conditions and the advantages to be gained by their adoption, it is proposed to discuss in some detail the building of an ordinary fixed span Bailey bridge, firstly by hand, and secondly with the help of the mechanical appliances and methods described in this and the previous paper.

1. *By hand*.—The Bailey bridge is a supreme example of a military equipment designed for manual handling. The basic handling drill in the assault is well known as follows :—

(*a*) The assembly of equipment before the assault in transport in a suitable marshalling harbour well back from the bridging site.

(*b*) The assault and capture of the site.

(*c*) Detailed reconnaissance.

(*d*) Site clearing, including the removal of mines and debris.

(*e*) The movement of vehicles to the site, and the unloading and laying out of stores. This is often complicated by irregularities in the ground.

(*f*) The building of the bridge, involving the carrying from their laid-out positions of all the stores, and their incorporation into the bridge.

Reflection will show that this procedure is a compromise following from the necessity for saving manual effort on handling the stores and time in the later stages of building the bridge, even at the expense of introducing the extra handling stages inherent in laying out the stores. The main variant to this is to try to avoid the effort of laying out stores by building off transport, but this often leads to other difficulties due to the lack of manpower to offload and build simultaneously, and to the delays involved in marshalling transport during building operations.

The weaknesses in the procedure, practically unavoidable in the last war, may be summarized as follows :—

(*a*) Transport delays and wastages due to the prolonged holding of equipment on wheels. This reaches an extreme whenever building takes place off transport.

Fig. 1.—Mathew Brothers' 2-ton "Matbro" forklift truck towing 3-ton Tasker trailer. Note the built-in stabilizing jacks on the trailer. The front and tail boards are removable, and can be used as ramps.

MEXE photo 7821.

Fig. 2.—2-ton "Matbro" forklift truck fitted with 1-cu. yd. shovel in lieu of forks.

Photo by courtesy of Mathew Brothers.

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Fig. 3.—2-ton "Matbro" forklift truck fitted with crane jib in place of forks.

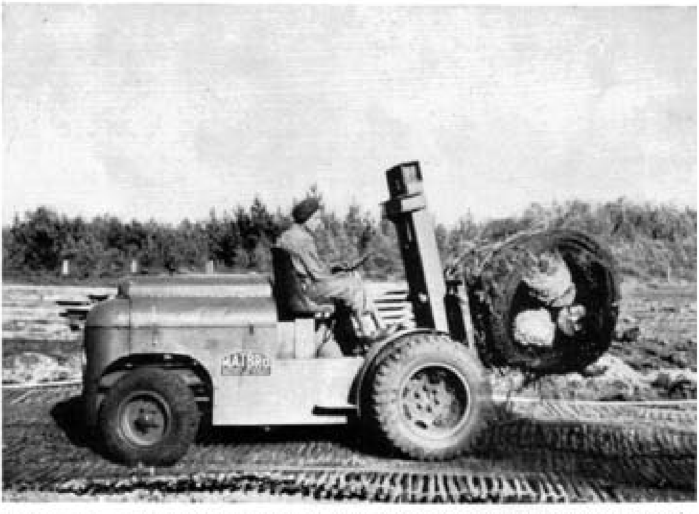

Fig. 4.—2-ton "Matbro" forklift truck carrying barbed wire parcel along a temporary track.

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Fig. 5.—2-ton "Mathro" forklift truck carrying a field-made 6 × 3 ft. 1 ton capacity, tray pallet with removable rail sides. The pallet is loaded with ammunition boxes filled with nails as part of the engineer stores in the Corps Maintenance area for Exercise "Surprise Packet".

Fig. 6.—Stockport Manufacturing Company's 1,000 lb. capacity prototype-tracked forklift truck "Roughrider", with "The Rodman" hydraulic clamp device, holding two cotton bales.

Photo by courtesy of Stockport Manufacturing Co. (1950) Ltd. and Materials Handling Equipment (Great Britain) Ltd.

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Fig. 7.—Clark 6,000-lb. capacity depot type forklift truck with solid tyres loading barbed wire parcel into a covered 3-ton lorry from the rear.

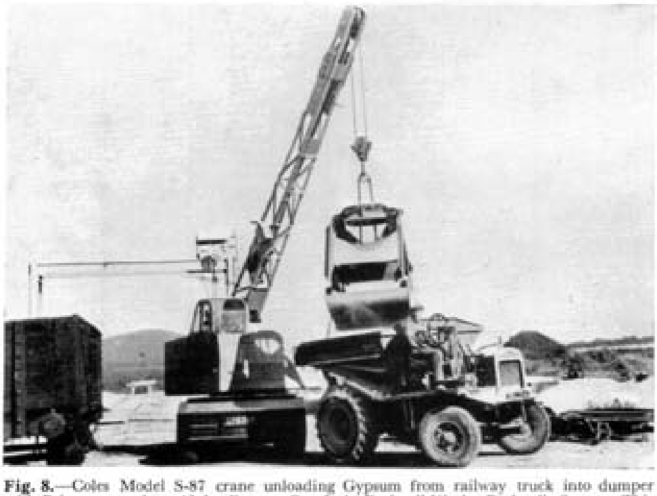

Fig. 8.—Coles Model S-87 crane unloading Gypsum from railway truck into dumper with Priestman grab at Alpha Cement Co., Ltd., Rodmell Works, Rodmell, Sussex. This grab is of a slightly different type from the one discussed in this article, but illustrates the general idea.

Photo by courtesy of Messrs. Steels Ltd., and Alpha Cement Co., Ltd.

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(*b*) The need to bring large numbers of vehicles right on to the site of work, and the consequent attractiveness of the target presented to the enemy.

(*c*) The unproductive work of unloading the stores, laying them out and carrying them to the point of incorporation outweighs the productive work of actually assembling the bridge.

(*d*) Casualties, being more or less proportional to man-hours on a site under fire, are thus largely incurred for unproductive rather than productive work.

2. *With the aid of mechanical appliances and methods*

It was stated previously that the use of mechanical handling methods can lead to two effects ; the reduction of manual effort, and the introduction of extra flexibility in stores deployment, leading to savings of time, space, transport and bloodshed. With Bailey bridge built by hand, limitations of manpower generally meant that the officer in charge of work had little choice in his stores deployment drill. The difference between manual and mechanical handling would be for him very like the difference between dining *table d'hôte* and *à la carte*. He will certainly get a much better meal, provided he understands his menu and goes to the trouble of making a proper choice. To continue the analogy, the stores deployment drill which follows must be treated rather like a menu, and taken in full only if really needed.

(*a*) *Stores Supply.*—As stated in the previous article, stores would arrive in convenient unit loads, either parcelled or, in rather special cases, palletized. Lorries would be without canopies and, if possible, without sides. This would allow the removal of loads from above, either by crane or by the humper jib arm, or from below by the humper forks. Removal from above, i.e., by slinging, gives about 75 per cent saving on manual unloading, and from below, i.e., without slinging, gives about 85 to 90 per cent saving.

(*b*) *The Transport Terminus.*—Transport would not necessarily go to the bridge site at all, but would frequently be unloaded at a transport terminus some distance away. The aim would be to effect early, safe and convenient unloading of the transport, possibly before H hour, but certainly as soon as possible thereafter. The transport terminus would normally have good road access, hard standings and cover from the air. It might well be dispersed over a wide area.

(*c*) *The Transport Terminus Dump.*—On being unloaded mechanically at the transport terminus, stores would be dumped ready for mechanical reloading.

(*d*) *The Local Transport Link.*—A local transport link, appropriate to site conditions, would be operated forward from the transport terminus dump. Such a link might be operated by humper, trailer or sledge. The humper, travelling laden at 5 m.p.h. and unladen at

15 m.p.h. would have a turn-round time of about five minutes over a quarter of a mile. Thus, with an average load of 1 ton, it could deliver about twelve tons per hour over such a distance. This would be quite adequate for Bailey bridging, remembering that stores could be accumulated while reconnaissances were being carried out, and bank-seats and roller positions prepared. It might be necessary sometimes to lay temporary track to allow humpers to move over particularly bad ground. In such cases the capabilities of the humper could be exploited to the full for making its own track.

Where ground conditions were very bad, sledges could be used. Such sledges would be similar to those used for the close support raft, but would be designed in accordance with the general mechanical handling scheme. The size and capacity of the sledges would be the same as that of a 3-ton lorry. They could be pulled either singly or in tandem by a bulldozer or other tracked vehicle. A humper would be the first load ; the link could then be worked by three operators, one at each end on humpers and one on the sledge tractor, helped by two or three other men. At towing speeds of 3 m.p.h. laden and 6 m.p.h. empty, and with loading and unloading times of 5 min. each, turn-round time over a quarter of a mile would be 17½ min., giving, as before, a delivery rate of about ten tons an hour. By using additional sledges the capacity could be increased to about twenty-five tons per hour, when the loading and unloading capacities of the humpers would be reached.

The efficiency of the system depends entirely on the rapid loading and unloading of the sledges by mechanical means. It should be particularly noted that only one sledge and one tractor would be required to maintain the stores flow to an average bridging site over a quarter of a mile of bad ground.

The details of the use of the stores trailer over such a link are sufficiently obvious not to require discussion in detail.

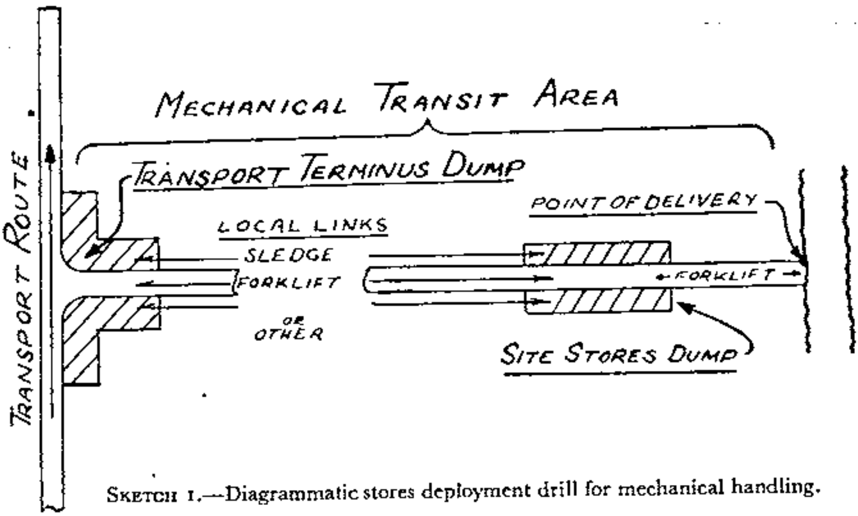
(*e*) *The Site Stores Dump.*—As in the case of bridging by hand, it would be necessary to have a site stores dump, for equipment waiting to be incorporated into the bridge. In contrast, however, this dump would not normally be on each side of the bridge centre line, but would be along the road running back from the bridge.

(*f*) *The Point of Delivery or Incorporation.*—The last stage in moving the stores would be for a humper to pick up the unit loads from the site stores dump and deliver them as required to the building party. The point of delivery would mark the end of the non-productive "handling" process and the beginning of the productive "incorporation" process. One humper would be able to keep a large number of building parties supplied. No building party would have to carry stores more than a few yards.

The flexibility, power and efficiency of this mechanical drill in comparison with the manual one can be appreciated. It is suggested that about 50 per cent of the man-hours required to build a Bailey bridge could be saved by the use of the methods suggested above. About 30 per cent of transport could also be saved, partly due to increased speeds of loading and unloading at dumps and on the site, but more owing to the earlier unloading made possible by the introduction of the extra handling stage at the transport terminus.

In particular it should be noted how a small, mechanically equipped party, comparable in size with an engineer reconnaissance party, could carry out the tedious and time-consuming processes of stores deployment independently of the movements of the main working parties. The advantages which would follow will be seen in the next section of this paper.

This stores deployment drill is shown diagrammatically in the following sketch :—



SKETCH 1.—Diagrammatic stores deployment drill for mechanical handling.

MECHANICAL HANDLING IN WITHDRAWAL AND DEFENCE

Mechanical handling can play an important part in many aspects of engineer work connected with defence or withdrawal, in particular in mine-laying, the handling of barbed wire and other defence stores, and in the construction of concrete field defences and shelters. The first two will be considered in turn, and will be followed by a general discussion on the tactical implications of mechanical handling in the withdrawal. The question of concrete will be dealt with in a separate section.

1. *Mine-laying.*—The tonnages of mines liable to be used in defence or withdrawal are considerable, and they often have to be handled by tired men over difficult ground. The tendency, therefore, is to

insist that mines should remain in the lorries in which they are delivered until they reach as nearly as possible the point at which they are to be laid. There is, however, still considerable effort in unloading and carrying the mines. There is also much transport wastage due to lorries being held full, instead of being unloaded and sent back immediately for more stores. The stores deployment drill described above for Bailey bridging can obviously also be followed for mines. Lorries having been unloaded mechanically at a transport terminus, could be released at the earliest possible moment, and the mines, in convenient unit loads, could be distributed forward by appropriate local links. In this connexion the use of the humper shovel for carrying mines should be noted again.

2. *Barbed Wire and Defence Stores.*—Barbed wire, particularly if used in conjunction with anti-tank and anti-personnel mines, is an extremely effective obstacle in the defence. Cat wire fences are quick to erect, and obstacles consisting of two rows of cat wire fence with loose wire in between are probably the most effective type. Barbed wire, particularly dannert, is very bulky and is extremely nasty to handle. As was shown in the previous article, approximately equal quantities of dannert and ordinary barbed wire can be combined in cylindrical parcels, which are very convenient for handling by crane or forklift truck (see Figs. 4 and 7). These cylinders can readily be rolled out of a lorry at the delivery point. Other defence stores such as pickets, corrugated iron and timber can also be parcelled and handled mechanically. It must be remembered that, with the increasing use of proximity fuses, the demands for such types of stores will substantially increase. This will impose an additional load on engineer stores channels, and it is of the greatest importance to the Corps to stimulate the interest of the infantry and of other arms and services in this type of loading. A strong case can be made out, though it will not be discussed here, for the holding of humpers in pioneer platoons in infantry battalions, in gunner batteries, and in certain other units. The handling of parcelled defence stores would then be part of the duties of these machines ; any users who had no mechanical aids available could easily cut the tapes of the parcels and handle the stores loose.

3. *The tactical implications of mechanical handling methods in the withdrawal.*—Stores, transport, manpower, time, are all major factors which tend to go wrong in a withdrawal. As mechanical handling is concerned with all these, it is of interest to consider what its main influences might be on this, the most difficult of all types of military operations, conducted in the conditions laid down in recent War Office exercises.

In withdrawing in the face of substantial ground and air superiority, the main engineer problems would be the preparation and firing of demolitions, the laying of minefields, the destruction of road and rail communications and of airfields, and the preparation of defensive positions. In addition, a major problem which might arise would be that of bridging in order to keep open withdrawal routes. This would require a continuous allocation and movement of stores, which might never be used. In addition there would be the problem of moving back other valuable engineer stores which might be required in the later stages of the withdrawal.

Demolitions and general destruction require a wide deployment of engineer resources of all kinds, but are not particularly suitable for receiving help from mechanical handling methods. The big withdrawal problem, however, is the preparation of minefields and defensive positions in rearward areas, while carrying out demolitions, or fighting in, or moving from, forward ones. Here mechanical handling methods can play a vital part. It was shown above that a small mechanical handling party, little more than an engineer reconnaissance party in strength, could operate a transport terminus and receive and lay out stores down to the point of delivery or incorporation, a process which by present methods takes a very substantial amount of the time and effort required for the work. It is suggested that composite, all arms, reconnaissance parties from a withdrawing formation, supported by suitable mechanical handling elements could undertake work of immense value in the preparation of a formation defensive position. Defence stores, ammunition and mines could be accepted and laid out in defended localities long before the formation arrived. When the fighting troops reached the position, the work remaining to be done would be merely the digging of individual weapon pits, the erection of wire, and the digging in of mines. A tremendous amount of work of this nature can be done even in 24 hours, if the stores are already laid out ready for use, but little can be done in that time, except to dig weapon pits, if the process of receiving and distributing stores (almost certainly from quite inadequate transport) cannot start until the fighting troops have reached the position. Napoleon said to his Marshals "Ask of me anything but time"; in a withdrawal, when time is all important, it is time that mechanical handling can give to anyone who cares to use it.

The other big use for mechanical handling equipment in withdrawal is against the unknown bridging problem. It could be used economically to keep bridging equipment readily available without having to keep it "on wheels," and with its aid sudden bridging tasks could be tackled without having to divert large numbers of sappers urgently needed for work on demolition and destruction.

The great contribution which mechanical handling methods could make towards the moving back of all kinds of stores dumps during the withdrawal is outside the scope of this paper.

Cement and Concrete

1. *Cement.*—Cement requirements in any future war are liable to be much higher than in the past. This will be due partly to the extended use of concrete for field defences and shelters, but much more to the development of soil stabilization methods based on the use of cement. Three to four thousand tons of cement would be required for each stabilized fighter strip, and the rate of incorporation of this cement would be high. It would be uneconomic and impracticable to attempt to handle such quantities of cement in bags by manual means. One solution would be the development of a returnable cement container of gross weight 1½ tons, designed for handling by crane or forklift truck on the same principles as normal 1½-ton parcels. Such a container could be designed with a removable lid so that lids and bodies could be nested when being returned empty.

2. *Concrete.*—Much special plant has been evolved for the mixing and laying of concrete, and there is no doubt that such plant is most efficient. The object of this section is not to suggest improvements to such plant, but to show how the general run of mechanical handling equipment, which it is proposed should be used in the field, can be applied to the same end.

The standard field handling level of 1½ tons suggests that the standard batch of concrete in the field should be 20 cu. ft. mixed, with a net weight of 3,000 lb. and a gross weight in a standard container of about 1½ tons. This is supported by the fact that the standard mixing cycle of 1½ to 2 minutes is comparable to the turn-round cycles of cranes and forklift trucks over short distances. Thus the standard concrete mixer should be of 28/20 capacity, as opposed to the 14/10 and 10/7 which have been standard military sizes since the 1914–18 war. Such mixers would be transportable in the third mechanical level, i.e., within the weights and ruling dimensions of the 3-ton class. They would be capable of being lifted by the 7-ton crane, travelling on the 3-ton stores and plant trailer, on the standard 3-ton sledge and on the 3-ton pallet/cargo board.

Two auxiliary equipments would be required, both of which could be theatre produced from standard designs. The first would be a simple aggregate hopper designed to be readily transportable within the 1½ ton level. This could be filled easily either by a crane with a grab, or by a forklift truck with shovel fitting. It would discharge through a hand-operated bottom gate into a measuring box, which could be swung and discharged into the loading hopper of the mixer. Two such aggregate hoppers would be required, one for coarse aggregate and one for sand. Cement from a standard 1½-ton container placed on a platform near the mixer would also be discharged through a measuring box into the mixer loading hopper.

Thus on the " dry " side of the mixer there would be one operator with a crane or a humper plus two men working the gates of the hoppers.

On the " wet " side the concrete would be handled in complete batches, either in the humper shovel, or in a special container (the second of the auxiliary equipments referred to above) which would be similar to the tipping buckets commonly seen on engineering works, but which would be designed for handling by crane or fork-lift truck on the same principles as the standard 1½-ton parcels or pallets. Thus the handling of the wet concrete would follow the processes discussed in detail for the supply of stores for bridging, and the placing of it would be by direct discharge from a container carried either on the forks of a forklift truck or on the hook of the 3-ton or 7-ton crane. The jib length and capacity of the latter crane is of particular importance in the placing of concrete.

Thus in straightforward cases the mixing and placing of concrete at a rate of 40 tons an hour could be carried out by a mechanical team of two humpers and one 28/20 mixer, requiring three operators and perhaps three or four other men, none of whom would be working at all hard. This is in sharp contrast to the manpower and physical effort required to produce similar outputs by time-honoured methods from 10/7 or even 14/10 machines.

Mechanical handling also has important applications to the movement of reinforcing and formwork. Providing due thought is given to it in initial design, mechanical handling methods will allow the preassembly of comparatively large reinforcing units and also the use of large units of prefabricated shuttering, perhaps up to a ton or more in weight. Such methods in conjunction with the rapid excavations possible by the use of modern mechanical earth-moving equipment, would allow the rapid construction of simple reinforced concrete shelters in the field.

General Engineering Work

It is clear from the wide range covered by the previous examples that mechanical handling methods have applications to the whole range of general engineering work, including hutting, transportation construction, P.O.L. installations and the handling of P.S.P. for airfields. Transport turn-round can be speeded up everywhere, and labour can be saved on the unloading and laying out of stores. Incoming small stores, such as bricks, concrete blocks, sanitary fittings and glass can be palletized for local handling. Box pallets and the humper shovel can replace wheelbarrows and the brick-layers hod. Hutting sections, corrugated iron and structural steel can be handled parcel loaded. The ability to handle stores locally with the minimum effort allows them to be kept well clear of the working area until required, and then delivered mechanically right up to the point of incorporation. In addition, cranes can be used for the erection of roof trusses of large huts, and forklift trucks for those of small ones.

Engineer Workshops and Productive Installations

There is ample scope here for the application of mechanical handling methods for dealing with incoming raw materials, for internal handling, and for dispatching outgoing products. Thus in a Workshop and Park unit making field structures, timber might be received parcelled from an Engineer Stores Base Depot into which it had been fed, parcelled from a sawmill. The components of the structures might be handled on tray pallets or in box pallets between the various productive processes. Completed units could be taken to a parcel assembly line, parcelled and then mechanically handled into store. Similar methods could be applied in a jerrican factory. Obviously, careful consideration would have to be given to each case, and in certain conditions it might be worth while installing specialized handling equipments in the same way as in permanent civil factories. It is suggested, however, that in the majority of cases adequately efficient material handling systems could be evolved for any type of engineer workshop or installation by the use of the equipments and methods discussed in this and the previous article.

