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2150—1-9-25.

THE ISHA-RAZMAK ROAD.

COMPILED FROM INFORMATION SUPPLIED BY OFFICERS WHO TOOK PART IN THE WORK.

THE POLICY.

THE advance of an Afghan Army in 1919 over the Durand Line into independent territory caused another of the periodical "flares" on the North West Frontier of India.

In the tract between the Kabul River and the Gomal, the Tochi and Wana Wazirs naturally sided with the invader, and as we had not the regular troops available to support them, the militia garrisons of Wana, in the south, and Datta Khel, in the north and Upper Tochi, were withdrawn.

The Mahsuds, living in the strategical heart of Waziristan, had always been the crux of the situation. Their strength lay in their inaccessibility. Now, although occupation of their territory was not beyond the powers of the Indian Army, the costly system of punitive expedition followed by withdrawal, was most certainly beyond the financial powers of the Government of India. A new policy was formulated which did not intend occupation by regular troops, but had resort to the principles so ably demonstrated by Sandeman. When a man's livelihood is raiding, it is not economically sound to simply keep on denying him this means of existence; it is also necessary to give him some other form of occupation, and consequent livelihood. The new policy aimed at informal control by means of Scouts (really the old militia much enlarged) and *khassadars*, backed by regulars. The employment of regulars necessitated communications, and a combination of irregulars and roads was less costly than regulars and roads.

Wana was re-occupied in 1920-21, and Datta Khel in 1921-22. Even so we were no nearer the main objective. The next move was to join Jandola to the Tochi by means of a road passing through Razmak. The occupation of Razmak, above and behind the Mahsud defences, was calculated to eliminate their inaccessibility, have a sobering effect on the barbaric characteristics of the Mahsud, and finally to form a healthy advanced base for the regular troops needed to support the irregulars, who were charged with the policing of the territory in detail. This policy, then, whilst providing an insurance against the abnormal frequency and cost of punitive expeditions, provided a form of employment for a large percentage of the population which was at once to their liking.

The line to Razmak from Jandola not only passed through Mahsud country, but also followed the very difficult line of the Takki Zam, which required a huge permanent picket garrison to make it safe pending a more reasonable attitude on the part of the Mahsuds. The line from the Tochi to Razmak, on the other hand, ran, throughout its length, in Wazir country, and was, on the average, more open.

FIRST RECONNAISSANCES.

It was decided to build the portion from the Tochi to Razmak first, and establish there the regular garrison; afterwards, under the protection of this garrison, to join the line down the Takki Zam to Jandola. Practically no engineer intelligence existed regarding the line between Razmak and the Tochi, as troops had marched over it last in 1860. No survey of the intervening ground had yet been made. At the beginning of May, 1922, the only data available for a road were the northern starting point and the southern finishing point. Looking back, it is clear how imperfectly the magnitude of the job to be accomplished was realized. The first reconnaissance on the ground was carried out by a composite party consisting of Major Deed in charge of the whole project, the Political Agent and the officer in charge of the survey party, with several officers from the Tochi Scouts, who knew some of the ground slightly. This party confined their energies to the location of ruling points, such as passes, bridge and causeway sites, and, hardest task of all, steered the alignment past villages, fields and graveyards.

An aerial photographic survey was made of the Khaisora, but as this gave no idea of slopes, was of little value. At one time the conclusion was reached that the plane had gone up the wrong nullah, so that little help was gained from this source. The survey party followed later, filling in between ruling points.

THE ROAD.

The work of construction was entrusted to Capt. (now Major) L. C. B. Deed, with Lieut. M. R. Jefferis as his assistant.

The Khaisora sub-district, Military Works Services, was especially formed for this project, and, when orders to proceed with the work were received at the end of May, 1922, headquarters were first opened in Bannu.

The general instructions regarding the performance of the work specified a second class road with causeways replacing bridges—it being intimated that the Tochi river would probably be bridged at a later date. Twenty-seven miles of road were required to pass light M.T. up to Milogai by December 5th, 1922.

The staff for supervision was to be obtained for the most part by advertisement, whilst contractors, and protection for the labour employed, were to be subject to the approval of the civil political authorities.

The funds sanctioned for the road, including the Tochi Bridge, were 1.6 lakhs of rupees per mile, making a total of 65 lakhs. Abstract estimates were to be submitted for sanction, and funds allotted, before any new work was commenced, the rates being those already paid to the Mahsuds in South Waziristan.

The specification was, roughly, as below :—

Twenty foot roadway, 12-ft. metalled with 4-ft. earth berm on each side. Two-ft. extra on each side allowed for drain or parapet wall.

Maximum gradient 1 in 13.

Minimum radius of curves, 35-ft.

Culverts, eight per mile, with a width between parapets of 20-ft. (16-ft. for minor bridges).

Soling, 13-ft. wide, 6-in. thick—9-in. on embankments.