Beaches, Docks, Depots and Air Terminals

The principles developed and discussed in this article will apply fully to the handling of stores over beaches, and at docks, depots and air terminals. The processes may be stated very briefly, and in general terms, as follows :—

1. The incoming stores carrier, whether ship, landing craft, railway truck, lorry or aircraft would contain stores either skid parcelled, parcelled, palletized or loose loaded. The transport terminus might be a beach, quayside, airfield, platform or landing zone.

2. The first priority would be to unload and release the long-distance stores carrier. The second to convert loose loaded stores into convenient unit loads for local handling, either by parcelling them, or by loading into box pallets on to tray pallets, or on to pallet/cargo boards.

3. The next stage would be the transfer of the stores to the main local stores dumps by means of local stores carriers, which might be lorries, forklift trucks, sledges, light railway trucks, or other appliances. In special cases, such as the unloading of landing craft, the local links, whether by sledge or other means, would operate either right into the landing craft or to the edge of its ramp, with a humper working in the landing craft to load the parcels or palletized stores on to the local stores carriers. The exception to this would be

skid-parcelled loads, which would simply need to be towed up the beach.

The handling out of stores from such areas would in principle be the reverse of handling in.

An exercise of the imagination, which is left to the reader, is to apply the above principles to the design and operation of an Engineer Stores Base Depot, and to consider the modifications which might be made to the current design of this installation.

Transport Savings due to Reduced Turn-round Time

It has been stated throughout this article that considerable transport savings can be made by reducing transport turn-round time. This can be done both by increasing the speed of loading and unloading and by advancing the time at which unloading and release takes place. The following table has been prepared to give some idea of the kind of savings that follow from increased speeds of loading and unloading. It deals with two cases, 3-ton lorries travelling singly, and R.A.S.C. platoons travelling in convoy. Speeds in each case are taken as 25 miles in 2 hours, but it is assumed for the R.A.S.C. platoon (of thirty lorries) that only five loading and unloading points are available, so that six lorries have to be loaded or unloaded in sequence at each point. The mechanical loading time is taken as 5 min. per lorry, the manual loading time as 30 min. Unloading times are taken as 5 and 20 min. respectively.

	Single Vehicles								R.A.S.C. Platoon			
	Manual				Mechanical				Manual		Mechanical	
Miles	1	5	25	50	1	5	25	50	25	50	25	50
Loading time	30	30	30	30	5	5	5	5	180	180	30	30
Travelling time	5	20	100	220	5	20	100	220	100	220	100	220
Unloading time	20	20	20	20	5	5	5	5	120	120	30	30
Returning time	5	20	100	220	5	20	100	220	100	220	100	220
Total time	60	90	250	490	20	50	210	450	500	740	260	500

In practice, loading and unloading times may vary considerably from those in the table, and the figures must obviously be treated with great caution. They do indicate, however, that substantial savings in transport time can be made, particularly in two cases:—

(*a*) When single vehicles are running over short distances.

(*b*) When loading and unloading delays are multiplied by the necessity for handling vehicles in convoys.

It is suggested that the three important savings in vehicles which can follow from the proper development of mechanical handling methods, viz. increased speed of turn-round as shown in the table above, earlier release owing to the general use of more flexible stores deployment drills, and the general reduction of the necessity to hold stores "on wheels," would go far towards "making" enough transport to bridge the gap between the stores tonnage figures of the last war and those of the future. This aspect of mechanical handling is not very well appreciated, and yet in it alone, without any consideration of manpower savings, may lie enough economy to justify the general introduction of mechanical handling methods.

Tipper Loading

In war, immense quantities of rubble, gravel, hardcore, ashes, sand and other low-grade locally available materials have to be supplied for making roads, hard standings, airfields (in areas where soil stabilization will not work, or where equipment is not available) and for general concreting work. Such material is handled in tippers. The importance of tippers has been so well recognized in post-war planning that they have been put on the establishments of even the smaller working units in the Corps. The main requirements for efficient tipper operation are short loading, waiting and running times. Mechanical loading reduces loading time, but the reduction of waiting and running times can follow only from the wide dispersion of mechanical loading devices; central loading, with tippers from a wide area working to one point, invariably leads to long queues and excessive time spent by tippers in travelling over congested roads. Roadwork is always ready to absorb whatever engineer effort is left over from other activities. Thus the ability to turn the mechanical handling aids, which are primarily intended for the handling of parcelled bridging stores, defence stores and other engineer equipment, to the handling of low-grade bulk materials is a particularly important factor in the general economics of the scheme.

With the equipment postulated in this paper it will be possible to load a tipper with hardcore, sand or gravel by 3-ton crane or by humper in 15 min., and by the 7-ton crane in 10 min. Over a 1-mile haul, with 15-min. loading, a tipper can make about two trips per hour. If the haul is increased to 5 miles, even if the loading time is reduced to 10 min., the tipper will only make one trip per hour. In view of the wide availability of suitable materials in the European theatre, and the great distances over which engineer troops get extended for road and other similar work, there is no doubt that increases in tipper haulage capacity in the order of a 100 per cent can be obtained by making mechanical loading generally available within the smallest sub-units.

Summary

The conclusions reached in this article so far may be summarized as follows :—

1. The manual handling of stores, though it will never lose its value, particularly for emergency use, represents a complete dead end in development.

2. Mechanical handling gives a new basis from which to start development, bearing in mind that the machine is capable of continual development, while man is not.

3. Field and other engineering methods based on manual handling should, therefore, be regarded only as secondary methods, of great value in certain conditions, but to be subordinated in general planning to new methods in which the machine replaces the man.

4. Mechanical stores handling is an essential corollary to mechanical methods of using and transporting stores.

5. Mechanical handling not only saves labour, but introduces a new flexibility in stores deployment drill, and leads to important methods of saving time and transport.

6. These savings come partly from the direct application of mechanical power, and partly from the ability, resulting from mechanical handling, to change readily from one form of transport to another.

7. Labour is saved not only in the loading and unloading of stores, but also in their delivery by mechanical means to the actual points of incorporation.

8. The small size of mechanical handling teams allows them to operate well ahead of the main working parties, a very important factor in tasks such as the preparation of defensive positions in the withdrawal.

9. The proposed simple mechanical handling methods not only have wide application to every main aspect of engineering work in the field, but have equally wide applications to other service stores handling problems.

10. The savings in manpower, time and transport which can be achieved by the use of mechanical handling methods will go far towards balancing the increased demands arising from the increased scale of future military engineering work.

Conclusion

In this article an attempt has been made to show how the general principles of mechanical handling discussed in the Author's previous paper, can be applied to engineer work in the field. What emerges is the fact that many current methods of military engineering, based on superficially simple uses of labour, transport and time, are in fact wasteful, and are no longer adequate for the problems which lie before the Corps. It can be seen, too, that mechanical handling is not some obscure function of "stores," but a vital factor which can permeate and enliven every aspect of engineering. Practical new methods are available by which mechanical power can be made not only to undertake innumerable material handling tasks formerly carried out by men, but also to contribute substantially to the "making" of transport and time. Such methods, though simple, cannot be readily improvised when the need for them is seen to be critical. They require careful planning and development, not so much in the experimental establishments of the Ministry of Supply, but in the minds and institutions of the military engineers who may have to use them in the field.

To fail to give due emphasis to this type of development will lead inevitably to the construction of a military body with magnificent limbs, but with a heart incapable of sustaining their proper actions under the stresses of war.

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CYCLONE IN BOMBAY

November 21st–22nd, 1948

By Major D. V. Deane, C.I.E., O.B.E., R.E. (Retd.)

"CHOTA Hazri, Sahib."

I opened my eyes to find that it was 6.30 a.m. on Sunday morning, and that Rahmat Khan, my faithful servant for over twenty years, had arrived with my morning tea.

I had arranged for a pleasant day's entertainment this Sunday, starting with a golf four-ball at Chembur, some seventeen miles distant from my house near Ballard Pier, to be followed by lunch and an afternoon siesta with friends who lived in Pali Hill, a residential suburb of Bombay, in the same general direction as Chembur. In the evening we proposed to play bridge till dinner-time, after which I would drive back to Bombay, and so to bed.

The day started much as any other November Sunday. A cool early morning breeze was blowing, perhaps a little fresher than usual, with that slight tang in it which presages the arrival of the so-called cold weather in Bombay. There had been reports in the press for the last day or two of a cyclone, which was steering a variable course a few hundred miles out to sea, but it was anticipated that this would pass well to the north of Bombay, and, apart from mild anxiety on the part of those who were expecting friends and relations to arrive shortly on an incoming liner, which might be delayed by the cyclone, no general interest was evinced over this news.

Cyclonic storms are by no means unknown in Bombay. There had been two in the previous six years, each of which resulted in the loss of some country craft, the uprooting of some of the less sturdy trees, and a certain amount of damage to the flimsier buildings in the city and its suburbs. No storm in living memory had caused greater damage than this, and thus the possibility of anything more serious on this occasion, should the cyclone decide to visit Bombay, was considered so unlikely as to be ignored. Certain advance precautions were taken, however, such as the issue of a warning signal to country craft, and the removal of the yachts belonging to members of the Royal Bombay Yacht Club, to safer anchorages.

Having arrived at Chembur, the wind was noticeably stronger. It was no more than a strong breeze, which rendered our round of golf all the pleasanter by keeping us cool and dry throughout the morning, and by necessitating some extra care in the playing of individual shots. In due course the game finished, a few rupees changed hands, and, as in the near-dry Province of Bombay the local Government has decreed that no alcoholic refreshment may be served in public places on Sundays, we wasted no time at the nineteenth hole, but departed to our respective destinations in search of iced beer.

Two hours later, pleasantly replete with my host's solid and liquid hospitality, I retired to my bedroom for a siesta before tea. It had developed into a gusty, blustery afternoon, and the sky was starting to cloud over. Somebody remarked that the weather had become more like a moonsoon day in July than a tranquil November day, but no real interest had yet been shown in the gradually deteriorating conditions.

By tea-time the wind was blowing still more strongly and the sky was entirely overcast. We settled ourselves down to bridge on my host's enclosed verandah, the windows of which shortly had to be shut, in order to prevent the cards from being blown off the table. At six o'clock, the rain started, fitfully at first, but gradually increasing until it reached a rate only equalled by the worst monsoon storms.

And all the time the force of the wind grew greater, until the first doubts began to assail me regarding the wisdom of setting forth under these conditions on the seventeen-mile drive back to my house. Shortly afterwards, at dinner, my host and hostess voiced the same doubts, and suggested that I should stay the night with them, and return home the next morning. I little knew that had I agreed to accept their hospitality, it would have been for a considerably longer period than one night.

In the end, I decided to start home, on the understanding that if I was unable to get through, due to fallen trees or other obstructions, I would return to Pali Hill for the night.

I had only recently returned from four months' home leave and had not as yet found any necessity to use the wind-screen wipers on my car. In the infuriating way that the appliances have, they proved to be out of order, and so, all through that slow and uncomfortable drive, I had to operate the wipers by hand almost continuously in order to clear the streaming rain from the windscreen. The drive itself proved to be uneventful, with no more dangerous obstructions en route than a few large palm fronds or small branches of trees. But the night had become wild indeed, with the wind at gale force and frequent rain-squalls of such intensity that visibility was reduced to a few yards.

Arrived safely home, I garaged the car, and then, becoming aware of an unusual noise above that of the wind, I mounted the steps by the sea wall which runs along one side of my garden. Here I should explain that my house stands on the main road which leads to Ballard Pier, so well known to all visitors to Bombay by sea, and only some 400 yards west of the mole against which the large liners are docked. This road is bounded by a sea wall along part of its length, until it reaches my garden wall, which itself flanks the sea at right angles to the roadway. Thus the mole of Ballard Pier, the main road leading to it, and my garden wall with its continuation beyond, form three sides of a shallow rectangle in which is contained a small and normally secluded backwater of Bombay Harbour. It is open to the sea only from the south-east, and it was from this direction that the wind was blowing on this dramatic night. The far side of the road to Ballard Pier is lined with large modern buildings, including the new Customs House and the Port Trust offices.

Having mounted the sea wall in my garden, in comparative calm due to the shelter from the wind which was afforded by the buildings to the south of where I stood, I was confronted by a very angry sea, roaring and snarling even though the tide was low, and a strip of sand was visible below me. There was also visible, immediately beneath me, and grounded in the sand, a large and completely deserted motor launch. It was clear that when the tide rose, this launch would inevitably be battered to pieces against the Ballard Road sea wall, only fifty yards away, but there was nothing that could be done about it at that hour of the night under the prevailing weather conditions, so I left it to its fate, and retired to bed.

My bedroom is air-conditioned, and possesses only one window, which is fitted with double glass panes for purposes of insulation. It is thus normally almost sound proof, but in spite of this I was awakened about two hours later by an unusual and persistent noise. I arose and went into my bathroom to investigate. The bathroom window, which was open, faces across the small harbour inlet, which I have already described, towards Ballard Pier. By the aid of the powerful electric lights along the mole, and of the street lights on Ballard Road, I was confronted with a truly awe-inspiring sight. The normally placid backwater in front of me had become a raging inferno, with great waves sweeping in towards the Ballard Road sea wall, aided by wind and tide. The tops of the waves were being whipped off so continuously by the strength of the wind as to give the impression that the entire surface of the sea was being swept away. This impression was strengthened by the driving sheets of rain, which were now travelling almost horizontally. The combined noise of wind, sea and rain was so powerful as to produce a continuous loud roar, of such intensity that it had penetrated into the peaceful atmosphere of my bedroom, and had thus aroused me.

This was undoubtedly a sight which is seldom to be witnessed under such civilized and comfortable conditions. I went back to my bedroom, where I collected a dressing-gown and a tin of cigarettes, and then returned to the bathroom, seated myself by the window, and started to examine the view more closely.

The tide was then at half-flood, and the waves were beginning to break over the Ballard Road sea wall on to the roadway beyond, and occasionally, on the rebound, to come over my garden wall also. The motor launch had already vanished, and it was evident from the mass of wreckage which was being battered against the sea wall by the relentless waves that it was not alone in its fate, as several other smaller craft must already have been destroyed in a similar manner.

Beyond Ballard Pier, in the main section of the harbour, several large cargo ships were anchored, awaiting admission to the docks. These were using their searchlights to scan the boiling waters, in order to locate any smaller craft which were still seeking shelter from the storm. Occasionally one of these small vessels would be illuminated in the beam of a searchlight, dimly visible through the driving rain and spray, alternately poised on the crest of a wave and then vanishing from sight completely in the following trough. The full reports of the loss of these small craft, which gradually became available in the days that followed, revealed the tragically large number that failed to survive the storm.

By 3 a.m., the spectacle was at its height. The wind was at hurricane force, green seas were pouring over the Ballard Road sea wall, and the main road beyond was knee deep in water, which dispersed itself along the subsidiary roads of Ballard Estate, and caused this section of Bombay to resemble a system of wreckage-strewn canals. The spray from the sea was being whipped over the roof of the Customs House, 80 ft. above road level, and the noise had become almost deafening.

At this moment, a large three-masted schooner, under bare poles and completely out of control, suddenly came in view fifty yards beyond my garden wall, drifting broadside on towards the Ballard Road sea wall. I watched it, fascinated, and when it was directly opposite my window, I saw to my horror that the crew were still aboard, clinging to the masts, and their cries for help could be heard even above the noise of the storm. It was evident that within a few minutes this large vessel would be pounded to pieces on the sloping side of the Ballard Road wall, and it was equally evident that some form of immediate assistance, in order to rescue the crew, was essential.

A friend of mine and his wife were staying in the house, and I entered their room, to find them both wide awake—indeed it was impossible to sleep at all that night, due to the roar of the wind and the sea. I rapidly explained the situation, and it was decided that my friend and I would dress and get down to the Ballard Road sea wall as quickly as possible, and meanwhile his wife would prepare hot drinks and baths in readiness for our return with any survivors from the ship.

Within a minute or two we had attired ourselves in shorts, shirts and mackintoshes, and a final glance at the ship before we set forth into the wind and rain revealed that she was just about to reach the sea wall, broadside on.

The distance from the front porch of the house to that part of the sea wall against which the schooner was lying was less than 100 yards, but the difficulty of fighting our way there in driving rain and spray against the force of the wind, along a road which was several inches under water and covered with debris, was such that it required perhaps four minutes for us to arrive there. Our first glance over the parapet wall showed that we were already too late. The schooner had completely disintegrated after having been lifted up bodily once or twice, and then hurled against the slope of the sea wall. All that remained was a tangled mass of masts, spars and wreckage floating in the sea.

A search of the immediate vicinity revealed a number of half-drowned and half-crazy survivors, who had been swept over the sea wall by successive waves after their ship had foundered. Most of them were too overwhelmed by their recent calamity to be capable of coherent speech, but we collected them together and asked the only man who had retained his senses to let us know how many of his companions were still missing. The reply was better than we had feared, as only two of the crew were not present. We attempted, between waves, to return to the parapet wall in the faint hope that we might be able to locate and rescue the two remaining men from the boiling seas on the other side of the wall, but it quickly became evident how impossible a task this would be. Furthermore, by then the wreckage of the schooner was being washed over the parapet wall and it was dangerous to remain in that area at all, with large baulks of timber being flung into the air and landing on the roadway beyond. It was also apparent that no human being could have survived in those seas for more than a few seconds, before being pulverized against the sea wall.

We therefore regretfully abandoned any further attempts at rescue work and returned to the survivors, whom we endeavoured to persuade to return to the house with us for hot drinks and dry clothes. But they were determined to remain where they were, apparently in the hope of salvaging any of their belongings which might still be washed ashore. Accordingly we left them, and made our way back to the house, where, after hot baths, we tried to get some sleep before dawn arrived.

It was by then 5 a.m., and at 5.45 a.m. all electric power in Bombay suddenly failed. The household arose early, red-eyed and sleepless, to find that the storm was raging as furiously as ever, and the view on all sides was one of damage and desolation. The roads were blocked by fallen trees, tiles had been ripped from sections of the roofs of near-by buildings, window panes were shattered and wreckage and debris were strewn in large quantities over every thoroughfare in sight. The sea beyond my garden wall was now covered with floating wreckage, as well as the large quantities that had been washed over the sea wall on to the road beyond.

We sat down to breakfast at 8 a.m., at which time the wind suddenly veered towards the west, and shortly afterwards reached its maximum intensity, gusts of nearly 100 m.p.h. being recorded in the more exposed areas around Bombay. This unexpected flank attack proved too much for thousands of trees in the city, which had hitherto weathered the storm, and one after another they succumbed, bringing down with them telegraph and telephone wires and overhead tramway cables. At this time my house suffered its first and only injury, due to a large tree falling across a section of the roof. This caused a large number of broken tiles, which in turn allowed the rain to penetrate freely into the rooms below.

By 10 a.m. the worst fury of the cyclone started to subside and by lunch-time the wind had decreased to occasional strong gusts, rendering it safe to move around the streets again. An inspection of the sea beyond my garden revealed the wreckage of at least fifteen craft of all sizes, from the large schooner, whose death throes I had witnessed, down to country craft and rowing boats. A beautiful yacht, belonging to the Commodore of the Royal Bombay Yacht Club, had a miraculous escape in this area. Having broken loose from the supposedly safe spot in which it had been secured the previous day with double moorings, it was blown during the night into the backwater of the harbour by my ouse, but instead of arriving at the western end of this backwater, where it must have been battered to pieces against the sloping sea wall, it reached the eastern end—only 300 yards away—and there landed up against a Port Trust tug which was safely moored to the vertical wall at this point. The crew of the tug secured the yacht, and its anxious owner, having located it early the next morning, whilst the storm was still at its height, somehow obtained a portable crane, and lifted his yacht bodily out of the sea on to the safety of dry land.

By tea-time, the wind had dropped entirely and I decided to set forth in my car to obtain an impression of the damage to the city before the work of clearing the debris had got under way.

Progress was difficult, as many roads were blocked, and frequent detours had to be made. The outstanding impression that I received after a two-hour tour was of the tragic amount of damage to the trees in the city, many of which were of flowering varieties and were one of Bombay's major attractions. In various principal thoroughfares, which were formerly shady avenues, hardly a tree remained standing. Subsequent estimates placed the total loss of trees in Bombay city alone at between 3,000 and 6,000.

Buildings had suffered damage in proportion to the robustness of their construction. Many *kaccha* houses and sheds had been flattened, and others had lost their roofs, but broken windows and patches of missing tiles were to be seen everywhere. One of the most spectacular sights was the sea wall on Apollo Bunder which stretches from the Gateway of India towards the well-known Taj Mahal Hotel. This exposed section had felt the full fury of the storm, and the sea had wrenched the large granite blocks of the wall—weighing perhaps a quarter of a ton each—from their beds, and thrown them indiscriminately on to the roadway beyond. The tables, chairs, benches and other outdoor equipment from the Radio Club were found in a shattered condition outside the Yacht Club premises, more than a quarter of a mile away, and the beautiful lawns of the Radio Club had been sadly damaged by sea water. At Chowpatti, where is the only open stretch of sand in Bombay, the roadway flanking the beach had vanished from sight under several inches of sand and shingle.

For two days, Bombay remained completely isolated from the rest of India. Road, rail and air communications had ceased to function, and all telegraph and telephone wires were severed. For this same period no electricity in any form was available, which therefore meant no newspapers, radio, cinemas, ice, or street lights, apart from the inconvenience caused domestically by no lights or fans. All factories were closed, and business was at a standstill. Due to the stoppage of trains, no fresh food supplies were available, and stocks of refrigerated foods were in danger of becoming unfit for consumption due to the failure of electric power. The price of candles rose rapidly to one rupee each (1s. 6d.) as these were the only source of illumination in most houses. Tramway services were suspended, and the few buses which plied had to travel by circuitous routes. Police and military patrolled the dark roads by night, with orders to shoot at sight any looters.

By dint of superhuman and continuous efforts on the part of the electric supply company, power was restored to one of the five high-tension feeders which supply Bombay with electricity, within forty-eight hours. This enabled the supply of electricity for domestic purposes to be resumed, with a small surplus which was allotted to the railways, in order to allow essential traffic to proceed and fresh food supplies to be brought to the city. The work of restoring Bombay to normal was started rapidly and efficiently by the civil authorities, with military assistance, and within two days most of the roads were cleared for traffic. Current was restored to a second feeder within a week, which enabled most factories to reopen, provided that they did not exceed a limited power load. After a fortnight, conditions were almost normal again, although the damage to one of the main generating stations was such that several months would elapse before unrestricted electric power could again be made available.

So ended the second most dramatic event in Bombay's history during living memory. The other great catastrophe was the tremendous explosion in the docks in 1944, when a ship laden with explosives blew up and set fire to the adjoining buildings, with tragic loss of life and property. This was described in the *R.E. Journal* for September, 1951. The total casualties caused by the cyclone will never be accurately known, due to the impossibility of accounting for the safety of the crews of the many country craft that were lost, but it has been established that at least a hundred lives were lost. To those who were present in Bombay that night, it was surprising that this figure was not very greatly exceeded.

THE "REAL WORKS BUSINESS"

By "M.F.W."

TWO years have passed since that highly controversial and quasi-humorous article, "This Works Business," appeared in the *R.E. Journal* (March, 1950).

Many of us were entertained by what was obviously written to encourage officers on their initial posting to works, to convince them that "This Works Business" is just another Sapper rôle and providing they "adopt the attitude of mind of, say, an infantry officer viewing an administrative staff appointment," all would be well.

The primary rôle of works services is work. That is carried out, not in offices but on the site. "This Works Business" costs the public millions of pounds annually. Can one then conscientiously and adequately safeguard the public's interest without a thorough knowledge of one's responsibilities, allied to the ability to act without (as so often happens) entirely relying upon the efficiency and integrity of one's subordinates?

The executive officer must know what happens on the site—why it happens and how it happens. Any officer, therefore, actually engaged on works must have, in addition to all his other qualifications, a thorough knowledge of building construction and works procedure. Without that knowledge he is prone to become a mere office boy. This applies equally to senior officers who should have gained practical experience of doing a tour of duty previously on works services in an executive capacity. At least, such are the conclusions of one who has had almost a quarter of a century's experience on works—mostly spent in an executive capacity.

For the root of the issue, let us look at the "Factors by which the works organization is claimed to be made efficient." Three were quoted. Only the first calls for comment, namely: "Many of your staff are civilians who have been in the same posts for a long time. My A.C.R.E. (Administration) had been in the place for twenty-four years. When I said to him, 'Who can build some steeple-chase fences for the 17/21st Lancers?' he knew at once whom to recommend."

This statement has stirred a veritable hornet's nest among the military members of the E.E.S. who are unquestionably the backbone of the organization and have proved themselves to be so since they founded it. They do not remain in the same posts for a long time, but travel far and wide, gaining knowledge and fresh experience that prove of utmost value in peace and war.

New entrants to the Corps, after reading " This Works Business," could be led astray by such sweeping assertions and may even imagine that military clerks of works do not exist.

Let us see this in its historical setting. In 1825—a notable year for the Corps—there began the first course of practical architecture for junior officers of the Royal Engineers. In a preface to his first outline of the course, Captain Charles Pasley remarked that " In expecting the same individuals to combine the habits and feelings of the military life with the laborious pursuits of men of business and in exacting both from the Corps, the Government appears to have acted more wisely than if they had confined the Corps to military duties." The scope of the course, originally for officers only, gradually embraced all the various branches of civil engineering, and in 1861 was extended to include non-commissioned officers of the Corps to be trained as military foremen of works. These M.F.Ws. become C. of Ws. and many have subsequently proved to be eminently suitable to take over the executive officers' duties. As a matter of general interest, infantry N.C.Os. were also trained for the " supervision and maintenance of sanitary appliances in barracks."

So, for ninety years, the Corps has produced a never-ending stream of men qualified by examination to become military foremen of works, and by further examination, military clerks of works. They are still being produced. Moreover their high level of efficiency is maintained and continues to earn the plaudits of civilian builders and technical schools alike.

At a recent conference of the London Master Builder's Association, the Vice-President was quoted as saying he " thought the industry might well follow the example of the Army and send the foremen and prospective foremen on short, full-time courses. It was not a question of whether they could afford to let the men go, they could not afford not to." If this is his estimate of the value of a short course, how much more highly would he, and those who think likewise, value the twelve months' intensive training given to military foremen ?

Several of our military clerks of works (construction) possess one or more of the following qualifications : Member of the Institute of Sanitary Engineers, Member of the Royal Sanitary Institute, Licentiate of the Institute of Builders, Higher National Certificate (Building), Member of the Institute of Clerks of Works. Part I of the I.C.W. has been obtained by many military students when only halfway through their M.F.W. course.

These are the men who play a major rôle in making the works organization efficient. Men who by their experience, versatility and adaptability can be sent anywhere, at any time, to do a job on works services. Their technical qualifications and military training combined have produced, and are producing, a body of men who, with the other branches of the engineer services, keep up the high standard.

Now a word on the financial claims of the article. *In truth, who spends the money?* The £200,000 of Part III funds was spent on maintenance, *on the site*, where the work was ordered, controlled and measured by the clerk of works. Only those who have been engaged in an executive capacity can hope to realize what work and responsibility that entails. Does it not follow, therefore, that no one should be engaged as an executive officer unless he can advise and assist the clerk of works in all aspects of his work and be *able to do his job* should the need arise. The Garrison Engineer is a troop commander and, as emphatically stated by the C.I.G.S. in his recent lecture at the S.M.E., the troop commander should be able to do the work of his subordinates even better than they can themselves. Obviously he cannot compete with individual tradesmen, but he should at least be as efficient as the best of his clerks of works and in all aspects of his work. We pay the piper millions of pounds annually and we should call the tune, but only those who are in close and intimate contact with the piper can really call the tune, or know if the tune be "on" or "off" pitch. Obviously this "Works Business" is a serious matter. The handling of other people's money entails enormous responsibility, and to fulfil that responsibility, the executive officers need to be thoroughly trained.

Among those eligible to fill these posts who could be better qualified than the military clerks of works who have been thoroughly trained; have qualified by examination; have passed a probationary period; have spent six years before being further promoted (then only after further examination); have devoted years of service to the E.E.S. in all parts of the world.

The military clerks of works, when their serving days are done, should be assured of civilian service and in a grade worthy of their experience and knowledge.

I have here made no mention of the other military members of the E.E.S., but what I have said applies to all serving personnel who play their part in an organization noted throughout the whole world.

THE EFFECTS OF SCOUR ON MILITARY BRIDGE DESIGN

By MAJOR W. G. A. LAWRIE, R.E.

ONE of the greatest difficulties in designing bridge piers and abutments is to arrive at a correct decision regarding the maximum depth of scour that may occur. This article, for which no claims for originality are made, is an attempt to summarize principles that were first laid down by Sir Francis Spring in his invaluable and classic work *River Training and Control*, first published in 1903, and later greatly amplified and extended by Sir Claude Inglis in his equally valuable and monumental work on *The Behaviour and Control of Rivers and Canals*, published in 1949.

In order to estimate the maximum depth of scour it is imperative to know the probable maximum discharge, without which the width of waterway cannot be computed. For many years the civil engineer in his calculations relied mainly on rainfall and flood level data. It was not, however, until 1930 that the Lacey equations made it possible to compute the width of waterway from the maximum flood, and the maximum scour from the flood discharge and the grade of bed material. More recently Sir Claude Inglis has derived from a great mass of data an equation for the length of river meanders in terms of the maximum discharge. These two equations complete the picture.

Unfortunately it is in respect of the probable maximum discharge that the military engineer, pressed for time, is most likely to be in complete ignorance. Sir Claude Inglis, however, has stated that where other means are not available the dominant discharge can generally be determined approximately from the meander length.

The writer acting on this suggestion has in this article obtained a direct equation for the depth of scour in terms of the meander length. As this is merely an algebraical substitution the writer can make no claim to having derived an original equation, but although the combination of two empirical formulae may be mathematically unjustifiable, the resulting equation may be quite sound in itself and can immediately be applied to maps and air photographs by the military engineer.

Further, without reference to recorded maximum discharges, this relationship can be verified independently by a direct correlation of meander length and maximum scour, and this the writer has attempted to do in Appendix " B."

What it all boils down to is this—that it may be possible to estimate fairly accurately the necessary depth of the foundations of bridge piers by merely taking some measurements off a map or air photograph. This method should be of assistance to the military engineer who may often be faced with the problem of designing a multi-span bridge over a dry river bed which will obviously be full of water at certain seasons of the year. He has to build piers which will withstand the worst possible conditions, but at the same time he does not want to waste time and resources by over-insurance.

When he is designing a bridge, the following are some of the points on which he must make up his mind :—

(*a*) The most suitable site from an engineering point of view—which may not always be possible for tactical reasons.

(*b*) The length and number of spans.

(*c*) The depth of pier foundations.

It will be seen that every one of these points is affected in one way or another by scour, and it is impossible to come to a reliable decision without understanding the cause and effects of this rather indeterminate factor. To enable us to do this we will examine a typical river and the way it behaves in various circumstances.

The prosperity of Pakistan and Northern India is largely dependent on irrigation, and the canal authorities have made a detailed study of the rivers on which they rely for their water. Most of these rivers rise in the Himalayas and are fed partly by melting snow and partly by local rain. We will assume that the type of bridge we are trying to design is required to be built in or just below the foothills. Here the slope of its bed may be about three feet per mile. As it flows over the plains this will flatten out to only three inches per mile near the sea.

From November to June there is very little water in our typical river. In May the snows begin to melt, early in June it begins to fill up, and it will be in flood till October at anything from eight to thirty feet above low-water level. A minor river will be half a mile to one mile wide, while the larger rivers may be ten miles wide or more.

Scour will occur in the bed of the river, and it will be worth while to examine more closely its shape and composition. According to Sir Claude Inglis, the bed may consist of three grades of material :—

Silt, with grains up to 0.08 mm. diameter.

Sand, with grains from 0.15 mm. to 0.5 mm., and

Coarse sand, gravel, pebbles, etc., greater than 0.6 mm.

The distinction is precise and important because the law governing the relation between m the weighted mean diameter and V_s, the terminal velocity of the particles falling in water, changes.

Silt, as defined by Sir Claude Inglis, obeys Stokes's law :—

$$V_s \propto m^2$$

Whereas for sand $V_s \propto m$ (approximately)

and for larger particles $V_s \propto m^{\frac{1}{2}}$

For grades between 0.08 and 0.15 mm., and 0.5 and 0.7 mm. there are transitional regions.

Water flowing over the bed of the river will tend to pick up and carry away some of the particles. As can be seen from the above laws an increase in the velocity of the water will move larger particles. If the velocity falls the larger particles will be deposited.

In normal straight flow the greatest velocity of the water will be in the centre of the top surface. Due to drag the velocity near the bed and the banks will be less. Thus along the bed of the river bigger particles will be picked up near the centre than at the sides and we may expect to find larger particles exposed near the centre.

In fact a typical small channel will have this cross-section :—

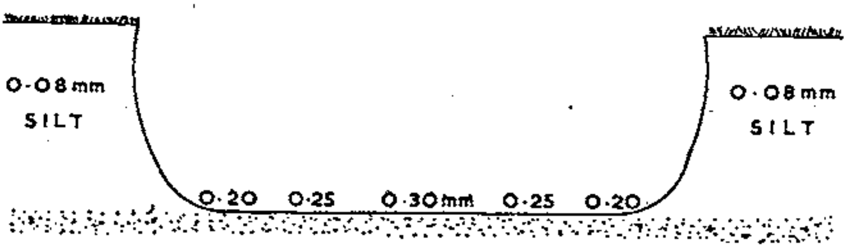


Fig. 1.—Typical small channel cross section. (Taken from *The Behaviour and Control of Rivers.*)

The reason for the abrupt change in slope of the banks is due to the change in laws governing silt and sand.

The important point to realize is that even slight local changes in velocity of any portion of the river will at once lead to corresponding changes in the bed.

Another result is that a river consisting of pebbles and coarse sand near the hills changes progressively to fine silt near the sea. This is partially due to weathering and abrasion, but more to the process of "sorting."

Large boulders move only under extreme conditions, pebbles intermittently and sand much faster, either in a progression of ripples or dunes or by sheet movement.

The second important point to grasp is that no river is ever in a state of equilibrium. It is always striving to reach it, and may in fact attain a state of comparative stability over a few years, but the behaviour of a river throughout its whole length depends in the first instance on the amount of water it receives from the hills and the type and quantity of the materials washed into it. These are highly variable and indeterminate factors from one year to the next, but over a long course of time the effect averages out between certain limits.

We have so far considered only a straight length of river, which rarely occurs in nature. What does occur is something like this :—

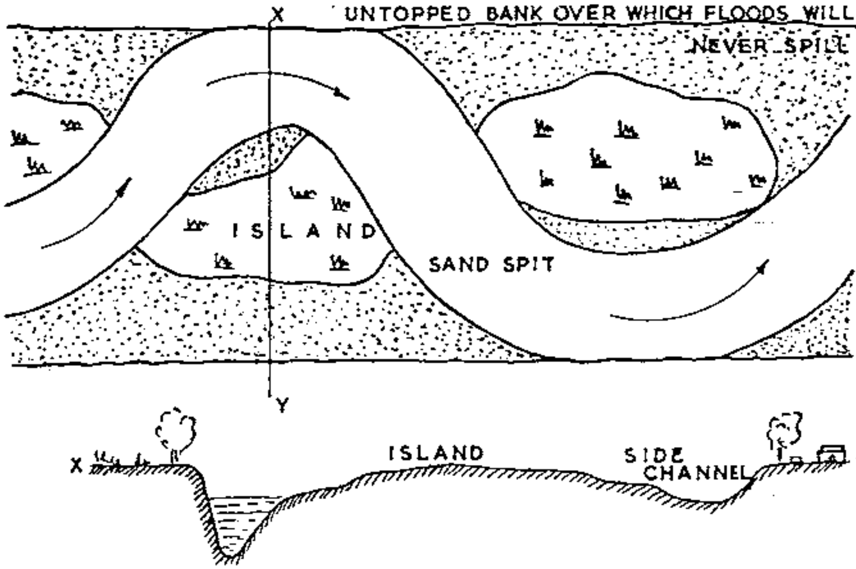


Fig. 2.—Form of typical alluvial river. (Taken from *River Training and Control.*)

The tendency of a river to meander is not due solely to the topography of the country. Experiments have been carried out under the direction of Sir Claude Inglis in a straight sandy channel and it has been found that a certain flow of water charged with a certain amount of particles in suspension will produce conditions closely approaching equilibrium. This flow is known as the "dominant discharge" for that channel. Small variations from the dominant condition are adjusted simply and automatically. If the particles in suspension are excessive the finer ones are deposited ; if they are insufficient, the finer grades will be picked up from the bed.

If, however, the flow of water is greatly increased the only way the channel can get back to its state of equilibrium is to increase its length, thus reducing the slope and hence the velocity. Hence meanders develop until the new length of the river is such as to produce equilibrium. But although the condition of the channel as a whole may be in equilibrium the actual meander loops are not. The state of affairs is analogous to a flag held to a flag pole at one end. In a strong breeze waves will develop and travel along the flag causing it to flap, but for any given set of conditions the size of the waves is constant.

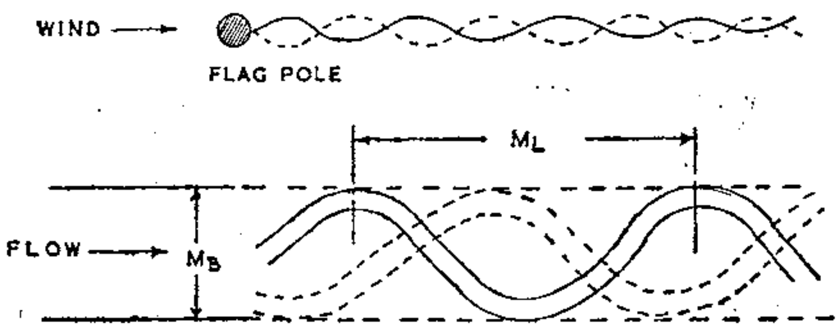


Fig. 3.—Meander analogy.

Thus under ideal conditions a straight sandy channel will form meander loops of constant length (M_L) within a meander belt of definite width (M_B). However, in practice these ideal conditions can never be attained. M_L will be found to vary considerably, although the average value of the lengths of a series of loops will be reasonably constant for a given set of conditions.

It is now necessary to see how far this applies to the alluvial rivers of Northern India. As Sir Francis Spring has pointed out, with the melting of the snows in June, a river finds, ready prepared since the previous year, a more or less tortuous and more or less deep channel. As it rises higher it spreads over the exposed sandy spits. The third stage is when it covers extensive areas covered with reeds and grass (the islands in Fig. 2). This condition may last for six months. The river finds itself taking shallow short cuts across great bends at a comparatively low velocity owing to the shallowness of the bed and then cataracting down into the main channel. The result of this is that the short cut may rapidly deepen and widen until it constitutes the main river. The old main channel will now become more or less a backwater and will rapidly silt up.

During flood time this sort of action is occurring all over the river bed and leads to utter lawlessness above and below each short cut until the river can increase its length by establishing a new bend. Then conditions will settle down until next year's flood establishes other short cuts.

As a result of this process it is found that the greater part of the Ganges, Indus and Brahmaputra and their thousands of miles of tributaries flow through flat-bottomed valleys between untopped banks. The soil of the valleys is sand from 50 to 200 feet deep capable of being lifted or dropped with small changes in velocity. The water surface slope is such that the soil is unable to support the velocity of a stream running straight along the river axis so that inevitably the river lengthens itself out into great bends between the permanent banks. Owing to short cuts in some places and silting in others these bends are continually changing.

Sir Claude Inglis has summed up by saying that meandering is nature's way of absorbing excess energy during a wide range of flow conditions, the pattern formed by the river being a function of the integrated effect of these variable conditions over a long period of time.

It has already been established that the primary variable is the quantity of material washed into the river. As was stated above, Sir Claude Inglis has obtained a relation experimentally between the meander length of a river and its maximum discharge, which he subsequently verified practically. This is stated as :—

$$M_L = 27\sqrt{Q_{max.}} \text{ where } Q \text{ is in cusecs} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

It is now time to examine more closely the phenomenon of scour. In any stream the bed is continually changing, particles below a certain size are constantly being picked up and deposited again a greater or lesser distance down stream. Whenever the bed velocity exceeds that for dominant conditions more particles will be picked up and scour will occur. Later the velocity may fall and deposition will take place. This is normal scour.

Abnormal scour occurs when particles are picked up and not replaced.

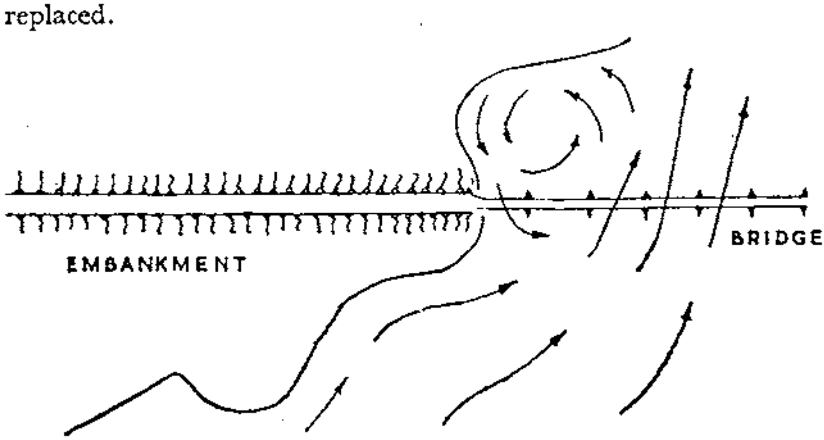


Fig. 4.—Formation of whirlpool (Taken from *River Training and Control.*)

This will take place when the main current is deflected by some obstruction behind which slack water can shelter. The one-sided pull of the current will turn this into a whirlpool with a high bed velocity. Particles picked up will be thrown into the stream by centrifugal force and they will not be replaced by fresh deposits. Thus a deep scour hole will be created.

Depths of scour have been investigated for varying conditions and Lacey's formula for scour round piers is generally accepted. Namely :—

$$d_s \;=\; 2 \times 0{\cdot}473 \left(\frac{Q}{f}\right)^{\frac{1}{3}} \text{.......................................} (2)$$

$$= \text{ depth of scour below H.F.L. in feet.}$$

where f is a function of the size of the bed material.

Replacing Q_{max} by the meander length as given by the Inglis equation at (1) above.

$$d_s \max = 0.10 M^{\frac{2}{3}} / f^{\frac{1}{3}}$$

Sir Claude Inglis has pointed out to the writer that there is some doubt as to whether size of material has any appreciable effect where there is deep scour, and recommends that f be taken as unity, giving :—

$$d_s \max = \frac{M^{\frac{2}{3}}}{10} \text{ ....} (3)$$

It is thus possible by combining the Lacey and Inglis equations to obtain a third equation from which the unknown maximum discharge has been eliminated and replaced by the meander length of a river, which can be measured from a map or air photograph.

It is possible to arrive at a reliable answer from this formula only if the meander length can be estimated with reasonable accuracy. It is suggested that the answer so obtained is checked by making a different substitution for Q_{max}.