Camber on the straight 1 in 40, with super-elevation on curves as necessary.

Causeway specification :—Road width (over drop walls), 18ft. ; down-stream drop wall of H.D. stone in cement on cement concrete footing, thickness $\frac{1}{3}$ x depth, taken down $1\frac{1}{2}$ times depth of flood + 5-ft. ; up-stream drop wall $1\frac{1}{2}$-ft. thick, taken down 3-ft. (depth to be increased if causeway not square across the nullah), flooring 4-in. p.c.c., 1 : 2 : 4 (shingle aggregate) on 8-in. lime concrete on 1-ft. hand-packed boulders.

The rates for work were :—Earthwork, Rs. 8/- ; conglomerate, Rs. 25/- to Rs. 35/- ; soft rock, Rs. 56/- ; hard rock, Rs. 75/- to Rs. 100/-.—all per 1,000 c.f. Lime masonry, Rs. 80/- ; cement masonry, Rs. 120/- ; revetment walling, Rs. 33/- for $\frac{1}{3}$ hammer-dressed, Rs. 46/- hammer-dressed throughout ; boulder walling, Rs. 5/—all per 100 c.f. Soling laid and consolidated, Rs. 10/- ; metal collection, Rs. 3/- ; metal consolidation, Rs. 10/—all per 100 c.f. Lime concrete, Rs. 45/- ; cement concrete, Rs. 133/- per 100 c.f. Earth lead, Rs. 1/- per 100 r.f. ; other lead, 2 annas per maund per mile. Coolie wages, Rs. 4/- ; masons, Rs. 2/8 to Rs. 4/8 ; donkeys, Rs. 1/8 ; camels (alleged), Rs. 5/-.

The work was divided into sections, the length of which depended on the amount of work required in each and on the capacity of the contractor obtained for that section.

The supervision staff varied, but was usually one S.D.O. for two sections (maximum), one sub-overseer and two *mistris* for two miles, one *mistri* on each group of masonry works, and one sub-overseer continuously on levels, for pegs were always disappearing. Important sections had their own S.D.O.'s. Two contractors

well at work were the most that an officer could properly look after—problems cropped up almost hourly, usually completely defeating the subordinate on the spot. Often these problems were of the nature of a pistol at one's head from a local inhabitant, rendering the stalwart M.E.S. subordinate more ready to make tracks for home than to give a decision.

Section estimates, as required by Headquarters, were only approximate, giving the sub-work, rate, total quantity and total value, but no details, and were accompanied by plans, reports, specifications, etc. Allowances for contingencies and protection were added to the gross amount. Detailed estimates were made later and were sanctioned by competent authority. These, in the case of sub-works, laborious or difficult to estimate—such as earthwork—were prepared in the form of lump-sum estimates. Such simple estimates were allowed in order to keep the officers free to push on the work. Accounts were kept by section and sub-work.

At the end of June, 1922, the headquarters were moved to Idak Camp, some 30 miles nearer Isha on the Tochi Road, at which point the Razmak Road commenced. At Idak was opened the tool and store dump, which gradually assumed immense proportions and was very ably run by Glazebrook.

Latterly a Financial Adviser was appointed from the Accounts Audit Branch, who was always of great assistance. His attachment established a precedent which should be followed in all future projects which may be carried out under similar conditions.

LOCAL POLITICAL SITUATION.

To understand fully the situation at this period, reference must now be made to the political situation. To all intents and purposes we were at peace with the Wazirs, who, by sub-sections, own the whole of the land on which the road was to be built. The actual boundary between Wazir and Mahsud is debatable for as long a period as any other question on the Frontier where a Wazir is concerned. Wazir territory is generally held to end south of Razmak Camp at the Shuran Algad.

In June, 1922, we had not recommenced, as far as the Wazirs of this tract were concerned, the system of " doles " or allowances, which, it can be appreciated, do so much to endear us to the inhabitants of the Frontier. Hitherto, these doles were paid only to *maliks*, who might or might not exercise their influence on our behalf over their sub-sections. The new policy was to get at the rank and file of the tribes, our faith having been somewhat shaken in the efficacy of *maliki* control. It was this idea which produced the " khassadar." The tribesman is undoubtedly what the babu calls " military man." He has a weakness for carrying a rifle

and a most unholy loathing for the shovel. Possibly when we have reversed this preference and stimulus is given to the "arts and crafts" and village industries, the Frontier problem will be nearing a settlement.

At a *jirga* held at Miranshah, the proposition was put to the Wazirs interested, and it has been officially reported that they invited us to proceed with the road, which would assist them against their ancient enemy, the Mahsud.

Subsequently, much *kurcha* was paid out, allowances fixed, and the enlistment of Wazir *khassadars* begun. Here a deviation to say, that unless you have seen *kurcha* paid out to Wazirs, seen their mouths dribbling at the sight of the bag of silver rupees, you cannot realise the hold of money over the tribesman.