Another of Lacey's well established formulae states that :—

$P = \frac{8}{3} \sqrt{Q}$ where P is the wetted perimeter of the active channel in feet.

When the water level is low the application of this formula is quite straightforward, but during flood conditions it has been found that the best results are obtained by taking P to be the length shown in the sketch below, and the discharge calculated from this to be 90 per cent of the total discharge over the whole width of the river.

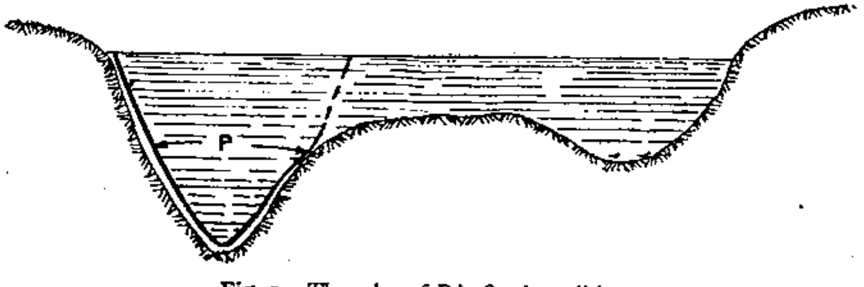


Fig. 5.—The value of P in flood conditions.

Substitution in formula (2) and taking f equal to unity, we get :—

$$d_s \text{ max} = \frac{0.946}{4} \times (9P^2)^{\frac{1}{3}}$$
$$= 1.02 \times P^{\frac{2}{3}} \quad \text{.......................(4)}$$

A third check with different variables may be obtained from the formulae

$$Q = AV \text{ by definition} \quad \text{.......................(5)}$$
$$\text{and } V = \frac{1.346 \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}}{N_a} \quad \text{.......................(6)}$$

where N_a = Lacey's coefficient of rugosity, say 0.03 in typical conditions under consideration, although this is rather a high figure for a river in sand.

R = hydraulic mean depth
= A/P

S = energy gradient

$$= \frac{H_1 - H_2}{L} \pm \frac{V_1^2 - V_2^2}{50}$$

or $\frac{H_1 - H_2}{L}$ where V_1 and V_2 are nearly equal

$$\text{Thus } Q_{\text{max}} = 4.46 \times \frac{A^{\frac{5}{3}}}{P^{\frac{2}{3}}} \times \left(\frac{H_1 - H_2}{L}\right)^{\frac{1}{2}} \quad \text{.......................(7)}$$

where A = cross sectional area at max. discharge in square feet,

P = wetted perimeter in feet (both for active channel)

and $\frac{H_1 - H_2}{L}$ = slope of river surface between two stations L feet apart.

All these can be measured or estimated at site from the shape of the bed or signs of old high flood levels ; and the value of $Q_{\text{max.}}$ so obtained substituted in formula (2), giving an independent check on the maximum depth of scour.

There are several other methods of arriving at values for d_s max. These are summarized in Appendix A and may be used as additional checks, though it is felt that they are of less general application.

What has been achieved so far is a theoretical value for the greatest possible depth of scour which might occur in the bed of any particular river, say once in fifty years. How does this help the military engineer who has to build a bridge over it ?

The first thing he has to do is to select the best possible site.

The following conditions would be ideal :—

(i) A straight reach of river.

(ii) The banks regular, approximately parallel and well-defined.

(iii) Far enough below tributaries and bends to be free from their disturbing effect on the current.

(iv) The bottom and banks of gravel rather than sand or silt.

(v) The average depth of waterway should be large compared with the maximum depth.

In such a site there would be little danger from scour to a military bridge, which may be required for one or two seasons only. But tactical or other considerations may rule out the best site from the point of view of the engineer and he may have to accept less favourable conditions.

Having decided on a particular site the next point to be settled is the number and length of spans. This will depend to a great extent on the length of stock spans, etc., available, but if he has several alternatives he may be guided by the factors given below.

Sir Francis Spring has said that if we examine any typical bridge with a number of spans we will see that nine-tenths of the flow throughout the year uses one-third of the spans. The other two-thirds take only one-tenth, and may continue to do so for many years. It has already been pointed out that scour depends on bed velocity. In whichever part of the river the velocity is greatest, so will the scour be greater and the channel deeper. In any one season the tendency is always in favour of the deeper scour going still deeper, though this will not remain in the same place over a long period of years due to the movement of meander loops.

Sir Francis Spring made a practice of assuming that the worst would happen, and contemplated the very unlikely, but still possible, contingency of the whole necessary enlargement of cross-sectional area occurring in only one-third, and that the deepest part of the breadth of a river ; and of designing his guide banks and his foundations as if each and every part of them were to be liable at one time or another during the period of their existence to be subjected to scour down to the depth so arrived at.

However, if a military bridge is likely to be required for one or even two seasons only it is suggested that a risk may be run by taking full precautions against maximum scour in the active third of the river only.

If the other two-thirds of the river's width is largely high and dry, it will grow rushes, scrub and low jungle, thus protecting itself still further against scour. The construction of piers will restrict the waterway and so inevitably increase the velocity and tend to deepen the scour where it is already deep. Therefore if possible the minimum number of piers should be located in the active part of the bed.

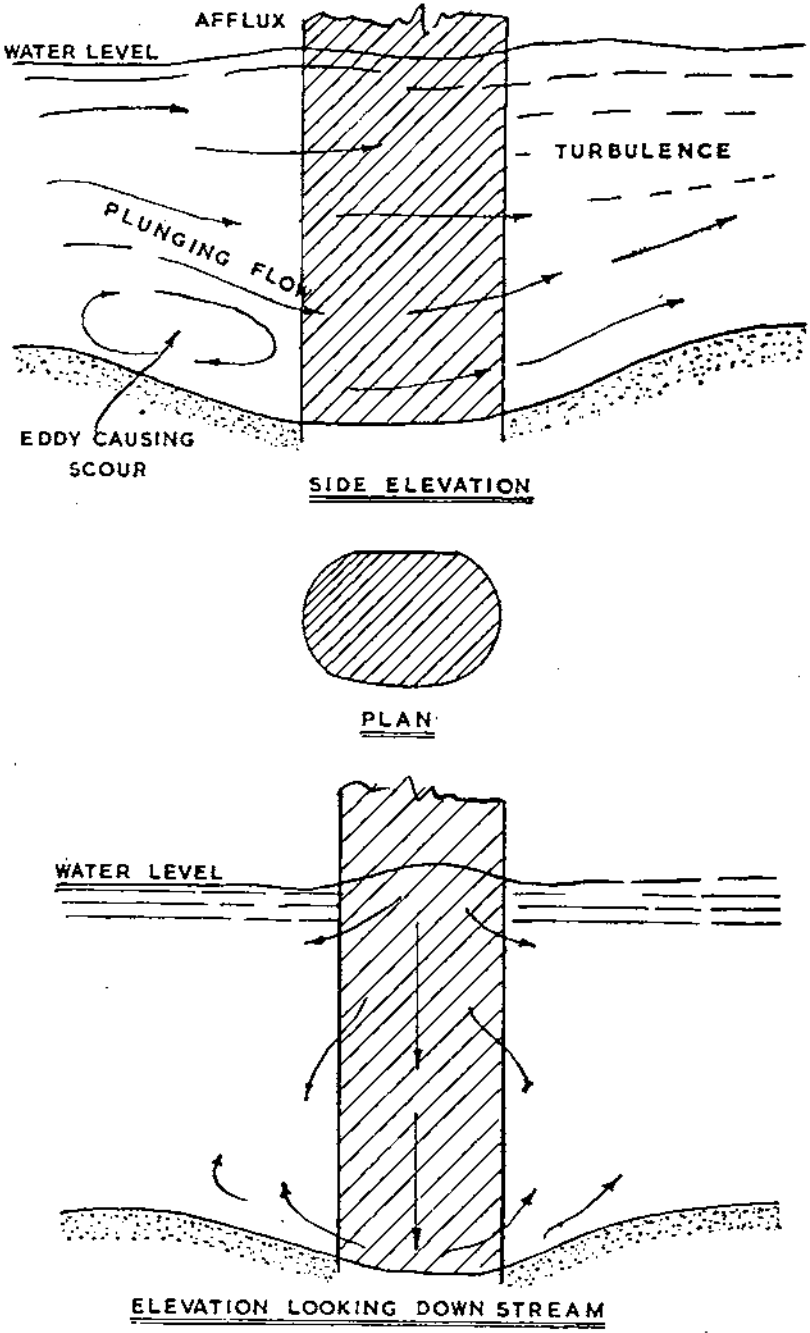


Fig. 6.—Typical scour effect on bridge pier. (Taken from *The Behaviour and Control of Rivers and Canals.*)

But constriction of the waterway will cause afflux above the bridge, plunging flow and increased velocity between the piers, and turbulence and whirlpools down stream unless guide banks are built to control the flow of water. This may be difficult or impossible in the middle of a campaign, but even temporary ones are better than none. In these circumstances scour may occur round the pier footings, in midspan, or down stream of the bridge, so our next problem is to decide how to reduce this danger to a minimum.

Fig. 6 illustrates the way in which deep scour may occur at piers. The lines of flow in these diagrams were obtained experimentally by Sir Claude Inglis. In extreme cases the value of d_s max obtained from formula (3) may be reached.

A common but ineffective way of trying to protect piers is to place heavy stones round the foot. These will not be moved by the plunging flow of the flood water which will be diverted to mid-span. The river in its striving for equilibrium will therefore scour away the bed of the river where it is unprotected. The next result is that the heavy stones round the piers will roll down into these new scour holes, leaving the pier footing as unprotected as before, but more liable to be damaged by scour since the mid-span portion of the river bed is now invulnerable (see Fig. 7).

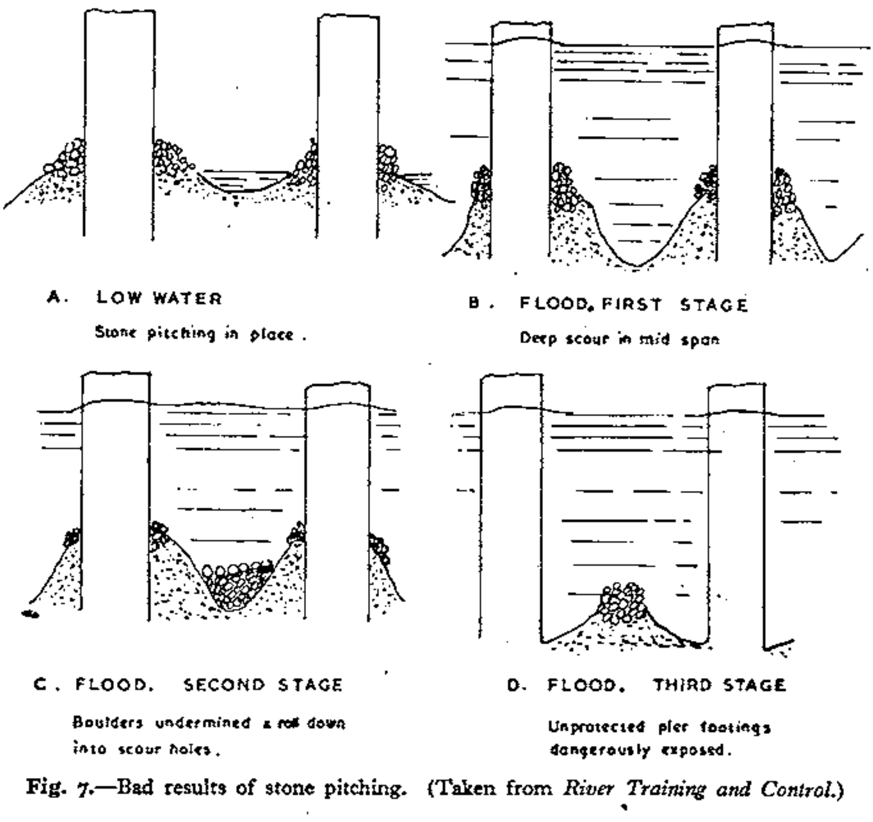


Fig. 7.—Bad results of stone pitching. (Taken from *River Training and Control.*)

To quote Sir Francis Spring—" In most cases it pays best to go deeper with the piers and not to trouble to arm them too heavily." Nevertheless, " Engineers are more comfortable . . . when they find stone heaped well up round their piers . . . In a given case it might prove cheaper to throw stone around a pier rather than to found it very deep."

To summarize the recommendations of this paper, the military engineer who is asked to design a multi-span bridge over an alluvial river should take the following steps :—

(*a*) Choose a site where the river is straight and the flow smooth.

(*b*) Design the bridge with the minimum number of piers, particularly trying to avoid constriction in the active portion of the bed.

(*c*) Calculate the maximum depth of scour from the formula :—

$$d_s \text{ max} = \frac{M_L^{\frac{1}{2}}}{10}$$

(*d*) Check the depth so calculated by other methods.

The reduced waterway at the bridge will induce an increase in bed velocity, hence greater scour than would be expected for that river, so that to be perfectly safe the foundations in the active channel would be dug half as deep again as the value of d_s max obtained from (*c*) above. The remaining pier foundations need not be so deep, but for this the engineer will have to use his judgement.

Appendix B provides evidence from several large rivers in Northern India and Pakistan which shows that this theory is consistent with practical observations and provides justification for making a survey of rivers of various sizes in different parts of the world with a view to comparing the actual and theoretical maximum values of scour under different conditions, and obtaining from a wide range of observations in alluvial channels an authoritative direct correlation of scour and meander length.

So far as the writer is aware this is the first occasion on which any direct correlation of these two factors has been attempted.

Bibliography

Technical Paper No. 153 of the Railway Board, India, *River Training and Control—the Guide Bank System*, by Sir Francis Spring.

Research Publication No. 13 of the Central Water-power, Irrigation and Navigation Research Station, Poona, *The Behaviour and Control of Rivers and Canals*, Parts I and II, by Sir Claude Inglis.

APPENDIX A

Other Methods of Calculating Maximum Depth of Scour

1. Using Lacey's formula

$$d_s = 2 \times 0.473 \times (Q/f)^{\frac{1}{3}}$$

The only unknown is Q, the maximum discharge.

Two methods of estimating this have been given above. Others are as follows :—

(*a*) Take the bridge site and two sites above and below this at a distance about six times the width between banks, and calculate the velocity at O.H.F. level from Manning's formula below

Cross-sectional area at O.H.F. $= A$ sq. ft.

Wetted perimeter $= P$ ft.

Hydraulic mean depth below O.H.F.L. $= r = \frac{A}{P}$ ft.

Slope of water surface $S = \frac{\text{Fall}}{\text{distance}}$

Coefficient of rugosity, $= n$ (Kutter)

Velocity in ft./sec. is given by $V = \frac{1.486}{n} \times r \times S^{\frac{1}{2}}$

Hence calculate the discharge at O.H.F.

$$Q \text{ (cusecs)} = AV$$

(*b*) Check results from this method by using one of the following formulae, based on run off, for calculating Q_1 (discharge at Maximum High Flood Level).

(Run off depends on extent, direction, intensity of rainfall, path of rain storms, natural or artificial storage, size and nature of catchment area, character of soil, slope of area, and various time factors.)

Dickens's formula $Q_1 = C\,M^{\frac{3}{4}}$

Ryve's formula $Q_1 = C\,M^{\frac{2}{3}}$

Inglis equation $Q_1 = \frac{7000\,M}{(M + 4)^{\frac{1}{2}}}$

In these formulae M = catchment area in square miles and C = 400–800 depending on type of country.

(Dun's Tables (Modified), *M.E.S. Handbook*, Vol. III, Table X.)

(*c*) In making this check allow that

Q_1 (M.H.F.) will be minimum $\frac{4}{3}\,Q$
maximum $2\,Q$

(*d*) Taking the physical conditions at the site, get the increased wetted perimeter cross sectional area, and rise in hydraulic mean level for the M.H.F. and from this calculate V_1.

Hence obtain $Q_1 = A_1 \times V_1$ and check that this value is approximately equal to the value of Q_1 obtained above.

2. Method in *M.E.S Handbook*, Vol. III.

(*a*) *Afflux*

Depending on the velocity of the river and the shape and size of the piers, the water surface above the bridge will rise above the M.H.F.L. calculated above (afflux = h ft.).

(Chap. V, Sec. 20.)

(*b*) *Velocity due to obstruction*

Allow 10 per cent increase. Hence calculate V_2 (velocity between piers) (Sec. 21).

(*c*) Use one of two empirical formulae based on velocities to get D_1 (the depth from M.H.F.L. to scour level) or use the following which is a compromise between those two methods :—

$$D_1 = \frac{1.3\,DV_2}{v} \quad \text{or} \quad \frac{2.1r\,V_2}{v} \qquad \text{for average sites}$$

$$= \frac{1.5D\,V_2}{v} \quad \text{or} \quad \frac{2.9r\,V_2}{v} \qquad \text{for bad sites (Sec. 22, 23)}$$

(Larger value of D_1 to be adopted in each case)

D = Depth from O.H.F.L. to scour holes in vicinity of site

r = hydraulic mean depth $= \dfrac{A}{P}$

APPENDIX B

1. *Verification of formula* $d_s\ max = \dfrac{M_L^{\frac{2}{3}}}{10}$

In order to test the new form of equation put forward in this paper a comparison has been made between the theoretical maximum depth of scour, obtained by measuring M_L from the map, and the actual maximum scour that has been observed at certain bridges in Northern India during the last twenty-five years.

It will be seen that for the seven rivers for which information is available from the annual report for 1944 of the Indian Waterways Experimental Station the observed maximum works out at about seven tenths of the theoretical maximum. This is to be expected, as in most cases river training works had been carried out up stream of the bridges long before the observations were made, with the precise object of reducing scour at the bridge sites. In the case of a new military bridge there would be no river training works and precautions should be taken against the full theoretical maximum scour.

2. Comparison of Observed and Theoretical Values of d_s max in Certain Rivers
(Observed figures quoted from *The Behaviour and Control of Rivers and Canals*)

River	Bridge	Map Sheet	Meander length M_L in feet (measured off map by the writer)	d_s max. in ft. (from formula $d_s = M_L^{\frac{2}{3}}/10$)	d_s max in ft. (observed)	Date of observation	Ratio—$\frac{\text{observed max scour}}{\text{theoretical max scour}}$
Jhelum	Shahpur	43 D/7	21,500	77.3	48	1938	0.62
Chenab	Shershah	39 N/8	15,600	62.4	45	1933	0.72
Chenab	Chiniot	44 A/13	23,700	82.5	65	1932	0.79
Ravi	Balloki	44 E/1 44 E/SE	22,000	78.5	65	1935	0.83
Sutlej	Phillaur	44 M/16	13,800	57.5	39	1929	0.68
Sutlej	Ferozepore	44 1/12	25,000	85.5	56	1944	0.66
Jumna	Delhi	53 H/NW	12,100	52.7	37	1941	0.70
Gandak	Bagaha	72 A/4	38,400	113.8	74	1924	0.65
Meghna	Asuganj	78 P/4	48,900	133.7	94	1938	0.70
					Average ratio		0.72

ARCHED FLOATING BRIDGE IN TASMANIA

By Dr. H. Gottfeldt, M.I.Struct.E.

(Reproduced by permission of the author and the International Association for Bridge and Structural Engineering, from the report of their Third Congress, held at Liege in September, 1948. The blocks for Photographs 2 and 3 have been kindly loaned by the Belgian Group of the Association, who printed the original report, and the drawings for Figures 1 and 2 and Photographs 1 and 4 have been lent by the author.)

EDITOR'S NOTE

The bridge described in this article should be of special interest to R.E. officers, who so often have to construct pontoon bridges, and it should be noted that the difficulties of anchoring the pontoons were overcome by the arch design.

Further interest is added by the fact that the author has a copy of a very fully reasoned paper, written by Captain W. Jacob of the Bombay Artillery in 1832, recommending a pontoon type of bridge for this site.

Captain Jacob had been stationed in Chatham while Colonel Pasley was commanding the Engineer Establishment and he had evidently studied the details of pontoon bridges very carefully. He discusses at considerable length the advantages and disadvantages of pontoons designed by Pasley, Blanshard and Colleton, as well as of many continental types. Models of the pontoons invented by the three Sapper officers mentioned above can all be seen in the R.E. Museum at Chatham.

THE bridging of a wide river is in itself a fascinating problem for the structural engineer. The width is the most manifest obstacle, but there are usually many others, less obvious but equally hard to conquer. Wide rivers are frequently of a commensurate depth, perhaps of several hundred feet, and even at that depth the river bed may be utterly unsuitable to support the weight of a bridge pier. Currents, tides, and atmospheric conditions will have to be considered. Last, but not least, the demands of the traffic *across* the river are usually diametrically opposed to those of the navigation *along* it; if the surrounding countryside is fairly flat the road user or railway engineer will ask for a crossing a few feet above the water level, so as to avoid the expenditure of money and energy on the climbing of long ramps, while sea-going ships require a clear headroom of 150 ft. and more and, of course, a corresponding clear width.

All these difficulties presented themselves in full measure to the successive generations of engineers who planned to bridge the river Derwent, at a place near its mouth where it is almost 4,000 ft. wide, with a view to connect Hobart, the capital of Tasmania, with its suburbs and generally with the east coast of the island. These plans remained a dream for more than a century, and only then a scheme was evolved that would not only overcome the technical difficulties but—and this is a further important consideration—would also be within the financial reach of a smallish community, the population of Tasmania being about 240,000, of whom one quarter live in the capital.

The first reaction of the modern engineer to such a problem would probably take the form of a sketch of a suspension bridge. The cost of such a design would, however, have been prohibitive, not only because the solid rock was in places no less than 200 ft. below the water level, but also on account of the long ramps that would have been necessary to give a headroom of 150 ft. for sea-going ships.