Broadly speaking, the *khassadars* were directly under the Political Agent, and were stationed at such centres as Jaler, Tal, Asad Khel, etc., whence they occupied picquet posts along the road.

Badraggas, on the other hand, were under the M.E.S., and were responsible for guarding the road supervision staff, M.E.S. property, contractors' camps and all work in progress.

Both categories were enlisted through the Political Agent; each man was paid one rupee per day, and provided himself with a rifle and a supply of ammunition. Ammunition expended in the defence of camps was recompensed at the rate of 6 to 8 annas a round. It is certain that long after the road is forgotten, stories describing the heroic defence of this or that contractor's camp will be told in Wazir villages, and reference to the prodigious expenditure of ammunition will not be forgotten. Owing to the slow progress made in finishing off the sections, with the consequent necessity of keeping on the "protection," it was found that 10 per cent. was an insufficient allowance to cover this latter item in the estimates.

That this system of protection was a success cannot be questioned, but it is as well to realize that the degree of "protection" afforded varied considerably with the importance to the Wazir of the person or persons protected.

Throughout the work co-operation with the Political Officer and the mutual recognition of difficulties were essential. The Political Agent, Tochi—George Cunningham, an old Scottish rugger captain—was the road's greatest asset. In dealings with the local inhabitants, in disputes with contractors and in labour questions, his help, advice and tact were invaluable.

It was soon evident that progress was facilitated by constant contact between the officers and the inhabitants. The only way to get on was by cajolery, even though it entailed much talk and endless waste of time at innumerable *jirgas*.

It was necessary to be hale-fellow-well-met with every sort of scoundrel, for though a Wazir may be persuaded or ridiculed, he cannot be driven. Many a crisis was averted, and many a situation restored by an answer coupling the claimant and his request with some utterly inane observation. The hardest struggles were with "backwoods" Wazirs, with whom there was no direct touch. These were invariably truculent, and were continually on the look out for profit from the necessities of the alignment or from robberies of cash or donkeys from contractors or coolies. However, with all their faults, they were cheery opportunists, and, by some, the road was well served.

CONSTRUCTION COMMENCED.

As has already been indicated, the road work commenced in charge of only two sapper officers, who had to start and evolve an organization literally from first principles. The "inside" organisation included the negotiations for offices and quarters in Idak Camp on the Tochi, the engagement of all clerical, drawing office and outside technical staff; the ordering of furniture, stationery, engineer stores, survey instruments and the keeping of all accounts connected with the project. Simultaneously, "outside," the location, survey, engagement of contractors, recruitment and importation of labour, setting out of work, negotiations with political authorities, engagement of protection, organisation of transport, reception of stores, siting of labourers' camps, preparation of estimates.

PLAN FOR THE OCCUPATION OF RAZMAK.

It was intended that construction should proceed without any regular military protection, until such time as a Force could be supported by mechanical transport up to Asad Khel. The Force would then proceed to Razani, where it could be supported from Asad Khel by camel transport. Meantime, the road would be completed to Razani for mechanical transport. From Razani, the "dash" on Razmak would be made, supplied by camel transport from Razani. Once established on the Razmak plateau, the Force would combine with a similar Force from South Waziristan, established at Tauda China, in a punitive expedition against Makin. The task with which all were confronted was, therefore, to construct a road suitable for M. T. for a distance of 25 miles within six working months, without military protection, at a cost considerably lower than any road in that part of the country had been constructed with protection before.

The difficulties of driving a road through the rugged spurs and waterless tracts of the frontier have many times been overcome. But in the case of the Isha-Razmak road a further difficulty

had to be overcome, in the form of the Wazir, whose itching palm alone bespoke friendliness, with the Mahsud in the background openly unfriendly. The effect of this element was that no contractor of wealth or standing would attempt or be allowed, by the local tribesmen, to attempt the work, and the coolie, even when offered the bait of triple pay, was hard to get.

A G.E. pestered to exasperation by a contractor for payment, once said : " Have you no money of your own to pay your labourers for one day's work until measurements can be taken ? " The answer came back at once: " Would any contractor who has two annas to clink together in his pocket or who was not deep in debt to the moneylenders risk his life and his name in this forsaken country ? "

Survey of the Road.

Active survey commenced on June 1st, 1922, and, beyond the fact that the road must pass Asad Khel, in the absence of maps on which to reach a more definite decision, it might run by any route.

The survey and laying out was effected as follows :—An officer reconnaissance having fixed the ruling points, two surveyors worked down from these points with De Lisle clinometers, marking an approximate line with whitewashed *bourgies* (piles of stones). (The exception to working down from a R.P. was working up from a causeway site. Bridges form only a partial exception, since adjustment can be made in the height of the piers.) Following these came two levellers with Dumpy levels, and two computors, who laid out the grade accurately and marked it with pegs at 100-ft. intervals, covering the pegs immediately with *bourgies*. One leveller with a level, working on cross slopes, came next, whilst, finally, a surveyor followed making a plane-table sketch of the route. Each surveyor was accompanied by three or four *badraggas* and two *khalassies*.