A poor alternative to such a design is a pontoon bridge, but here again the anchoring of the pontoons and especially of the portion to be floated out for shipping purposes would have offered formidable and, in view of the storms prevailing at some seasons of the year, perhaps insurmountable difficulties. The idea was, therefore, put forward to build the whole bridge in the form of one huge pontoon, with a lift bridge of appropriate dimensions at one end. If such a pontoon, of about 3,000 feet length, were to have been designed as one straight beam, spanning from shore to shore and resisting the horizontal pressure of wind, waves, currents, and tides, it would have required a width of anything between 200 and 300 ft., wholly unnecessary even for the heaviest traffic, and if built in reinforced concrete it would even then have been impossible to guarantee continued watertightness of the tension zone; the cost of such a structure would have been enormous.

It was, therefore, imperative to adopt a design that would ensure predominantly compressive stresses and the final answer was found in a huge horizontal floating arch. In this way the width could be reduced to reasonable dimensions, just sufficient to accommodate the required roadway of 30 ft. width with a footpath of 6 ft. on one side.

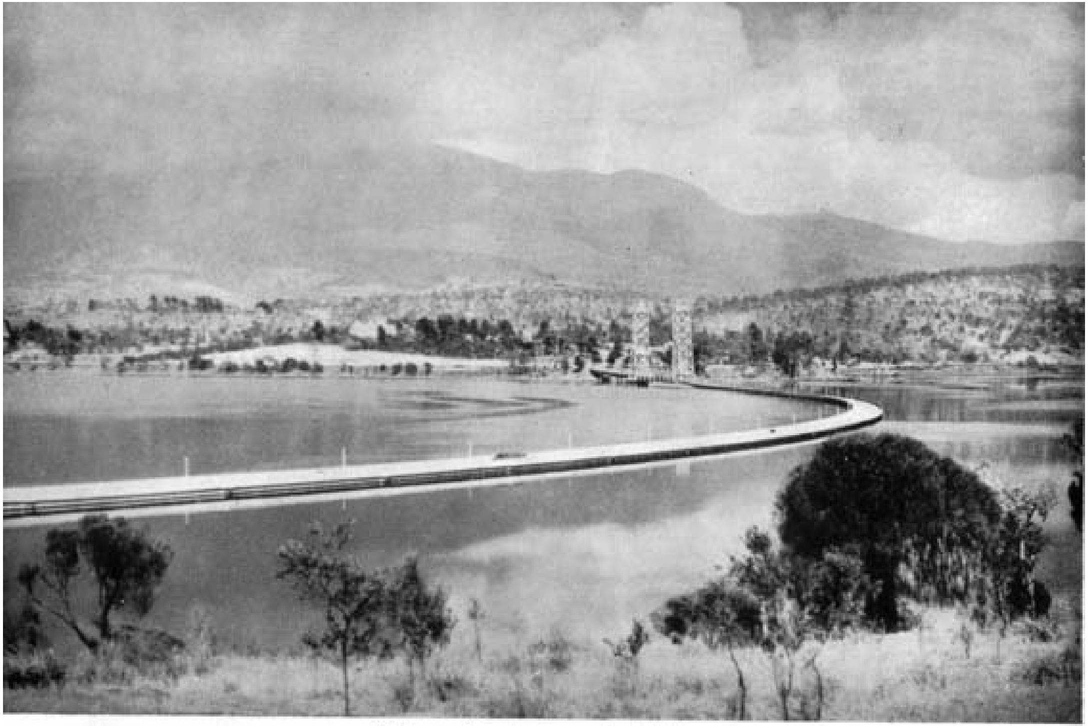
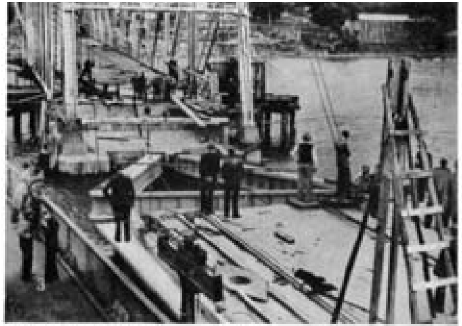


Photo 1.—View of the completed Bridge.

Arched Floating Bridge In Tasmania 1



hoto 2.—View of the three-leg link of welded plate girder design.

Photo 3.—Joining of the two halves at the centre.

Photo 4.—Lift Bridge portion in foreground.

Arched Floating Bridge In Tasmania 2,3,4

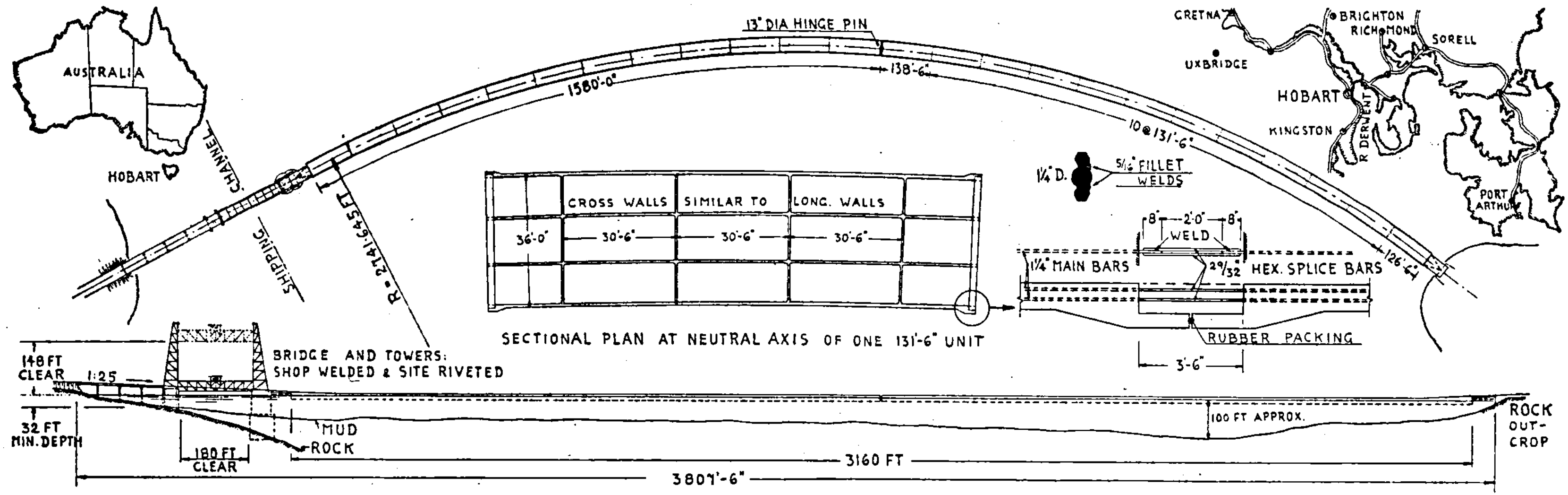


FIG. 1.—Location and general arrangement of Bridge.
Details of 131 ft. 6 in. Unit.

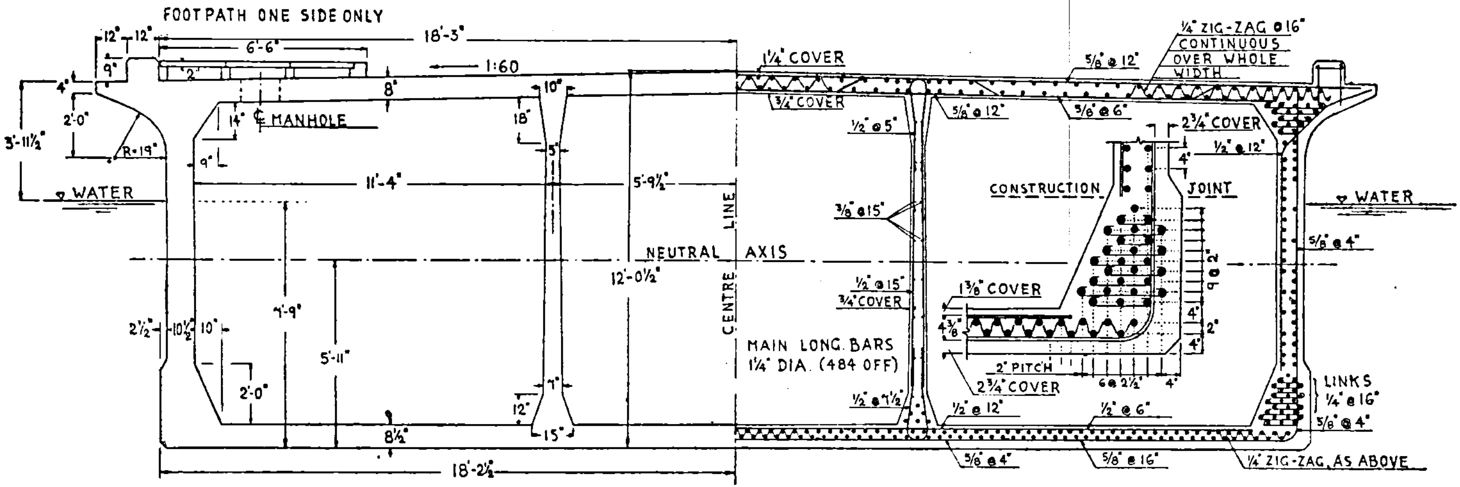


FIG. 2.—Section through Pontoon.

Figure 1 shows the general layout of this unique bridge and its main dimensions. A few short approach spans next to the western shore are followed by the lift bridge, which gives 148 ft. headroom for a clear width of 180 ft. at a minimum depth of water of 32 ft. The towers are about 180 feet high to centres of sheaves, the bridge has a span of 204 ft. The members of the towers, as well as those of the bridge, are of shop-welded design, with riveted connexions at the nodes. The tower next to the shore rests on four reinforced concrete cylinders of 9 ft. and 7 ft. diameter respectively; the solid ground is here only thirty to forty feet below the water line but falls rapidly away. The other tower stands on a mass concrete pier of 130 ft. depth, with a base of 65 × 42.5 ft. and a total weight of 18,000 tons.

This pier supports not only the tower of the lift bridge, but acts also as abutment for the floating arch. The latter is, however, not directly connected to it, as allowance had to be made for a normal tidal range of ± 3 ft., a value that in extreme conditions may rise to ± 4 ft. 6 in. The necessary flexibility has been achieved by interposing a ramp of 60 ft. length between arch and abutment, which is capable of following the rise and fall of the tide but does not transmit the thrust of the arch. The latter is taken up by a triangular linking arrangement underneath the ramp; the three legs of this link are of welded plate girder design (Photo 2). It is connected to the abutment by means of a single pin of 13 in. diameter, weighing about one ton, and by two smaller pins to the end of the arch. A similar connexion is provided at the other end of the bridge. Fortunately, the rock here comes to the surface and the anchorage of the arch offered no difficulties.

The floating portion is undoubtedly the most interesting and outstanding part of this bridge. It is in the form of a three-pinned arch of 2,740 ft. radius, 3,160 ft. length, and 443 ft. "rise." The dimensions of the cross-section and details of the reinforcement are shown in Fig. 2, and a sectional plan of one of the twenty-four sections of which the arch was built in Fig. 1; this shows the subdivision into cells by means of cross walls and longitudinal walls. These sections, of 131 ft. 6 in. length each, were built on land and their ends temporarily sealed so that they would float when launched. They were then temporarily bolted together, with rubber packings between adjacent ends so that the sealing walls could be removed. Suitable recesses had been provided at the ends into which the 484 longitudinal reinforcing bars of 1¼-in. diameter projected and where they could be jointed by means of welding (see detail Fig. 1). The recesses were then filled with concrete, so that by then two sections formed one monolithic unit of twice the length of the sections.

This process continued until all twelve sections of a half-arch had been moulded into one huge monolithic pontoon of 1,580 ft. length with a weight of about 12,000 tons, that is 24,000 tons for the whole length of the arch; this figure includes 3,100 tons of steel reinforcement. It is interesting to compare the dimensions of this pontoon with the well-known floating units of the Mulberry harbour. In cross-section the latter are much more impressive, as the largest of them had a width of 56 ft. and a height of 60 ft. They were, however, "only" 204 ft. long and had a displacement of no more than half that of the pontoon here described, namely 6,044 tons as compared with 12,000 tons.

The work so far described proceeded in a protected spot a few miles up stream. The structural and the launching difficulties that were encountered with this unprecedented design were by no means small and more than once the sceptics were on the point of being proved right; it took five months to get the first 1,000-ton section into its element. The lessons were, however, soon learnt, and the time was later cut to only twenty days per section of 131 ft. 6 in. length.

After both halves had been completed they were towed to the site on two consecutive days and temporarily moored there, and the following day saw the delicate operation of assembling them in their final position and attaching them to each other and to the abutments. Photo 1 shows the completed bridge. Photo 2 shows the arch approaching one of the abutments and gives at the same time a view of the triangulated linking arrangement previously described. In Photo 3 the two halves are about to be joined at the centre. Photo 4 shows the lift bridge and its towers. The assembly on the site took place on 23rd October, 1943, and the bridge was officially opened for traffic on 1st January, 1944.

The author, who was not himself connected with the design of this bridge, is of the opinion that it represents an outstanding example of the art of the bridge builder, an example, moreover, where the designer has freed himself completely from all tradition and prejudice, has studied the particular problems right down to their roots, and has arrived at a unique and wholly unprecedented solution which deserves a foremost place amongst examples of long span reinforced concrete bridges.

The design is due to Mr. A. W. Knight, Chief Engineer of the Public Works Department, Hobart, Tasmania. The author is indebted to this department and to the Agent General for Tasmania in London, for their assistance in the preparation of this paper.

THE THIRTY YEARS WAR IN MODERN DRESS

By MAJOR-GENERAL B. T. WILSON, C.B., D.S.O.

SOME distinguished observers of the calamitous events of the cold war compare them with those which finally culminated in the disastrous struggle known as the Thirty Years War (1618–48) and suggest that a study of its history will help us to understand the trend of international events to-day.

Few soldiers on the active list have, however, much time for the serious reading of history, especially that of the exceedingly complicated period of Europe in the sixteenth and seventeenth centuries.

An attempt, therefore, to bring the genesis of the Thirty Years War into focus with what is happening now may be stimulating and even useful to those who have little time except for the hurly-burly of their everyday professional life.

TWO HISTORIC INCIDENTS SEPARATED BY A HUNDRED YEARS

Martin Luther started the German Reformation in 1517 by nailing to the door of the castle church at Wittenberg his famous ninety-five articles attacking the abuses of the Catholic religion. Almost exactly a century later at Prague, an even more picturesque incident took place, which is generally accepted as the beginning of the Thirty Years War.

In the Bohemia of those days, the commonly accepted method of expressingly disapproval of unpopular public men was to push them through a window. The deputies of the aged Emperor Mathias in Prague had earned the obloquy of the Bohemians during a dispute about a church. On 23rd May, 1618, two of them duly made a rapid descent of seventy feet into the dry moat of the royal castle of the Hradschin. A secretary was also thrown out as an afterthought. Marvellously none of them was killed since they chanced to land on an extensive dunghill. The secretary scrambling to his feet expostulated loudly that he, a mere scribe, had been honoured thus with "defenestration."

The Thirty Years War chronicles many serio-comic barbarities of this kind, but this one was rather unique in that it infuriated the Emperor into taking condign action against the rebellious Bohemians.

That the incubation period of the war lasted as long as a hundred years was due to the complications of the European political scene at the end of the sixteenth century, particularly in a divided Germany where no great Protestant ruler emerged to shake off the medieval shackles of the Empire and to fashion a united country with its own reformed religion.

Contemporary Europe about 1600–18

Spain

Spain, the foremost champion of the Catholic cause, was still dominant on the Continent. Her hereditary possessions included the Spanish Netherlands, the large kingdom of Naples, Austria, Lombardy, Bohemia and Hungary, not to mention Mexico and Peru. Germany, although not part of her direct possessions, formed a large part of the Holy Roman Empire which stretched from the Danube to the North Sea and the Baltic.

The Netherlands, whose commerce and wealth were essential to the gimcrack economic structure of Spain, had been profoundly affected by the Reformation. After over twenty-five years of savage fighting the rebelling Dutch compelled Spain to sign a twelve years' truce with their new and triumphant republic. What is now Belgium, with a large stretch of country to the south-west of it (e.g., Lens, Cambrai, Arras), remained as the Spanish Netherlands.

The Spanish and Austrian branches of the Hapsburg family maintained a hazardous overlordship of all these various countries. Both were perpetually short of money. Only Spain had a regular army, which was never large enough for the jobs on hand.

France

France became busy in the latter half of the sixteenth century with the religious civil wars of the Huguenots, which nearly wrecked the hard-won unity of the country. The massacre of St. Bartholomew's Day took place in 1572. The Edict of Nantes, famous as the first measure of religious toleration in Europe, issued in 1598. Soon afterwards, Henri Quatre, the splendid monarch of the majestic châteaux in the Loire Valley, was contemplating war to the knife with Spain when he was struck down by a Jesuit assassin. During the opening years of the seventeenth century, Richelieu, the Cardinal-statesman, whose contemporary portrait is one of the most notable in our National Gallery, was consolidating the power of the youthful Louis XIII and settling the French religious quarrels by wise measures of toleration. By 1632, he was able to intervene powerfully in the German religious war, not to assist the Catholic cause, but in alliance with Protestants to weaken Spain and Austria, the arch enemies of France.

Sweden and Denmark

In Sweden the first task of the youthful Gustavus Adolphus, when he came to the throne in 1611, was the expulsion of the Danish armies which had overrun his country. He then tidied up the Baltic so effectively that Russia could not launch a boat upon that bleak tideless sea without Swedish permission. Poland was another of his early military problems, since the medieval structure of the Empire gave the sovereignty of Sweden to his cousin Sigismund, the King of Poland, just as it gave Bohemia to Ferdinand II and the Netherlands to Spain.

As the Reformation had taken early root in Sweden and Denmark, it is hardly surprising that Gustavus looked upon the Hapsburgs and the Catholic religion as a single monster with two heads, both of which it was imperative to remove.

Christian IV of Denmark had, in 1618, every cause to be anxious about the future of his country, since a united Catholic Germany would make short work of his Protestant bishoprics and his strongholds on the Weser and the Elbe. His political views about the Empire and the Catholic religion, therefore, coincided exactly with those of Gustavus Adolphus. They were, however, clouded by the rivalry between Denmark and Sweden, which made it difficult for these two seafaring neighbours to co-operate effectively.

England

England began her struggles of the Reformation rather later than Germany. Henry VIII was most English in his fondness for the sea, but just the reverse in his passion for theology, which in that age was of great political importance, just as the science of economics is to-day. He actually earned the proud title of "Fidei Defensor" from Pope Leo X for writing a pamphlet in refutation of Lutheranism. When he dismissed Cardinal Wolsey he proved perfectly capable of ordering the affairs of the Church of England himself.

The Reformation in England was, in fact, more a breach with Rome over the question of ecclesiastical power, than any radical change of faith. As the Pope was bound hand and foot to Spain, England inevitably became involved in war with that country, a war which outlasted even Elizabeth and Philip II and was only concluded in 1604, one year after the accession to the English and Scottish thrones of James I.

Eastern flank

On the eastern flank of the Empire, Hungary was sometimes at war with the Turks and sometimes in league with them against their more civilized western neighbours. Poland was being converted by the Jesuits to the Catholic faith, which almost to the present day has differentiated that country so greatly from Russia whose religion came from Byzantium. Russia, itself, sunk in oriental barbarism and gloom, hardly impinged at all on the religious and political struggles of Europe. For nearly another a hundred years she was to be kept fully occupied within the confines of her vast forests and wide steppes.

The Condition of Germany

Germany on which the ferment of the Reformation worked so potently, was a strange motley of electorships, principalities, duchies, bishoprics and small states. In all, the various dependencies of the Empire numbered over 300. Legally they were all vassals of the elected Emperor, whose power depended on his ability to keep some sort of order amongst this large conglomeration of well-fed, quarrelsome minor potentates. The General Assembly, or Diet, elected the Emperor who used it as best he could for giving shape to his policy. It never entered the heads of the splendid princes and powerful prelates of the Diet to summon to it any representatives of the common people. Ordinary men formed neither part nor parcel of the Councils of Germany and have often been excluded from them in more modern times.

As the Catholic ecclesiasts and princes of the Diet were in the majority, the Protestants could never expect from it any decisions favourable to their cause, even although at the end of the sixteenth century a very large percentage of ordinary Germans were Protestants. Like the League of Nations of 1918 and U.N.O. of 1945, neither the Emperor nor the Diet disposed of any standing army to carry out policy by force if peaceful methods failed. When confronted with a serious impasse, the various Electors, princes, dukes and bishops raised armies *ad hoc* and picked sides to fight it out. For this reason, Germany ultimately became the happy hunting ground of soldiers of fortune of all nationalities, most of them foreigners. They gave the Thirty Years War its particular cachet. Nearly all of them were of aristocratic origin. Even the murderers of Wallenstein, the great Bohemian soldier, were well connected.

The Reformation

It was in a divided Germany of this kind that Martin Luther, till his death in 1546, led his crusade against the abuses of the Roman religion. Although a religious genius, he was not a revolutionary, for like most men of his race he had great respect for law and order. Far from countenancing the social revolt of the downtrodden peasants of 1525, he supported the cause of the princes in a famous treatise, in spite of the fact that he himself was of peasant stock. His spiritual home was Wittenberg in Saxony, where the

Elector himself sheltered him from his enemies. His bold defiance of the Pope made him for some vital years a popular figure throughout Germany, especially with the middle-class inhabitants of the towns. Yet in spite of the astounding first successes of Lutheranism, the reformers did not succeed in converting the whole of Germany. For religion in Europe has never been divorced from politics. The patchwork structure of Germany in the sixteenth century conduced to that political anarchy which has so often been the bane of Germany. No soldier statesman of German race of the calibre of Gustavus Adolphus appeared on the scene to unite the country.

Nevertheless, by 1539 the Lutheran religion was professed by the rulers and people of Saxony, Hesse, Brunswick, Brandenburg and Prussia as well as in many important cities in the north and south of Germany. Calvinism too was established in the Palatinate athwart the Rhine about Mainz.

This all happened without much rejoinder from the Emperor or the Catholic princes of Germany, who if they had been so minded, could have destroyed any army which the Protestants might have put into the field. Here again politics came into the question. In reality neither the Catholic nor the Lutheran princes were prepared to fight under the Emperor or anyone else for the unification of Germany. They liked their loosely co-ordinated little autocracies. If they fought at all, they did so to maintain their power or to add to it.

Even so, after a peace with France in 1544, Charles V, on one of his rare visits to the Empire, did attempt to deal with Saxony and Hesse, not because they were heretics, but because they were rebellious. His imperial army, mostly found by the Pope, defeated the Protestant generals at Mühlenberg on the Elbe in 1547. It was, however, an empty victory since political anarchy still prevailed.

Later on, the treacherous Maurice of Saxony and the defeated Lutheran generals did not hesitate to invite the French into Alsace. The Lutherans were then able to advance on Innsbruck and caused Charles V to flee for his life over the Brenner Pass into Italy. After this debacle he never reappeared in Germany. His brother, Ferdinand I, who succeeded him, was wiser and more tolerant than most of the Hapsburgs. He quickly perceived that to try to reconcile the rival religions by any compromise of doctrines was a hopeless task.

At the Peace of Augsburg in 1555, therefore, the religious question was settled by the ruling, "*Cujus regio, ejus religio*," which, with Latin brevity, gave the princes the right to decide how their various peoples should worship. For over fifty years this rough and ready edict gave an uneasy religious peace, not only to Germany, but also to Austria, Bohemia and Hungary, where many people had also deserted the Catholic faith.

The reader should note that in its gradual conquest of the Germans, Lutheranism did not cause the kind of panic which causes men to believe that they are confronted with a system hostile to all the decencies and cherished traditions of their previous existence. On the contrary its object was to preserve them.

The Country's Reformation

Even without the formidable promptings of the Protestant reformers, the decadence of the Roman faith had not escaped the attention of ardent Catholics. The Popes and princes of the Catholic church began to mend their ways. The Council of Trent sat for ten years in review of Catholic doctrine.

As early as 1534, a band of Catholic devotees in Paris took vows to pass their lives in true holiness. They were led by Ignatius Loyala, Francisco Xavier and Laínez who were soon to become famous for the foundation of the Jesuit Order.

The twentieth century has had ample proof of the accuracy of the belief that long-range changes in the spiritual outlook of mankind must be based on the school. In a generation, a people can, in fact, be taught almost anything, whether good or bad, true or untrue.

No religious body was quicker to enlist the power of the school than the Jesuit Order. It knew also that the world in the main is ruled by station, wealth and intellect. The Jesuits preferred, therefore, to train the elect rather than to preach to the multitude.

Between 1557 and 1559 Jesuit schools and universities began to spring up in Austria, Bavaria and the Rhine Valley. Both Ferdinand II, the future Emperor, and Maximilian, destined to be Duke of Bavaria, were educated at the Jesuit university of Ingolstadt in Bavaria. These two men played a prominent part on the Catholic side in the clash of religions which the growth of the Counter Reformation made inevitable.

Ferdinand II, was perhaps more than any other single man, responsible for the spread of the war from Bohemia to almost every corner of Germany and also for its long duration. For the whole of his life, he was as much a monk as an emperor, hating the Protestants with all the fibres of his being. Before being elected Emperor he had quickly extirpated the Protestant "heretics" from his Austrian domains, whilst his plan to do likewise in Bohemia brought about the "defenestration" of the deputy-governors in Prague which has already been described. Maximilian, who was closely related to Ferdinand II by marriage, began also to deal roughly with "heresy" in Bavaria.

The growing militant attitude of these powerful Catholic rulers gave serious concern to the Protestant princes, who until about 1608 had not been greatly threatened. Under John George, Elector of

Saxony, they now formed the Protestant Union to oppose the far stronger forces of the Catholic League which was in alliance with Spain.

When Bohemia finally revolted in 1618, Frederick, the Calvinist Elector of the Palatinate, unwisely offered himself as its new King. Seldom in history have "fools rushed in where angels feared to tread" more flagrantly than Frederick and Elizabeth his wife, the beautiful daughter of James I. Their action, although prompted by a real desire to strike a great blow for the Protestant faith, was ill conceived and unsupported by many of the Protestant princes, in particular John George, the Elector of Saxony.

The Palatinate was in the heart of the Rhine Valley and coveted by Maximilian, the Catholic Duke of Bavaria. With the defeat of the Elector Palatine in Bohemia, the war could no longer be localized and spread like a slow fire to almost every corner of Germany. The now almost legendary figures of Mansfield, Tilly, Wallenstein, Gustavus Adolphus, Bernhard of Saxe-Weimar, Condé, Turenne, together with many others of less enduring fame, proceeded in turn to spread havoc and destruction from Bohemia to the Baltic and from the Meuse to the Elbe.

Western Democracy *v.* Communism

Although the princes and the soldiers of the Thirty Years War were hard men, cruel and barbarous, politics and the lust for power were not their sole ruling passions. Most of them believed profoundly in the battle, which they were fighting for the Christian religion. This fact lends a certain splendour to the story of the Reformation in Germany, which is sadly lacking to-day in the history of the cold war of materialism.

The struggle between western democracy and communism, i.e., the cold war, is related in the main to the industrial revolution of the last century and the two World Wars of this one. The industrial revolution, whilst adding enormously to the development of the world, bore hardly on the manual labourers who helped to achieve it. Extremes of riches and poverty in the Victorian age created a disparity of living conditions, which gave embittered reformers of the depressed classes every cause to search for drastic remedies.

Amongst them was Karl Marx. In his famous works, *The Communist Manifesto* and *Das Kapital*, he propounded a new social system. Ignoring the genius of inventors and the bold enterprise of industrialists, he asserted that the value of a commodity is solely the value of the labour required for its production. The labourers, he said, produce far more than they are ever allowed to consume, so that "a surplus value" is created which, in a capitalist state, is unjustly seized by the employers. The latter are therefore social enemies, ripe for violent removal.

Before World War I, the political systems of the west, which also gradually took action to improve the lot of the workers, were far too well organized to be vulnerable to Marxist violence. Indeed, in the more progressive democracies, notably the U.S.A., a man prepared to work hard with his hands came not only to live well, but also to be socially important in the community.

But to the down-trodden, poverty-stricken masses of Czarist Russia, the doctrines of Marx had all the force of a new religion. Before the end of World War I the Russian revolution broke out. Kerensky's mild form of it was soon swept away by Lenin who, as the veritable god of Marxist communism, proceeded to destroy the crazy capitalist structure of Czarist Russia with all the ruthless violence advocated by Marx.

During the years between the wars, the U.S.S.R. were fully occupied thrashing out the details of the communist system, which soon came to differ profoundly from that of Marx, but still required to be world-wide before it could work with even moderate efficiency. In order to bring this about, the Soviet leaders invested their communism with the sanctity of a religion, to be propagated in every possible way to the frustrated and discontented of every class all over the world.

Chester Wilmot has well shown in his *Struggle for Europe* how the Allies completely defeated the Axis powers in World War II, but presented the Soviets with precisely the chance of making communism the world system, which its inefficiency requires.

Belief in communism, kept up to concert pitch with all the ingenious resources of modern police states, is now general in eastern Europe and large tracts of Asia. Vast armaments with masses of men trained to use them enable the Soviets and their satellites to increased the tension of the cold war, which can be fanned at will into considerable rebellions anywhere on the periphery of communist Eurasia.

Germany, once the sure bulwark of western Europe against the East, is divided and prostrate. The other continental nations of the West are torn by political factions and blasted by economic blizzards. Had it not been for the practical generosity of the U.S.A. and the staunchness of Great Britain, the cold war would have been already lost.

For western Europe is at once the strategic and material object of the Soviets. They want, if possible, to secure it intact, in working order so that the mines, the great industries, the commerce and all the rich resources of the Atlantic countries may, under obedient Quislings, be put at once to the service of Communism. Even now their fond hope seems to be that the economic strain of resisting the physical thrusts and moral pressures of Communism will overwhelm the Western Citadel.

The western democracies, who have forgotten more about the art of living than the Soviets ever knew, cannot do otherwise than arm themselves against the prospect of being overwhelmed by such a bleak and merciless tyranny.

Thus the rival forces of Communism and the Atlantic Democracies glower at each other in the east and west, much as the armies of the Catholic League and the Protestants did in miniature in the Germany of 350 years ago. Right amongst them, the Germany of to-day with characteristic toughness and matchless industry goes ahead with the rebuilding of her country. " If I intended to plant an apple tree to-day and suddenly heard that the world was to be destroyed to-morrow, I would still plant the apple tree " (Martin Luther).

Some Resemblances

No observer, however distinguished, can truthfully say that the struggle between Western Democracy and Communism is in any way an historical repetition of the storm which gathered between the Reformation and the Catholic Church before the outbreak of the Thirty Years War.

One was a spiritual conflict ; the other is a material one. The influence of power and politics is apparent in both. Each was, or is, a prevailing anxiety of mankind. If it be permissible, however, to compare such widely differing human anxieties, some striking resemblances do present themselves. The social progress of the western democracies can be likened to the unregimented, haphazard advance of the Reformation in Germany. At the same time, the rigid formation of the Communist system recalls the words with which Lord Acton, the Catholic historian, describes the doctrine of the Counter Reformation " It impressed on the Church the stamp of an intolerant age and perpetrated by its decrees the spirit of an austere immorality." The Inquisition in Spain and the Netherlands, the stamping out of heresy by force in Austria, Bohemia and even Bavaria and the ejection of Protestant priests from their livings all over Germany caused precisely the same sort of panic then, as the tyranny of the Communist system does to-day. Nor are the Soviets backward in their long-term use of the school for the correct orientation of their youth.

As in the opening years of the seventeenth century so now, the eyes of the world are fixed on Germany with whose future the outcome of the cold war is inextricably entwined. Foreign armies are quartered in her divided country, which has yet to settle how it is to be finally governed. If it came to real war, it is also for Germany that the contending forces of western democracy and communism would fight.

The moral and economic struggle between the capitalist system and communism has already been going on for over thirty years. If the long incubation period of the German religious war is any criterion, it might well take another generation before a *modus vivendi* between western democracy and communism is arrived at.

THE LESSONS

When the Thirty Years War finally came to an end in 1648, at the peace of Westphalia, owing to the exhaustion of the combatants, it had in reality settled very little. It merely crystallized the religious *status quo* which had existed before the war began. It decided none of the great problems of Europe. Like the Treaty of Versailles, it just rearranged the map of Europe in such a way that further war was almost inevitable. The Empire became a mere geographical term. Germany continued even more than before to be a mosaic of quarrelsome independent states, instead of emerging as a strong and united country.

If this famous war of the past has any lesson for the world to-day, it is surely to show the futility of compulsion for the settlement of any great clash in the beliefs of mankind. Even in 1618 those nations prospered best, which in an intolerant age were more tolerant than their neighbours. In the end men revolt against tyranny : things must come as they can.

The second lesson, which is as clear to-day as it was both before and after the Thirty Years War, is the crying need for the good government of Germany. The Allies made great political errors in the final stages of World War II, but they at least postponed the conclusion of an immediate peace treaty with Germany. If they had not done so it would have no doubt been as faulty as that of Westphalia in 1648 or of Versailles in 1919.

In the years to come the world may have cause to be thankful that the intransigence of the Soviets has caused such profound delays in the settlement of Europe. They may unwittingly have enlisted time on the side of peace by enabling Germany to work out gradually a sound constitution, which will interlock with those of her neighbours as part of a united Western Europe. Time is an irresistible remedy for evil passions and violent ambitions. The storms pass and reason returns. A cold war lasting for a long time may prove to be a blessing in disguise.

ON BURSARS AND BURSARING

By One of Them

SAPPER officers, especially those who have some staff experience, have so many of the qualifications required by a bursar that they may be interested to read something of how to set about becoming a bursar and of what a bursar does.

Some schools and university colleges do not advertise vacancies, but find their bursars privately, by invitation or personal recommendation. In these cases, of course, there is nothing to be done by the would-be bursar except to hope that he will get such an offer. If he has contacts among Fellows of colleges, headmasters or members of governing bodies, he can make sure that they know he is in the market, but beyond that there is little or nothing he can do himself. College bursars, for the most part, have to be graduates of a British university, but Sappers who have a degree are eligible and ought to stand a good chance of success. Public schools do not usually insist on any such qualification and the field there is open to all.

Many schools obtain a new bursar when they want one by advertising in the "personal" or "official" columns of *The Times*, *Daily Telegraph*, or similar papers. Such announcements seldom appear more than once and applications for the more attractive posts may number several hundreds. Of these, a large proportion can and must be ruled out at sight, so it is all the more important that applications should be clearly typed and as brief as possible, whilst stating qualifications and experience in terms which civilians will understand.

The decision whether to put in for any particular job must rest with the individual concerned, of course, but obvious preference will go to the jobs which carry a house or residence as part of the emoluments. Salaries and conditions vary vastly between schools, some of the less prosperous of which still have to rely on getting a man who already has a pension, since they can offer perhaps only £400 or so per annum as salary. On the other hand schools which have not much spare cash to offer as salary can often make the bursar's job more attractive by offering other emoluments in kind. The more obvious forms of this are free produce from the school garden, free firewood from the estate, use of school car or the running expenses of the bursar's own car, and so on. In another direction, but with the same effect, one school offered a new bursar free education for his sons at the school—no mean consideration at the present time! Such emoluments raise delicate questions in relation to income tax, and will not usually, for this reason, be set out in any detail in the announcement of a vacancy. Moreover applicants should realize that the tax position is by no means clear at the present time and that a school may find itself forced to withdraw some or all of the valuable emoluments in kind. Since their real worth to-day is often double their face value, few if any schools which now remunerate their bursars on this basis would be able to make them as well off on a wholly cash basis. However, this may not happen, and the chance is probably well worth taking.

Canvassing for a post is usually forbidden, either expressly or by implication, but it is as well to face the fact that with such a large field as every good bursarship attracts nowadays it is probable that the last three or five, or however many are selected for interview, may well be, to all intents and purposes, equally well qualified and suitable. How, then, will the winner be picked ? Obviously a candidate who is personally known to one of the selectors or to a Governor of the school will have that little pull over the others that may land him the job. This is not favouritism or graft, but plain common sense, and the inference is obvious.

Now for the job, if and when you get it. It is important to realize that the professional public school bursar is a comparatively recent innovation. Not more than a generation or two back a large part of what is now the bursar's work was probably done by the headmaster and the remainder by members of the staff who might or might not be relieved of some of their teaching periods to give them time for their bursarial duties. A second stage was the appointment of full-time bursars, but selected from masters who were getting too old to teach, were not quite fit or for some other reason could not go on as masters. Some schools did use the title of bursar for a sort of superior clerk or foreman, but it is only within the last few decades, in most cases, that schools generally have looked outside their own staffs for someone competent and qualified to tackle the administrative problems of running their affairs and have appointed full-time non-teaching bursars whose experience has been gained outside the world of letters. For this reason the duties of a bursar and his relations with the headmaster and with the governing body will vary greatly according to the stage of development which a particular school has reached in this respect. In some the bursar will still be little more than a superior clerk, directly under the orders of the headmaster. Others regard the bursar as directly subordinate to the headmaster, but much on the level of the assistant masters—though he is probably older and more experienced than most of them. Finally there are schools in which the bursar, appointed directly by the Governors, is not subordinate to the headmaster, but is answerable directly to the Governors who appointed him. His relationship with the headmaster is not usually laid down in black and white and it is better that this should not be so. Obviously the bursar must and will co-operate very closely with the headmaster and will meet his wishes as far as he can and as far as they appear to him to be within the policy outlined to him by the Governors. But where the appointment has been made on this basis, the bursar has, as it were, a dual loyalty, to the headmaster and to the Governors, with the right and duty to report direct to the latter on any matter within his province in which, after due consideration, he has been unable to reach agreement or at least compromise with the headmaster. The position is not one which lends itself to clear definition on paper or in detail and tact plays a large part in making it work, but unless there is a complete clash of personalities it does work, and that is the thing that matters.

The range and scope of a bursar's duties vary tremendously in different schools. He may be required only to carry out instructions given to him in detail or he may have the whole financial policy of the school in his hands. Between these extremes lies a multitude of duties and responsibilities which may be his. Where there is central catering and feeding, these will be his concern. Almost always he will have responsibilities for the upkeep and decoration of buildings, for the office organization, including the preparation and collection of bills, for the maintenance of gardens and estates if any, perhaps including woodlands. He may be concerned with the registration and entry of boys, though more often this is done by the headmaster and his own secretary. And he may have one or more school shops or trading departments on his hands. In general, he may be the stooge to whom everything comes which is not thought to be the job of a master and responsible for the entire daily running of the school apart from actual teaching, or he may be a rather remote figure who has no contact with boys and little with masters but who sits in an office and deals with financial policy without having much to do with the daily and detailed problems. Somewhere between these two extremes lies the description of probably every bursar's work and equally probably no two are exactly alike in their responsibilities and limitations.

One thing for which the bursar is certain to be personally responsible is the upkeep and maintenance of buildings. In many schools, these are now of an age at which major repairs to roofs and structures are inevitable, and since little or nothing could be or was done during the war years, there is always a big lag to be made up in minor repairs and decorations. So a bursar must expect to give a good deal of his time to this part of the work, and the presence of a really reliable and energetic clerk of works, or assistant in that grade, will be a tremendous asset. In some places the actual work is done entirely by contract. In others there is a small permanent maintenance staff to deal with emergencies and minor repairs, whilst projects and major repair works are put out to contract. In yet others, there is a larger permanent staff, capable of undertaking everything except major projects. The merits and demerits of these three systems can be debated *ad infinitum*. Each has advantages and disadvantages and the choice between them must be made for a particular school in the light of its own particular problems, chief among which will be the nature and size of the buildings as well as their age and condition and the availability locally of satisfactory contractors. Usually there will be a school architect or surveyor to help in this important department of the bursar's responsibilities. He may be purely a consultant who only comes when called in for a special purpose, or he may have a more general and continuing responsibility for the buildings, perhaps involving an annual survey and report on which can be based the year's programme of major work. The extent of his responsibility in detail and for supervision of work in progress will clearly depend on what resources the school has in the way of a clerk of works and maintenance staff, and again probably no two schools have identical arrangements with their architects or surveyors. In general, the bursar's job will be to make the best use of their expert advice and experience whilst retaining to himself the right to decide priorities and details. The bursar will also have to maintain good relations with local and other authorities who nowadays have so much to say in the matter of licensing, planning and other aspects of building and repairs. These authorities, it seems, vary greatly in their approachability and helpfulness, but the Sapper-bursar will be unlucky if he does not find somewhere, in some ministry or department connected with this branch of his work, another ex-member of the Corps to help him find his way successfully through the labyrinth of forms and formalities which have to be negotiated before he can put in hand any but the smallest building project.

The value of personal contacts is generally realized, but one example may not be out of place. We wanted to do some work on a building in the grounds, to make it more suitable for occupation by a member of the staff. The building had originally been an ornamental temple, one of many put up in the spacious days before the school had been thought of. From the beginning the school authorities had been careful not to spoil the façade of any of the old temples and shrines and to give full attention to the æsthetic aspect of any proposal for alteration or building. Then the Ministry of Town and Country Planning got into its stride. Somebody told them that this particular temple was an ancient monument. It wasn't, but when this was pointed out the rejoinder was that it was, or should have been, scheduled as being "of historic or architectural interest."

Arguments and correspondence went on for weeks between the school, the Ministry, the local council and other bodies until at last, fortunately, I got a letter signed by a man with whom I had served. He asked a host of questions, more or less going back to the beginning of the case, but my reply was brief. In essence it said "This has been going on for ages. Before either of us wastes any more time over it, come and see it for yourself and bring your experts with you." He did. Within half an hour the whole thing was settled and the contract for the work prepared. As it happens, that particular *Deus ex Ministra* was not a Sapper, but the principle is the same.

One of the bigger headaches that a bursar will have to face if his school is one in which the catering and feeding is centralized is to get and keep any sort of reliable domestic staff. He may find one or two old retainers but the rank and file provide a permanent problem. If he is lucky enough to find that the school in the past had sufficient foresight (and funds) to provide married quarters for the bulk of its employees, the problem will not be nearly so difficult, for the offer of married accommodation is often sufficient inducement to many good servants to come and stay. Even if quarters are available, there may be snags. Nowadays a wise bursar will invoke legal advice and ensure that they are all occupied on "service agreements" so that employees must vacate them immediately they leave the service of the school for any reason whatever. In the past this was seldom the practice, and many cottages and flats, badly needed for staff, are still occupied by ex-servants who cannot be dislodged.

If, on the other hand, there are no married quarters and all the staff have to be unmarried and resident, the bursar is in for unending trouble. Where "dailies" are available, they help, of course, though they are not a complete solution as they will seldom come early enough or stay late enough. In some schools, too, the boys themselves do many of the domestic chores, but even so, indoor staff is perhaps the worst problem a bursar has to face. There is not only the problem of getting them. Their quarters may be small, dark or inconvenient, in which case they will not stay. The school may be too far from the "local" and the cinema, and they will soon leave such rural simplicity. In desperation, when the only alternative is to start a term hopelessly short-handed, you may have to take on servants without references, only to discover after a week or so that all unwittingly you have engaged the entire bad hats of the worst streets of Jarrow—or so it will seem to you. One thing is certain—they do respond to what may be called "welfare" arrangements. What is equally certain is that they will be quite incapable of expressing any appreciation of anything that is done for them in this respect. But gratitude is there and will gradually show itself—by increasing self-respect and by fewer failures to return after a holiday or departures without notice.