On completion of the survey of each section the whole party returned to Headquarters to prepare estimates and drawings. This procedure was necessitated by lack of staff, but it also secured for the party a spell of comparative comfort.

Contractors.

The next problem was the procurement of contractors for the sections as they became sanctioned.

It must be understood that there was no possibility of calling for tenders for the work, since it was accepted that the work in any particular section was the privilege of the inhabitants of that section. It was obvious that these inhabitants could not do the work themselves, and so the procedure was for the Political Agent to persuade them to accept a contractor who was already acceptable

to the M.E.S. Five per cent. of the nett bills paid to contractors was paid direct by the M.E.S. to the tribes concerned, and the contractor, if he was wise, also privately squared the local *maliks*.

The contracts specified bi-monthly payments to contractors of 75 per cent. of the work done. The bills were necessarily rough, for the officer staff was fully occupied in pushing on the work and very little was to be gained by greater accuracy, as there could be no continuity in the measurements, two days' work changing everything, though the Audit Branch would never see it. Final bills were, of course, fully measured. Idle days of labour, if justifiable, were paid at eight annas per man day, though contractors wanted more.

In order to increase their profits, especially towards the end of their work, contractors put in all manner of claims almost daily, the settlement of which was a work in itself. In spite of written contracts considerable latitude had to be allowed, as there was neither time nor staff to replace a contractor, and any such harsh action would have incensed the local inhabitants—a serious consideration in the heart of a hostile country.

Contractors recruited and imported their own labour, of which, with the exception of masons from the Punjab, quite half were trans-frontier Pathans of every conceivable kind, even Afghans. The best were Khattaks from British territory, closely followed by Hazaras and Mahsuds. Kashmiris arrived in the autumn, but they were very poor workers. Contractors arranged for the rations of their men.

In order to reduce the time and the heavy cost of protection, it was usually stipulated that a contractor should supply 1,500 men per section. Except in the ninth and last section, a three-months limit of time—excluding fourteen days for bringing up the labour and building a defensive camp—was rigorously enforced, and it was found that three miles were the most they could tackle in the time. The contractor was then paid and moved to a new section, any remaining work being polished off by the swarm of petty contractors who were always wanting a job.

The men were at first accommodated in tents, over 1,000 of which were hired from the Ordnance Department, but these were cold in winter, so, at Damdil, Jefferis made rough huts. Later on contractors found the provision of huts so profitable that they were inclined to overdo this item.

To prevent an increase of rates in sections further along the line rates for the carriage of rations were allowed—one-half for the third section and full beyond. A satisfactory system of payment was evolved on the following basis :—As 2 per mile of carriage per Rs. 100 of contractor's bill (flat rate of labour being taken at As. 12 and carriage As. 1.6 per maund mile.)

Railway warrants for bringing up labour for the 3rd Section and beyond were given. A stipulated number should have been fixed, for, months later, it appeared that the contractor on settling-up day invariably under-paid his labour, being certain of getting a fresh lot of men up free of cost. His reasons were irrefutable—husbandry at home, for instance—and as work could not be delayed there was nothing for it but to give him a warrant for fresh labour.

Details of Construction.

The country through which the road was carried is much the same as the rest of the Frontier—hills bare and stony in the lower ranges, scrub-covered higher up and seamed by the inevitable nullahs with precipitous banks, often 120-ft. high. There were three ranges to cross: Chinikai, five miles south of the Tochi (1,400-ft. rise), Damdil (over which a way was found with a rise of a mile at 1 in 20), and the Razmak range (some 1,700-ft. rise in 6½ miles), datum levels being Tochi River, 2,100-ft.; Chinakai Pass, 3,500-ft.: Razani, 5,500-ft., Razmak Narai, 7,200-ft., and Razmak Camp, 5,800-ft. The Dizh Narai, a small pass, lay between the first two. The only rivers were the Tochi and the Khaisora (M.S. 23), the former a considerable stream, the latter usually dry. Watering places were few, viz., at Isha, Tochi, Jalair (two miles south of M.S.8), Asad Khel (M.S.14), Milogai and above Rizani (M.S.27), Naghar, in a parallel nullah north of Damdil, was not discovered till August.

Between the ranges there lay most useful stretches of high level plains; beyond the Rocha (M.S.18) these "raghzas" were obviously water-formed terraces, those towards Razani being on the heavy grade of about 1 in 18.

The sub-soil was usually hard conglomerate (shale in the Shini basin, 50 per cent. earth on Alexandra Ridge) with rock strata lying at every conceivable angle and full of boulders, many of considerable size. Some of this conglomerate was practically natural concrete, notably in the last mile to the Rocha nullah. Much hard rock (usually limestone) occurred in wide belts in all side cuttings, the longest being in the last mile to the Tochi, and the first mile of the 8th section. Shaly rock, both red and black, was found in all side cuttings. Beyond Razmak Narai the ground was alluvial overlying conglomerate.

Side slopes varied from 1/2 to 1/1. The strike of the strata was favourable for road alignment on the east and south faces of the ridges up to Pariat (M.S.28), when it changed to west, admirably suiting the military requirements, which, for ease of piquetting, required that the road should be taken up Alexandra Ridge.

The method of carrying out the work in hill country, where diversions were not possible, was roughly as follows:—After the level pegs had been laid out at the grade on the cutting line, the

contractor dug in the ordered distance, following the curves of the hill side, and made only the essential culverts on straight alignments and rough temporary culverts at the re-entrants. The permanent culverts at these points were made later outside the road, often when traffic was running. Soling was often laid as soon as the width of the cutting was 15-ft. This, when well blinded with shale, allowed for one way traffic, meanwhile the contractor completed the further cutting, side drains and catch-water drains. Normally, of course, the road was cut at once full width, in order to simplify measuring and to better the grade. At times consolidation had to be done under traffic, but this was awkward and led to claims for idle labour when convoys were passing. On plain sections the road could be made in the regular manner, traffic using a diversion.

Metal was, if possible, broken and stacked on the soling, this being the speediest and easiest way for measuring; otherwise it was broken above the road and thrown down, but this introduced undesirable dirt. The method of metalling half the road and excavating the other half later also had the disadvantage of making the road dirty, as the coolies would not use wheelbarrows, and, working three on a spade, shovelled the earth in stages across the road.

Zigzags, unfortunately, had to be introduced on the later sections. If well laid out they offer little hindrance to H.M.T.; the points to look for being:—(*a*) Choose a knob or a flattened place on a ridge, giving a really good turning circle, and scheme the road down to it; (*b*) take the road round level, if possible; (*c*) give double the super-elevation you think necessary to allow for settlement, since revetment walling will invariably be necessary, with a portion of the road on filling; (*d*) largely increase the super-elevation on the outer berm—some fool is sure to think it is Brooklands, and an extra "saucer" will save him; (*e*) remove all high ground from inside the zigzag—it will go in the filling; (*f*) make the corner 50 per cent. wider than the road and give a low strong centre wall to separate up-going from down-going traffic; (*g*) be very careful over drainage, make stone drains of large size round the inside of the corner, or heavy rain will cut right across it.

Culverts were, whenever possible, C.G.I. tubes singly or in pairs, 2¼ or 3-ft. diameter, well let down into the ground, and laid at a slope of 1 in 7. At first they were cased in lime concrete, but this took time, so that later, when the completion of the road became urgent, the tubes were merely surrounded by a good layer of hand-packed stone—as was done in 1897 on the Malakand road and was still perfect in 1915.

Larger waterways were crossed by R.C.C. slab culverts. Water openings were calculated by Colonel Paul's larger formula and

withstood a cloud-burst. The Paitopangi Bridge above Razani was R.S.J. on stone piers with R.C.C. decking.

The Tochi Causeway was built, according to the N.W.F.P. Civil Specification, with shallow drop walls of stone in lime, the two top courses being in cement (D.S. drop wall only 3-ft. 6-ins.), depending entirely on a water cushion apron formed of six rows of C.C. slabs, 6-ft. x 6-ft. x 6-ins., wired together both ways by two 1-in. steel ropes. Cement being short, this apron was actually made of boulder stone in 6-in. mesh telegraph wire crates, 2-ft. thick and 12-ft. wide. A 6-in. floor reinforced with telegraph wire was soon added, defects owing to too rapid construction having become evident. This causeway stood well, but constant repairs were necessary to the apron.

This design had obviously insufficient strength to withstand the horizontal pressure of a moving bed, and experiments were made later by giving toe walls 2½-ft. high 20-ft. down stream, the top being level with the footing of the D.S. walls, and strutting across with 6-in. x 6-in. R.C.C. beams 6-ft. apart, one additional beam in each case being given longitudinally. The spaces between the beams were filled in with 2-ft. hand-packed quarried stone and wired, and the excavations filled in level. Floods never scoured more than 4-ft. down the aprons, and at this distance semi-natural water cushions were formed. Four causeways were made to this design, and all were satisfactory, representing an undoubted economy in cement and cost; the only possible objection being the necessity of good workmen and first-class supervision.

The only failure occurred on the 20° skew Lukki Khula Causeway, where a big flood caught the work before the spoil banks had been cleared. This 3-ft. flood, coming down a nullah sloping at 1 in 50, rushed through a narrow opening cleared in the spoil bank and carried away 120-ft. of the causeway, although the D.S. wall was 8½-ft. deep.