In many schools the bursar will have at least some responsibility for catering and feeding. The ultimate cost of feeding will certainly be his concern, and it is very hard to control at the present time if reasonably high standards are to be maintained. Since he cannot be expected to be an expert caterer or dietician, he will have to depend in this department on a subordinate who has the necessary qualifications and here he may have a delicate problem. A few schools still retain male stewards for this purpose but the majority employ women, and to find the right one is by no means easy. There are plenty who have all the training and experience needed and whose credentials on paper look admirable, but the real success or otherwise of the person employed depends largely on personality and temperament. The most efficient and scientifically sound caterer in the country will be a failure in a school unless she can keep and get the best out of the domestic staff, hear without resenting the sort of crude criticism which will always come from boys (and sometimes from masters too) and keep the peace between all those who cook, serve, or eat the meals she designs, or wash up. Where there is a master's " mess " or common-room for meals, this will often provide the most difficult part of her job and it will frequently be worth while sacrificing a little technical efficiency for the sake of a personality which will get on with every grade throughout the school and earn their respect and liking.

The bursar who finds himself in a school where the feeding is entirely by houses is much more fortunate, for he is saved much daily and detailed worry, since this falls on the housemasters or, to be more correct, their wives or matrons. In these cases the bursar's responsibility will usually be limited to a general supervision of the over-all cost of feeding, but even here much tact can be required. It is not easy to tell a senior master that his wife must be inefficient or wasteful, since she has spent so much more than the others in feeding the same number of boys, but sometimes a way has to be found of conveying this impression

A great deal of a bursar's time will naturally be spent in his office though—as elsewhere—the more he can get out and about the better. Owing to the way in which many bursar's jobs have " just growed " without any planning, it will often be the case that the office staff are admirable from the point of view of loyalty, industry, and reliability but seriously lacking in method and experience. When, as often happens, one or more of the staff have been in the job for many years, it is hard to persuade them that their methods are not the best and that time and money can be saved at the same time as efficiency is improved. Much can be done by patience and perseverance and it is something of a reward when the oldest clerk, having stubbornly resisted some change in procedure, is at last persuaded to try it and some time afterwards voluntarily admits that it is an improvement. When this has once been achieved the next change or improvement will come far more easily. This experience is not, of course, confined to bursars' offices but it is perhaps more marked in schools than elsewhere since the clerks are so often not trained clerks at all but men or women who have at some early stage been brought in "to help in the office" and have stayed on until their local knowledge proves so valuable that professional ability or the lack of it has been overlooked.

The soldier-bursar may find schoolmasters a strange race to deal with, though at the present time he will be helped by the fact that most of the younger members of the staff will have been in the services and will be to that extent more human. But among the older ones there is an inevitable tendency to such a narrow outlook that they find it genuinely difficult to see beyond the confines of their own particular problems and to believe that a mere bursar can possibly understand anything academic. There is often, too, a curious inability to delegate responsibility. I have heard a senior master, when approached regarding something that had gone a bit wrong, say that he had delegated the matter to so-and-so and it was therefore no longer his responsibility and he could not discuss it! A commander who took that line would not last very long. But schoolmasters will respond fully to a willingness on the part of the bursar to listen to their problems and discuss them frankly, even if his answer has so often got to be discouraging. He must be accessible and prepared to receive complaints or requests at literally any time, regardless of the hour or the circumstances. He may keep reasonably fixed office hours himself, but it is fair to say that the good schoolmaster does not—he is "on the job" in one way or another for the whole of his waking hours in term time and must be forgiven if he forgets that the bursar does not enjoy the same degree of freedom in the holidays and must, therefore, if he is to retain his health and sanity, put some limit to the number of hours on duty in term time.

Contact with boys is not easy to establish or to maintain and the extent to which it is desirable is open to question. Here again, schools vary tremendously. In some, it is a habit of masters to tell a boy to "go and see the bursar" about any trivial thing which does not happen to be the master's own concern. This system certainly helps the bursar to get to know some boys—if he wants to—but has its disadvantages and may lead to his being smothered in a mass of petty detail to the detriment of his judgement in broader matters. Opinions differ as to how much the boys should be told of the financial and economic problems of schools. Since there seems to be an increasing tendency on the part of parents to give boys an allowance out of which they must pay their own school bills—or at any rate their "extras," if not actual fees—it seems only fair that they should, at least after a certain age, know something of the difficulties which face schools to-day and the reasons why certain economies have to be made, why servants of all kinds have to be considered so carefully and why, for instance, certain forms of damage, though perhaps not very costly in money, are definitely anti-social in these days of licences, shortages of material and so on. Anyone can, from books of reference, find out what the fees of a particular school are and by multiplying that figure by the number of boys, discover its gross fee income. The result will be a large figure, particularly in the eyes of a boy or a parent of modest means, and it is easy to say " What, so many hundred thousand pounds a year coming in and we can't have this or that! Ridiculous!" Yet there are few if any schools to-day that can balance their budgets and it is at least arguable that senior boys should know something of the general position and the problems that schools have to solve in order to maintain their standards. At the same time, it must always be remembered that the school depends for its existence on keeping up its numbers, and any careless disclosure of its financial difficulties may well discourage potential parents from sending their boys. Moreover, facts can easily be distorted and those retailed by boys or even masters, though given to them in good faith and in confidence, might well be presented to others in such a way as to react unfavourably on the entries to the school. So taking all things into consideration it is perhaps best not to divulge too many detailed facts about the economic position of a school, but at the same time it should do no harm to give masters and boys a little more general information on this subject than they usually have had.

As in the services and elsewhere, games and " out of school " activities provide the best opportunities for getting to know both boys and masters. Whether a bursar is more interested in games or in music, art, debating or model railways, he will almost certainly find something going on during the term in which he can take part and to which he can contribute. Participation in activities of this kind will not only give him his own pleasure and relaxation but will also make him known to both masters and boys and help them to realize that he is human and reasonable, not an "abominable No-man" who sits in an office making difficulties, enforcing unpopular economies, sending out bills and generally dispensing gloom and discouragement.

One word of warning to those who fancy the idea of becoming a bursar. It is not " a nice soft job." Admittedly the bursar is not tied to a time-table or even to rigid office hours. Generally speaking, the job is there to be done and it is his own affair how and when he does it. But it is a big job and one which entails a lot of hours of work all the year round. Some people think that because the job is at a school the bursar will obviously get the nice long school holidays. Not a bit of it. Often he is busier in the holidays than in term time.

To begin with, there are the term's bills to be prepared and sent out. Whilst little if any of the mechanical work here will fall to him, it is surprising how many questions will arise while it is going on which require the bursar's personal attention. Then it is only in the holidays that major works of repair and decoration can be done, and although again the supervision of these will fall to the clerk of works, and the instructions will have been given in advance, there are few days when some problem does not arise to which only the bursar himself can give the answer. Before the beginning of the next term there are many things to be done, especially if there is new staff to be got, and the holidays soon pass. It is, in fact, easier for the bursar to get away during term time—about three to four weeks after the beginning of the term, when the school has settled down to routine and the immediate problems have been solved is usually the best time—though even then he will find it difficult to be away for more than about a week at a time. On the other hand, he can take his short holidays in, say, June and October, two of the loveliest months in the year, when hotels and resorts are not crowded, and the psychological effect of taking a holiday when all his colleagues are working hard makes up for a lot.

It has been argued at great length whether it is better for a bursar to live right in the school grounds or well outside, say two or more miles away. The answer depends a lot on the man, but also on his particular job and the location. If he is right on the spot he will have no peace, for schoolmasters are quite without conscience as regards intruding on a mere bursar at any hour of the day or night. On the other hand he does not waste time travelling and can often combine business and pleasure by an evening walk around the estate. If he lives well away from the school he does at least get a complete change of atmosphere every evening to compensate for the shortness of his proper holidays. At the present time, however, there is little object in arguing this point, for a Bursar will usually have to live wherever there is a house available for him, and the question of choosing for himself will seldom arise.

By the very nature of the job, the surroundings and his associates, a bursar's life can be a very pleasant one and he can get great satisfaction out of the feeling that he is helping to preserve the tradition of the public schools and to enable them to carry on their work against all the odds of the present difficult days. On the other hand a bursar's job is not one to be undertaken by anyone who is only looking for "something to do" with a salary attached. Financially, bursarships are, in most cases, not lucrative but reasonable propositions, and in some schools there is a pension scheme which is an added attraction. Plenty to do, in pleasant surroundings with congenial colleagues—there is much to be said for these things and there is nobody better qualified to enjoy them than a Sapper officer.

THE TERMITE PROOFING OF BUILDINGS IN SOUTH AFRICA

By CAPTAIN (S.W.) T. G. LAYTON, F.F.B., F.A.B.S.S., M.R.SAN.I., M.I.C.W., R.E. (RETD.)

DESTRUCTIVE termite infestation is a natural and common problem to southern Africa, and calls for the greatest possible degree of careful study and protective methods of construction. To be successful, these protective methods must be well designed and constructed as a permanent feature in building works, since the failure of such protective methods may well lead to serious loss and damage to property.

It is now common practice in this part of the world, to pre-treat *all* structural timber in framing and finishings before incorporation into the works, and to prepare building sites, particularly in foundation work, before any structural work is commenced. Further, a system of metallic "ant-guards" are built into foundation walls below ground floor level, to ensure complete security from attack through the passage of time.

It is proposed in this short paper to give readers a clear picture of what should be looked for, and what should be done, in dealing with this type of work, and it will facilitate the study of the subject if followed in the following stages :—

(1) Site excavations.
(2) Foundation excavations.
(3) Foundation concrete.
(4) Foundation walls to floor bearer level.
(5) Carcassing and finishings.

1. SITE EXCAVATIONS

The building area should be thoroughly cleared of all cellular growth and particularly of tree roots and stumps, which should be burnt, or disposed of, clear of the site. An area of at least fifteen feet all round the plinth line of the building should be similarly cleared and dealt with.

With clearance completed, the area should be examined for the presence of termite infestation, and soils containing a preponderance of clay or clay-marl should be suspect, particularly if inclined to be damp. Soft spots should be excavated and any " white ant " nests dug out and burned. The nest area should be heavily doused with a solution made up from equal parts of diesel sludge and power paraffin and then filled in with hard material and well rammed to consolidation.

Experience has shown that white ant infestation can be discouraged to some degree by treating the whole building area with a heavy saturation of the solution referred to above. Yet another useful treatment can be obtained by spreading a 6-in. layer of sea sand over the areas between walls under new buildings. A similar effect can be obtained by spreading rock salt crushings over such areas, to a depth of at least four inches in thickness.

In every case the above treatments break down and kill off possible cellular growth, and make the surface soil difficult for the insects to " work."

The writer obtained a measure of success by employing a layer of furnace ash, screened free of dust, laid 4 in. in thickness over areas between walls, and then spraying the areas with the diesel sludge/power paraffin solution, previously referred to. No growth of any kind, and no termite activity has taken place over these areas.

Yet another method that can be employed with success, is that of laying down a bed of clean, dry, crushed, hard stone.

In general then, all covering materials should be dry, free of any dust, and if possible salty, in order to render it impossible for termites to work, that is, build up their " tunnels " and " hills " from damp, fine particles in the coverage.

2. Foundation Excavations

During the excavation of foundation trenches, care should be taken to watch for deep roots, soft spots, and signs of termite nests. It cannot be too heavily stressed that a few hours spent at this stage will probably save endless trouble later on. It is a sound proposition to prod over the bottoms of trenches with a stout metal rod to discover spots which, whilst looking quite sound, may form part of a " crust " of earth covering a " live " (working) or a " dead " (abandoned) nest. *Without fail*, dig them out, treat, and fill them.

If the foundations are cast with, and form part of, a monolithic slab, a layer of sieved furnace ash, 4 in. thick, should be laid over the whole area and this should be treated with a thorough soaking of a solution composed of 5 per cent pentachlorophenol in oil, at the rate of at least 1 gallon to the square yard, paying particular attention to the sides of trenches which will come into contact with concrete when foundations are poured. Level pegs should be of mild steel bar offcuts. Timber pegs, if used, *must* be pulled out as soon as the concrete is levelled.

Where strip foundations are laid down and floors are suspended, trenches may be left untreated since the structure will be proofed at a level above that of the surrounding ground.

The pentachlorophenol solution is a toxic treatment which actually kills off those insects coming into contact with it, as distinct from the previously mentioned types, which actively discourage termite life by their value as a repellant.

3. Foundation Concrete

While the design, mix values and general application of concrete foundations are not, in themselves, affected by the subject under review, it is as well to consider the possible effects of termite infestation below foundation levels. It is quite possible that damage to foundations may occur from the activities of termites, as nests may well be formed many years after the building has been completed, and it is in this connexion that the question of concrete is considered. Care should be taken to ensure that concrete in foundations is of consistent density, leaving no kind of harbourage for termites to build into or against, and since the formation of nests can mean a weakening of the bearing value of the ground beneath foundations, it is sound practice to reinforce foundations against this possible contingency. Generally, such reinforcement comprises lateral bars $\frac{1}{2}$ in. in diameter, one bar being provided for each $4\frac{1}{2}$ in. thickness of wall work in the structure. These are hooked at ends, and secured at 5 ft. intervals with $\frac{3}{8}$-in. cross binders, the whole set into position about one inch up from the bottom of the foundations.

It will, of course, be appreciated that this reinforcement will not be required where foundations are cut into, or formed on to rock formations, but in any other kind of excavation it is good practice to afford the additional cost of reinforcement as a well-advised safeguard.

4. Foundation Walls, to Floor Bearer Level

It cannot be too strongly stressed that *all* brickwork in foundation walls should be grouted up at each course. Experience shows that termites will take full advantage of any void or crack to find a path to their natural food, cellular material of any description. This means timber, paper, and combinations of the same in certain types of building boards. These they will attack and consume at a rate which must be seen to be believed. It is imperative that they *must* be stopped, and a pre-requisite to this end is the sound construction of foundation brickwork.

Free access to the underside of floors must at all times be provided, and in practice it is usual to arrange for a minimum clear space, *within* external walls, of 24 in. between ground level and the underside of floor joists, to enable inspections to be made.

Since the termites avoid light and free air (except during the mating period), and will build themselves small tunnels of clay-earth in vertical runs above ground level, it is good practice to arrange for as much light and air to be available to the underside of floors as possible. This can be best arranged by providing as many access openings as practicable around outside walls, and providing similar openings through all internal walls, usually under doorway positions. The general practice is to provide one or more access openings on outside walls, with $4\frac{1}{2} \times 3$-in. vents (headers left out) at 18-in. centres, along at least three sides of the structure.

Each access opening is provided with a suitable brick or concrete lintel, and all internal wall surfaces should be "bagged," that is roughly rendered and rubbed smooth in a mortar mix of about one part cement to seven parts of clean river or pit sand.

When thoroughly dry, all surfaces, including those on any sleeper piers, are limewashed two coats in white to reflect as much light as possible. An admixture of "Gemmaxene," or other suitable insecticide, will be of advantage when so limewhiting. Provided these whitened surfaces are kept clean, any attempt by termites to travel up the surfaces of these walls will be quite easily seen and dealt with. A great deal of avoidable damage is done through the failure to comply with normal and reasonable measures, and of failure to carry out regular and adequate inspections.

Dealing with constructional work, the normal damp course is provided usually by means of an asphaltic felt course, and in this connexion, a brushing of cold bituminous emulsion on the brick bed when laying the damp course, will improve the damp proofing value of the course and act as an added deterrent to possible attack through the body of the brickwork.

In all good-class construction, one further course of brickwork is laid above the damp course level and the top of this course is well grouted in and levelled up with mortar, to take the termite proofing course, more generally known as the "ant-guard."

This ant-guard course is prepared from No. 24 gauge, plain, galvanized steel sheeting, laid down on *all* walls, and at the same level all round. The metal must be of the full thickness of the wall and must project a minimum of 2 in. past the internal faces of all walls. All joints must be lapped and riveted into position and then soldered securely together. To avoid double thickness of metal at the outer (inside) edge of the ant-guard, a small diagonal snip is made on the end of one sheet and this prevents possible crawling of termites around the thickened joints.

Every sleeper pier must be similarly treated and in these cases the ant-guard must project a minimum of 2 in. *all round*. At this stage, attention must be drawn to the necessity for providing effective ant-guards to all chimney breasts, and similar foundations. This may be effected in two ways, either by taking the sheet metal through the full thickness of the brickwork with projection on all inside wall faces, or by arranging such foundations as hollow boxes with access openings to the inside surfaces. The ant-guard may in this case be arranged to project on the inside face of external walls and to project on *both* sides of all internal walls.

Similarly, where water, waste, or vent pipes pass necessarily *below* the level of these ant-guards, such pipes *must* be provided with metal aprons arranged as square or circular apron pieces sweated on to pipes at ant-guard level. These are necessary to ensure that termites do not by-pass the ant-guards on walls via pipe runs to floor levels above.

In practice, these ant-guards prevent termites from crawling up the internal faces of walls and gaining access to cellular materials in wood floors, roof framing and finishings. The termites reach the underside of the guards, but are physically unable to climb around the thin edge of the guard and fall off when attempting to do so.

It should be carefully noted that all steps from ground level to floor level should be arranged as free standings with the soffit readily accessible either from each side, or from the inside of the structure. Again, it is good policy to provide a metal ant-guard built into the soffit of the steps at ant-guard level to ensure that termites do not gain access to brickwork above the ant-guard level. Care must be taken to ensure that all wooden centring and formwork is removed from hidden positions, and that surfaces thus disclosed are whitened.

In spite of every precaution taken, it is still possible for infestation to take place through termites forming small ant-hills under floors away from ant-guard positions, and the only reliable safeguard against this is to ensure regular and thorough inspection of *all* under-floor areas. Any indication of activity found must be promptly and effectively dealt with to ensure maximum destruction and prevention of future trouble.

So far, we have dealt only with the " Termite Badius " or " flying ant " which flies *only* during the mating period, nests in the earth and finds its food in the cellular growth or products of that growth in structural materials. It must be constantly remembered that the multiplication and activity of these termites is a factor to be dealt with at all times with the greatest care and persistence.

5. Carcassing and Finishings

Now we deal with the fabric of the structure above ground floor level. Provided always that the foregoing precautions have been taken and regular maintenance inspections are carried out there is little chance of infestation from the type of termite previously referred to. There is, however, another and equally destructive termite, the "Cryptotermes Brevis," more commonly known as the "borer." This very much smaller insect flies freely and takes up its abode in any kind of cellular material. Further, its depredations are not so easily seen and evidence of infestation is difficult to locate until it is too late to do very much about it. Generally, the examination of infected wood specimens will reveal small holes in the surface of the timber, with long running tunnels traversing the length of the material. In common with every type of termite infestation, the "heart" of the material becomes eaten away, leaving the shell or outer skin of the material intact. Therein lies the danger to structural stability and safety.

It will be observed that the outer skin is generally left intact by these insects, and therein again lies the key to the possible treatments.

Avoidance of light and a distinct dislike for any kind of fabric treated with oils, such as paraffin, turpentine, or the heavier carbon distillates used in the preparation of wood preservatives and/or paints, are characteristics of all termite life. So the answer is to treat *all* timber, without exception, with a highly penetrating oil, and, if possible, under pressure. If, in addition, it is possible to introduce a toxic agent at the same time, the treatment will be so much more effective.

In the coastal areas of Natal where termite infestation is common and constant, *all* structural timber, in both carcassing and finishings, is pretreated in a solution containing 5 per cent pentachlorophenol (which is a toxic agent), with white spirit or paraffin to act as a penetrating agent, together with a binding agent to prevent the formation of phenol crystals on the surfaces. The treatment is carried out by the low pressure cylinder method, but treatment in the spraying tunnel will be found effective.

The major timber suppliers have now installed suitable plant, and *all* timber leaves the stockyard in a heavily treated condition. The suppliers have contrived to produce, and with some success, a non-staining treatment to which paint can be applied, but while this claim is substantially true, it is wise to ensure that all timber earmarked for painted finishes, should be allowed to air-dry for about seven days before being painted. Similarly, care should be taken to ensure that all cut ends are treated before being fixed into position. The ends of truss members and ends of rafters, purlins and floor joists require special attention.

All this entails extra work, but care taken in doing this particular work will ensure the maximum possible protection. Costs in materials and labour to carry out the treatment mean an average increase of about 11 per cent on timber totals, but in areas infected by termite life this additional cost is very well worth while.

To round off this brief paper, it may be of interest to quote actual cases where the writer has dealt with specific treatment services.

Firstly, whilst in Egypt in 1937, it was necessary to rush prefabricated camp structures from the Western Desert area to the troubled districts of Palestine. The structures were passed through a servicing and repair section in Cairo. As many parts were found to be infested with borers, all parts were heavily brushed with a solution of diesel sludge and power paraffin in equal parts to obviate any chance of further infestation, and also to prevent, if possible, the introduction of this trouble into Palestine, where it does not exist under ordinary conditions. No infestation or damage from termites took place in these structures up till the time they were disposed of in 1945.

Again in Natal in 1946, wood block floors of pre-treated blocks, over a concrete slab-on-the-ground base, with the soil treated with a pentachlorophenol solution, are standing up well to conditions of heavy infestation.

Some 600 individual dwellings in various parts of southern Africa have had all timber pretreated and provided with safeguards as described, and in no case has termite infestation gained a hold on the structures concerned.

It will be seen from the foregoing that it is possible to anticipate a long life to building structures, even in heavily infested areas, provided always that proper structural precautions are taken, and that adequate inspections and maintenance works are provided.