A causeway must be sited at the true nullah level, which can only be found by taking a long section of the bed from one mile above to one mile below the site, plotting this on a large scale, drawing in the mean slope of the nullah and giving the causeway the level at which this mean slope crosses the site. It sometimes helps to give the causeway a side slope of 1 in 50.

In shingle nullahs protection of the banks was found to be best effected by stone "bunds," which, run out perpendicularly to the bank, or slightly up stream, allowed the bank to silt up. These bunds were constructed either of boulders in a wire crate, or after the country pattern, of boulders laid with layers of brushwood in between. The latter method, besides being the cheaper, usually lasted longer, since the wire on the former kind was generally stolen.

WATER SUPPLY.

The water supply at Tal came from a shallow well near the Tochi, the water being pumped through a 2-inch rising main to a 16,000-gallon concrete reservoir in Tal Camp, a Worthington pump and portable boiler being installed alongside the well.

The supply of Asad Khel, Damdil, Dizh Narai, and Chinakai was finally effected from a well at Asad Khel. Although it was at first intended to use the Jalair springs, it was afterwards found best to pump from the wells at Asad Khel, which tapped the certain supply of the Khaisora River, to a reservoir of 22,800 gallons capacity on a hill behind the camp. From here a gravity supply was piped to reservoirs at Asad Khel Camp (5,000 gallons), Damdil (4,300 gallons), Dizh (9,750 gallons) and Chinakai (16,500 gallons).

The plant at Asad Khel consisted of two 12 h.p. vertical boilers supplying two Worthington two-throw pumps, the whole being housed in a defensive tower of stone. The rising main was 4-in. diam. W.I. pipe, as was the delivery as far as Damdil, with 2-in. diam., reducing to 1½-in., beyond. Above Asad Khel it had been hoped to tap a supply at the Sura Mela Algad, but the determined hostility of the villagers made it necessary to abandon the scheme. On the discovery of a *korez** at Tamre Oba, plant, similar to that at Asad Khel, was put in and the site proved to be better than that originally intended. Much reconnaissance and trial digging was done around Razani before a spring was discovered some three miles away under Shin Dhur. This, when built up, and defended by a picquet tower, provided a splendid gravity supply, piped to the camp by a 2-in. pipe.

A good source of supply was found for Razmak Camp in a spring some three miles to the west of the camp site.

Excluding the head works and the defensive tower, the work, which also comprised two 25,000 gallon reservoirs, was carried out by the 13th Co. S. & M. This scheme proved very expensive owing to the amount of "compensation" which had to be paid to the locals and to the cost of transporting pipes to Razmak before the 8th Section was available for transport.

All pipe lines were buried 2-ft., except at Damdil, and at this depth withstood frost, whilst as an additional precaution leaks were arranged at all taps.

DESCRIPTION OF THE EARLY ROAD SECTIONS.

The new road takes off from the very fine Tochi road, which was built in 1919 and 1920, a few yards west of Isha, and follows an old track to the River Tochi, which is the first obstacle. This was the obvious point to end the first section.

* A "korez" is an ancient underground masonry channel laid at a small slope, tapping a deep-seated spring by gravity flow.

On reaching this point the keenness of the Survey party evaporated, but Jefferis, by personally taking charge, made the excellent rate of 1½ miles per day, and by July 18th had carried the trace beyond Asad Khel.

Many days were spent in aligning the first section satisfactorily to both bridge and causeway sites. The former was fixed at the upper end of a long sloping solid rock bank, 100-ft. high, where a road would have been too costly. The causeway had to be made upstream of the bridge site, and no amount of laying out could evolve any better arrangement than to make a steep, 1 in 15, approach to it, trusting that funds would be available later for the bridge.

The first sod was cut on July 11th, 1922, with considerable *tamasha*, and work started in earnest on July 14th.

The contractor gave much trouble, and this section—of great importance, since the Force Dump was to be formed at Tal, beyond the Tochi—was only finished in time by much driving, fining, and by putting on outside labour.

The Tochi causeway was constructed by Bradney's 13th Co. S. & M., which was assisted later by the 32nd and 34th Sikh Pioneers.

On the south bank of the Tochi the road rises on an embankment and bends round below the old militia post at Tal. This post had been repaired by the Political Agent to form a *khassadar* headquarters, and subsequently camps had been built at Jalair and Asad Khel for a similar purpose. These posts served as refuges, at which officers working up the line could stay by night.

The road rises evenly to the Chinakai Pass, in soft shale, which became a species of porridge in the rains and again impressed the necessity for ample catchwater drains and culverts.

In July Jefferis went on a month's leave as a result of fever and frontier sores. He was replaced by Dickson, who was lent from the 13th Co. S. & M.

Early in August, survey was allowed beyond Asad Khel, and thereupon commenced endless difficulties engineered by the occupants of this village.

The ground beyond the Rocha Algad had not looked promising in earlier reconnaissances, however, as a result of ignoring the misrepresentations of the Asad Khel villagers, terraces and a three-mile plain were discovered on the left bank of the Khaisora river, which, when linked up, proved ideal.

This alignment avoided completely the large burial ground of Khani Ziarat on the right bank, which the Asad Khel villagers had been so anxious to drag in as a reason for compensation. The Rocha and Tamre Oba nullahs took a lot of defeating, and several zigzags and hairpins were of necessity included, in order to negotiate

the almost sheer sides of the *algads* down to the Khaisora river bed.

At one period progress was made against the local villagers, only after yard by yard argument, until, raising an old political grievance, they declared that they would shoot anyone proceeding further. In spite of all this intimidation, Dickson went forward with the survey party and the native political, and after a couple of miserable nights in Wazir villages completed the survey to Milogai, and was fired on as he returned. The Political Agent finally settled the dispute by the exercise of much tact, and by the end of August contractors had been found for the work up to Asad Khel.

DIFFICULTIES OF THE UNDERTAKING.

It is profitable at this point to try to gain some idea of the conditions under which all this work was being tackled.

You are asked to picture the scene at the office at Idak, where, for some weeks, one solitary man struggled with the "inside" or paper work, supported only by a hastily gathered staff of *babus*.

Under the verandah, on the ground, and on forms, squat, sit and lie all manner of unwashed bearded men. Some have Snider rifles and wonderful cartridge belts. There is a strong scent of goat-*cum*-camel in the atmosphere, which rises quickly, as the shade temperature is hovering around 110 degrees. Some are asleep, others are expectorating, many are declaiming. Save for those asleep, a kind of wave passes over the multitude as a strange *sahib* reaches the entrance to the office, and some deign to rise as he approaches. (They rise much quicker when it's the *sahib* who makes their payments.)

In the middle of a concrete floor, bounded by whitewashed walls, which are covered with blue prints, sits a harassed officer in shirt and shorts, with pipe in mouth. He is sitting at a desk littered with papers and plans. At his side is another table covered with trays, catalogues and maps. A murderous-looking villain stands at his side, and is in process of making a long oration in Pushtu.

Sit down over there, you won't be under the only fan, but we haven't really got the office properly fixed up yet—not much time really, as there's no E. & M. Officer here yet—and the weekly progress report is due to be posted to Simla to-day, and Mir Jani, the contractor, is screaming for more work to be set out, and there are about thirty lorries waiting outside for instructions as to where to dump their loads—but sit down, and look around.

You will probably gather the trend of the conversation. It is obvious that the gentleman in filthy white (it has been computed by some sportsman that a Wazir spends eightpence a year on clothes and nothing on washing) will not be pacified—he is gesticulat-

ing now, and although you cannot understand a word, it is clear that he is a ruined man morally, financially and in every other way, and you wonder at the " spirit " which makes him hang on to life so long. The conversation goes on crescendo until finally a climax is reached. A *chit* is written—you catch the word accountant—and the murderous gentleman regains in a second his moral and financial status—breathes a prayer for longevity and prosperity on the head of the harassed officer, and salaaming, takes his departure behind the flapping spring doors.

A scuffle ensues outside and he is immediately replaced by another villain, who is well into his tale of woe before you have time to take breath. He is a *badragga*, who has fought a hand-to-hand fight to preserve the labour camp at Tal for some nights now. His expenditure in ammunition has been prodigious, and he wants it replaced, or better still, money in lieu, at once.

Meanwhile, the lorries have dumped all their gear where no one wants it, several camels have rushed the by-pass gate with corrugated iron drain tubes dragging behind them, the telephone has rung eight times, which has meant the harassed officer listening to the story of the murderous villain *re* " cartouces " all over again, with additions as he warmed to his work. The draughtsman has hovered in the portals with miles of longitudinal sections—tea has arrived and gone cold long ago, *chaprassis* have continued to pile up files on the table, and now have recourse to the floor. The Accountant has intimated that the Audit Branch require the whole of the last five months' accounts recast in a completely new form. A more respectable looking gentleman announces that he has 4,000 coolies waiting at Campbellpur railway station, each of whom he is supporting out of his own pocket at an exorbitant sum per diem, and please can he have railway warrants for the lot ?

Well, you have seen a very typical day. This *tamasha* goes on week after week.

The only respite from scenes such as these is the open road. Riding and walking over miles of rough hillside, with a De Lisle clinometer, locating the road line, always under a burning sun, and " protected " by an array of prize cut-throats.

Another officer was living " up the road " alone. He was out all the hours of daylight on foot, tramping all over the place, discovering a suitable line for the road, checking it roughly with a clinometer, and encouraging the timid survey party which was naturally in the forefront ; further back, cursing slow and lazy contractors, being all things to all men with the *badragga* escort, which held his life in their hands, at a rupee a day ; finally, coming back day after day to the shelter of a torn 80-lb. tent, to eat an enormous meal, occasionally to send back a crumpled note

asking for "more drink when you next come up," still less often to come himself into Idak—the metropolis—for a night.