Brigadier GEH Sim DSO MC

MEMOIR

BRIGADIER G. E. H. SIM, D.S.O., M.C.

GEORGE EDWARD HERMAN SIM was born on 15th August, 1886. Son of an officer of the Royal Engineers, Colonel George Hamilton Sim, he was educated at Rugby, and passed into the "Shop" in January, 1904. Commissioned in the Corps on 13th February, 1906, after his course at the S.M.E. he was posted to 7th Field Company at Shorncliffe in 1907. In 1910 he joined 2nd Field Troop, then commanded by Captain C. R. Johnston, at Potchefstroom in South Africa. On the withdrawal of the Imperial troops from South Africa in 1913, he returned with the troop to Aldershot. Here, in April, 1914, 1st, 2nd, 3rd and 5th Field Troops were amalgamated into 1st Field Squadron, of which unit Sim became senior subaltern.

On the outbreak of war, in August, 1914, 1st Field Squadron went to France with the Cavalry Division and was employed with that formation in the early stages of the retreat on the left flank of II Corps, at first on the demolition of bridges and then, its transport and tools having been sent to the rear, for a time as mounted infantry. Towards the end of the year, Sim was appointed to the command of 11th Field Company in 2nd Division. After seeing considerable active operations with that division, Sim with his unit was transferred to 33rd Division before the Battle of the Somme. Here the company was involved in some very intense fighting, in the early part of which Sim was awarded the Military Cross. Between 15th and 22nd July, 1916, the operations of the division culminated in the capture of High Wood in which the company sustained heavy casualties, four officers and sixty-four other ranks being killed or wounded. Among the wounded was Sim himself, he being seriously hit in the right arm which had to be amputated. For his gallantry in the action he was given an immediate award of the Distinguished Service Order, the citation stating : "For conspicuous gallantry in action. He led forward his company with great bravery in the assault on a wood, and then advanced himself under heavy fire of all kinds to locate strong points for the defence of the wood. Finally after putting his men to work, he was severely wounded." The award was largely made as a result of a letter, sent against all normal military procedure, by the men of the company to the G.O.C. of the division. Sim was seriously ill for some time, as his wound became septic, and it was three months before he could be evacuated home.

When fit for duty, he served for a few weeks in the office of Officer i/c R.E. Records, and then was posted as Staff Captain in A.G.7 at the War Office, later being promoted D.A.A.G. in the same office. In June, 1918, he was given a Brevet Majority, and in the next year was decorated with the Order of Wen Hu, 5th Class. He was, in all, Mentioned in Despatches three times.

After the war he attended the first course at the Staff College. He then returned to the War Office, first as Staff Captain and then as G.S.O.2, till 1922 when he went to Chatham as Brigade Major S.M.E. Three years later he was sent as Chief Instructor in Military Engineering at the "Shop," at the end of which appointment he was promoted Brevet Lieut.-Colonel.

From 1929 to 1934 he served in India, holding in turn the appointments of Garrison Engineer Bannu, S.O.R.E. Northern Command and C.R.E. Deccan District. After a short spell of half pay and attending the course at the Naval Staff College, he was posted to Bulford as A.A. & Q.M.G., 3rd Division, having been promoted Colonel, dating from 1932. Here he was kept busy with much reorganization, and was also largely responsible for the running of the Tidworth Tattoo, no easy task. In 1938 he returned to the War Office as A.Q.M.G. (T.A.) with the rank of Brigadier, advancing next year to Deputy Director in the same office. This latter appointment, coinciding as it did with the doubling of the Territorial Army and closely followed by the outbreak of World War II, threw a heavy strain on his department, and he worked for long hours at very high pressure. Later he was in charge of a branch of A.G's. department responsible for consideration of applications for discharge of personnel for essential civil employment. He had never been strong since the loss of his arm, and at the end of these strenuous appointments he retired in 1942. He had been appointed A.D.C. to the King in 1939. Even after his retirement he worked on, now in the Ministry of Labour, on similar work on the civil side to that which he had been doing at the end of his time at the War Office. From 1945 he lived, till his death last March, at Marden near Devizes. While taking a lot of interest, in close co-operation with his wife, in parochial affairs and his garden, he devoted much of his time to the making of children's toys, a hobby at which, in spite of the loss of his arm, he became marvellously adept. Indeed throughout his life after the first World War he never allowed the lack of an arm to curtail his activities. As a young man he had taken part in most of the sporting pursuits available, as a Y.O. playing rugby football for the Corps in the team which went so near winning the Army Cup in 1906. A keen yachtsman, he also played a good game of tennis, and in South Africa played polo. After he had lost his arm he painstakingly set to work to relearn tennis and with considerable success.

The writer well remembers, when playing tennis with him in a tournament at Chatham in 1924, the uncanny accuracy with which in serving he threw up the ball with his racquet hand and followed smoothly through the stroke to produce a fast and accurate service. In those days he was also a keen follower of the Beagles and his quick appreciation of the run of the hunt made him a very useful Field Master, which post he frequently filled.

From the earliest days of his service "Bill" Sim was always a quiet individual. One of his contemporaries writes: "He was what I would call a very steady character. He did not go busting round, and when more rowdy Y.Os. got a little wild and noisy in the mess, Sim always remained quiet and acted as very efficient ballast. He probably did not know he was doing this, but the effect was there." This quiet steadiness tended to increase in later life, probably from a sense of weariness from the effects of his wound. But those who knew him well invariably experienced a sense of friendly interest and understanding which made his friendship something to value. But his outstanding characteristic was the quiet courage and sense of duty with which he faced the events of life and illness. His courage in battle is exemplified by the deed which won for him his D.S.O., and vouched for by the appreciation of his men in petitioning for his decoration. A letter from one of his ex-officers, previously unknown to his wife, speaks of his "kindness to one of Kitchener's 'temporary gentlemen,' and the example he set of how to face danger." This same bravery, though less spectacularly, was shown by the quiet way he set about to reorganize his life after losing his arm, and to carry on in strenuous appointments through illness and fatigue. In all this, and particularly when in the last four years of his life a serious illness, followed by others, rendered him incapable of anything but the mildest activity, he was greatly helped and encouraged by his wife, Agnes Hepburn Brodrick, daughter of Brodrick Dale of Stocksfield, Northumberland, whom he married in October, 1915. His widow and two daughters, both married, survive him.

R.P.P-W.

BOOK REVIEWS

THE HAPPY HUNTED

By Brigadier George Clifton, D.S.O., M.C.

(Published by Cassell & Co., 1952. Price 21s.)

Somewhere in his many writings on war, Lord Wavell points out that the front line soldier of to-day requires not merely to be brave and intelligent, but must combine the opportunism of the gangster with the cunning of the cat burglar. The wisdom of this shrewd comment is well revealed in this story of the *Happy Hunted* whose high spots deal pre-eminently with the lightning tactics of close encounter with the enemy.

Tommy guns and automatic pistols are so murderous at close quarters that their use on the unarmed is disagreeable, except to natural murderers, which most soldiers are not. This fact undoubtedly saved Brigadier Clifton from sudden death on several occasions, for he had more close encounters with the enemy than falls to the lot of most soldiers even in a long war. He describes them so vividly that the reader inexperienced in such excitements can see them all happening and can wonder with some misgivings how he himself would have behaved.

As a New Zealand Sapper, his story is particularly interesting to the Corps. Amongst many others to whom he makes sympathetic reference, Brigadier Kisch, Chief Engineer Eighth Army, Field Marshal Rommel and Herr Doktor Max Frisch receive particular attention. The last named set the author's bullet shattered leg in the skilful manner of the German doctors of the old school, of whose efficiency, often accompanied with great kindness, it is always pleasant to read. The book retains its interest right up to the last adventurous page and is well worth reading.

B.T.W.

ALWAYS INTO BATTLE

By Lieut.-General Sir George MacMunn, K.C.B., K.C.S.I., D.S.O.

(Published by Gale & Polden, Ltd. Price 10s. 6d.)

Always into Battle is a collection of forgotten sagas of the British Army. Many of the battles and episodes are unremembered, because they have had no brilliant historian, or because they have been overshadowed by greater events. These are no battles of the Marne or Warsaw, no Alameins or Stalingrads. Rather they are the Epic of Eugène, that Holy Roman cavalryman and comrade of Marlborough, who must take credit with him for the joint victories over Louis XIV. Then there is the rather discreditable story of Lord George Sackville, who as British Commander-in-Chief at Minden, by his inertia failed to turn a " glorious defeat " of the French into a " disastrous rout." Twenty years later he again appears as Secretary for War and the Colonies, responsible for the political mishandling of the revolt of the American Colonies. Well did he give to posterity the phrase " Getting the Sack."

The ever-green wisdom of the Duke of Wellington is here as well. " I have long been of the opinion that the British Army could bear neither success nor failure, and I have had manifest truth in the first of these premises in the recent conduct of the soldiers of this army. They have plundered the country most terribly . . ." But there is another story of the British Legion in 1837, bringing humanity to Spain during her Civil Wars.

There are stories of the dramas of the First Afghan War 1839-42; the account of the lost legion (the Oudh irregular force); Napier's famous campaign in Abyssinia; the saving of Waringman Kha in Northern Burma; and the tale of Zoueetfontein in the later stages of the Boer War. There is a lesson for to-day in the last story, where a British Force ambushed a Boer Commando by dressing up as the women about a Dutch farm in South Africa.

There are other stories also. The evacuation of Gallipoli is a first-hand account, for the author was then Quartermaster-General of the Dardenelles Army. It shows how meticulous planning and deception fooled "Johnnie Turk" into believing that we were still ashore in force, when only a few automatic booby traps remained on the peninsula.

Finally there is the pleasant little fantasy of Napoleon and his Marshals riding in ghostly company with the Duke of Wellington around the British lines in Flanders. Here is at last comradeship between the former age-long enemies.

There is a lot of forgotten history in this little book, and many previously accepted ideas are given a new slant. It shows how politics too often have influenced strategy, and brings out some unremembered faults of Ministers. If you like breezy colourful writing, you should read this book. D.G.B.B.

PRISONERS OF HOPE

By MICHAEL CALVERT

(Published by Johnathan Cape, Bedford Square. Price 16s.)

The history of World War II is rapidly becoming a tangled jungle. Every week new books appear which bring fresh evidence to bear on old controversies. As such they demand attention. *Prisoners of Hope* is one of them. It deals with the operations of Wingate's Special Force in Northern Burma in 1944. Brigadier Calvert commanded one of its six brigades. His rôle was to establish, "all by air," a stronghold 150 miles behind the Japanese front line. From there he was to cut, and keep cut, the road and rail communications running north to the enemy formations, which were fighting General Stillwell's Chinese troops for the control of the Burma Road. The other brigades were to harass the Japanese communications running west to the Chindwin.

The description of the arrival of the advance guard of 77 Brigade at the stronghold, in gliders by moonlight, is breath-taking. The touch-down alone cost about 25 per cent casualties in killed, wounded and missing. But Calvert's men could take punishment. The air strip was duly made and the Dakotas arrived with the main body according to plan. Within a few days the Special Force was at work in an area over a hundred miles square, from the Irrawaddy to the Chindwin—12,000 men, 3 000 mules with A.A. and field artillery. More about the feeding and handling of those mules would have been interesting.

New methods of warfare take time to get into the right form and are very costly in men and materials. Cf. *La Cimetière des tanks* on the Passchendaele battlefield. The operations of the Special Force, made possible only by the possession of air superiority, were no exception. The casualties dealt out and received were very heavy. "Strongholds" seized by armour and supplied from the air seem likely to be a feature of the warfare of the future. Judging from the *Prisoners of Hope*, to establish such "strongholds" by glider seems hardly to be a fair hazard of war, even for such devoted officers and men as those of the Special Force. Peter Fleming enriches this striking book with an official report, beautifully written, which describes how he and his glider crew marched back over a hundred miles through enemy territory to Assam.

B.T.W.

MATHEMATICS—QUEEN AND SERVANT OF SCIENCE

By E. T. Bell

(Published by G. Bell & Sons, London. Price 21s.)

This is an excellent book, but a most difficult one. Professor Bell sketches out the scope and the limits of contemporary mathematics in a way which is satisfyingly direct, but which makes great demands upon the concentration and mental flexibility of his readers. His book is best read piecemeal (as he suggests) for the parts which interest one ; for no man but a trained mathematician could face the whole, taken consecutively.

Professor Bell's view of mathematics is a broadly historical one, and his anecdotes of the great heroes make the liveliest reading of the book. But perhaps the most telling feature is the romantic undercurrent which allows us to share the mind of a man who loves mathematics passionately, and for its own sake alone. He can write with deep cynicism of most spheres of human activity, and indeed of humanity itself: "Of course 'defence' in the shape of an atomic war may sterilize the race, or transmute its genes to those of subhuman monstrosities incapable of carrying food to their mouths. This might be the happy issue out of all its afflictions that our race has been praying for all these centuries." For religion, as normally understood, he clearly feels nothing but hostility and he regularly uses the word "mysticism" as a synonym for "mystification." Yet his whole writing is lit up by a faith as pure and as straightforward as the Christian's. Though whole branches of mathematics prove barren or meaningless ; though the very foundations of logic and mathematics have lain in deep uncertainty for nearly fifty years, yet "Wisdom was not born with us, nor will it perish when we descend into the shadows with a regretful backward glance ; that other eyes than ours are already lit by the dawn of a new and sounder mathematics and one that is closer than the old to human capacity and human needs."

Is this the comic philosophizing of a fanatical enthusiast? Perhaps so. And yet I think that his love for mathematics is one which God Himself (who after all invented it) would find very close to His own heart.

W.G.H.B.

ELEMENTS OF STATISTICS

By C. G. Lambe, Ph.D.

(Published by Longmans, Green & Co. Ltd. Price 8s. 6d.)

It is common knowledge that the collection and analysis of statistics is of vital interest to the actuary and the welfare state. It is not so well known that the subject has now become important to all branches of science both physical and social, and to such diverse personalities as the pools enthusiast and the factory manager. A glance through Dr. Lambe's excellent introduction to the subject will demonstrate the breadth of its field. The Author takes his examples from the work of the doctor, meteorologist, gunner, examiner, surveyor, airman, chemist, bridge player, gambler, grocer and machinist, to mention only a few. Some knowledge of this fascinating subject is useful also to the ordinary engineer.

The first step in understanding a new science is to learn the jargon. The language of statistics is confusing at first, but the author of this book clearly explains such terms as variance, deviation and histogram, and the difference between a median and a mode. The reader should not be unduly put off by the exponentials and sigmas which appear frequently in its pages—the majority of them are reduced to simple arithmetic when applied to real problems. A run through some of the chapters will indicate the scope of the subject. The first few explain how to make sense of a large number of apparently random results. The next deals with probability, and explains incidentally why you always lose on horses. Others are concerned with the correlation of two variables such as the height and weight of people, the probable error of a number of observations, and the methods of sampling and quality control in production.

This book is strongly recommended to anyone with a mild mathematical bent who would like to understand the principles of a subject which is now used almost as universally as geometry. It will help him, incidentally, to solve the problems in his evening paper. M.E.T.

EARTH RETAINING STRUCTURES: CIVIL ENGINEERING CODE OF PRACTICE NO. 2

(Published by the Institution of Structural Engineers. Price 15s.)

The publication of this Code of Practice has been eagerly awaited by the engineering profession, and the reason is not hard to find. During the last twenty years the engineering press has been swamped with papers describing the latest theories of earth pressures and retaining wall design. Engineers have found themselves so deeply involved in the intricacies of slip circles and logarithmic spirals that it has been difficult to keep a sense of proportion. By misusing the relatively new science of soil mechanics for example, it is possible to justify the most improbable designs; the ordinary engineer has been at the mercy of the expert.

We now have an authoritative statement on the design of all types of earth retaining structure. Its scope is so wide that a short review can only indicate the subjects covered. In over 200 pages, containing 100 tables and drawings, the Code deals with the design and construction of gravity, reinforced concrete and sheet pile walls: cribwork, revetments and sea walls are discussed, and appendices give examples of wall failures and earth pressure calculations. There is an excellent bibliography and index.

It is stated in the introduction that the code represents a standard of good practice and takes the form of recommendations. Anything to do with soils is bound to be controversial. However, the distinguished panel of experts who compiled the text have struck a fair compromise between being too dogmatic on the one hand and failing to produce clear cut rules for design on the other. Unlike some codes it is both a textbook and a book of rules, and it could be used by someone with little background knowledge of soil theory.

It is no use pretending, however, that the subject has been simplified. The sapper officer confronted with a small retaining wall problem would be horrified by the complexity of the calculations it requires. However the Code is indispensable to anyone who has any large earth retaining structure to construct, and it is a major contribution to engineering literature.

M.E.T.

TECHNICAL NOTES

THE MILITARY ENGINEER

(The Journal of the Society of American Military Engineers)

January–February, 1952

"Substitute Atomic Warfare" by Jack de Ment

Atomic bombs are as yet in very short supply, and are stockpiled after considerable production effort. The author, in an interesting article, deals with the advantages to be gained by the use, either alone or suitably mixed with genuine atomic bombs, of substitute weapons reproducing all the visible effects of an atomic explosion including flash, cloud, sound and, if necessary, the residual radiological effect by including in the weapon radio-active contaminants such as fission by-products from plutonium manufacture. With these substitute weapons it is not possible to reproduce the initial penetrating surge of gamma radiation, or the full blast of a 20,000-ton T.N.T. equivalent explosion, but even without these the substitute weapon is held to be more than sufficient to exploit to the full the new psychological disorder defined as "radiophobia."

The judicious combined use of substitute and genuine atomic weapons has the added advantage of misleading (enemy) intelligence as to the size of the remaining stockpile of real weapons available for immediate use. The author considers that in some cases a substitute atomic bombing should be quite sufficient to interrupt industry and cause hysteria and panic with consequent demoralization, and this might well be true unless civil defence training had already included the obvious precaution of preparing potential target cities by practice attacks with substitute atom bombs. The radio-active element would, of course, be omitted or reduced to safe tracer proportions sufficient only to exercise the defence detector equipment. As little as .4 c.c. of a mixture of three parts of tetranitromethane and one part of toluene in argon explodes to release up to 14 million candles of light, very much exceeding the brightness of the sun. London's first Civil Defence exercise against substitute atomic warfare might suitably be timed for 5th November, and similar exercises over coastal ports included in the local regatta week.

In 1949, the United States Navy employed simulated atomic warfare in its Caribbean exercises and some months earlier the British Navy used a bundle of three flares which exploded with a flash of 9 million candle power in combined air-sea manœuvres. Since then, improvements have been made and weapons have been designed which vary from single two-chamber designs to projectors releasing rockets in a three-dimensional pattern. The rockets carry light-producing and smoke-forming material with or without a radio-active contaminant.

THE ENGINEERING JOURNAL OF CANADA

The following are brief notes from interesting articles published in the *Engineering Journal of Canada*. The dates in brackets refer to the date of issue. Copies of these journals are available in the R.E. Library.

1. The Anlaw Bridge, involving the launching in Columbia of a 250-ft. main span over two 210-ft. triple triple Bailey spans, cantilevered out. (October, 1951.)

2. Glued laminated timber, and its use instead of structural steel. (April, 1952.)

3. The industrial gas turbine, its development and characteristics. (March, 1952.)

4. Small pipe system for warm air heating; investigations are discussed in considerable detail, but the article finishes with a clear summary of essential requirements. (January, 1952.)

5. Brabazon assembly plant. A description of the design of the hangar, erected at Filton, for the giant Brabazon air liner. (October, 1951).

6. Aluminium for aircraft hangars. A description of the design of an aluminium alloy hangar, which can now be seen at London Airport. With 90 per cent of parts prefabricated, the speed of erection is remarkable. (October, 1951.)

TESTS ON PRESTRESSED CONCRETE BRIDGE

(*Civil Engineering and Public Works Review*, dated June, 1952.)

Many people who have expressed doubt as to the safety factor allowed in the design of the slender prestressed concrete bridge leading from Waterloo Bridge to the South Bank Festival Site, will be interested to hear that someone has now, so to speak, " sucked it and seen." The bridge was tested, finally to destruction, by the Cement and Concrete Association and the Prestressed Concrete Development Group, with the assistance of many of the contractors engaged in erecting and demolishing the exhibition.

The bridge involved consisted of three continuous spans, of 76, 59 and 76 ft. respectively, prestressed with twenty-four Freyssinet cables of twelve wires each. The construction was in the form of a wide shallow T-beam, with one rib of breadth 4 ft. and depth 1 ft. 10 in., the total width of deck being 11 ft. 10½ in. The deck thickness tapered from 3 in. at the edges to 12½ in. at the centre over the rib. The whole was designed to carry foot passengers, a live load of 100 lb./sq. ft. being allowed for. The testing was fourfold, comprising :—

(*a*) Behaviour of the bridge at design load.
(*b*) Recovery after 150 per cent live load.
(*c*) Recovery after 200 per cent live load.
(*d*) Loading to the point of collapse.

All the loading was applied to one of the 76-ft. end spans. It is, unfortunately, not possible to reproduce the deflection curves which were obtained, but the results, briefly, were :—

(*a*) The bridge showed excellent recovery after the application of both the 150 and 200 per cent overloads, although a certain amount of creep occurred when the former load was left on overnight.

(*b*) Some hogging occurred in the middle span, but very little deflection in the far end span, suggesting that the continuity effect did not extend beyond the second pier.

(*c*) The bridge finally collapsed under a load equivalent to about 250 lb./sq. ft., or 2½ times the design load. Failure occurred simultaneously in the middle of the loaded span and over the second support.

(*d*) No general failure of the steel occurred, although it was found that there was no bond between the wires and the concrete, due to the failure of the grout to penetrate from the ends of the cables.

The tests appear to show that present design allows a factor of safety of about 2.5, and that prestressed concrete bridges are quite capable of carrying a double load, provided that it is not of long duration.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