And far into the night, by the light of a hurricane lamp, on an upturned box, he would scribble the data on which an "approximate" estimate might be made for a section, which estimate would be knocked into some sort of shape by the "head office," and, finally, be landed in Simla for microscopic examination, criticism and return.

CONTINUATION OF THE PROJECT.

At the end of August, Col. W. H. Evans, the Deputy Engineer-in-Chief, arrived to inspect the progress. He at once saw that the job was very understaffed, particularly as active operations were imminent, requiring much additional work in preparing camps, permanent piquets, and a reliable water supply. As a direct result of his visit additional officers began to arrive, and the work began to receive the supervision that its magnitude and the circumstances demanded.

The Asad Khel *maliks* soon found a fresh source of claim, and a considerable dispute arose over the use of an essential saddle close to their village. This trouble was settled by the improvement of certain portions of their main irrigation channel.

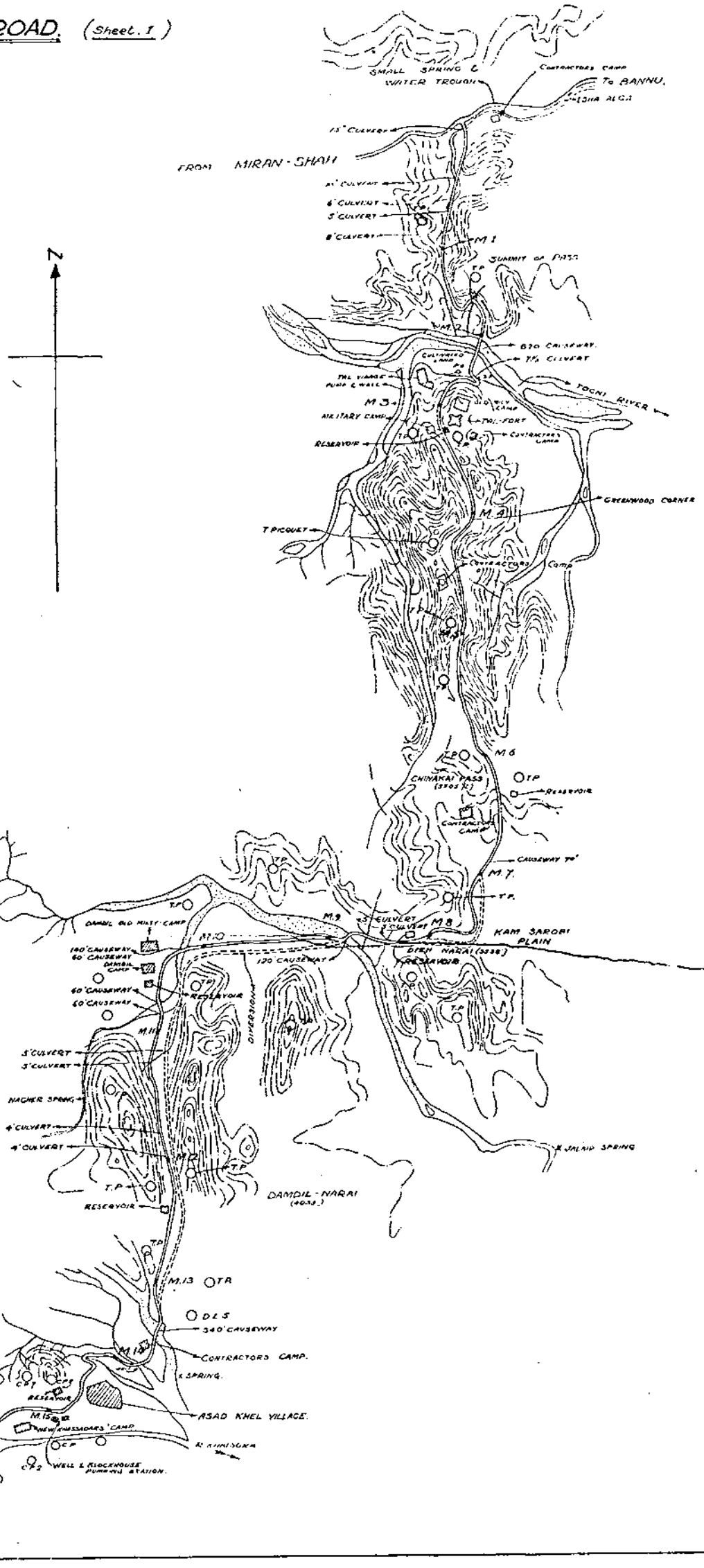
In September the Signals commenced the construction of a permanent air line along the road under Captain T. J. Evans, a most fearless and capable officer.

At this time the section which gave most trouble was 3B. The original contractor failed to live up to his wonderful *chits*, and, as reliable contractors were hard to come by, the work had been carried on by a daily labour contractor, who could never muster sufficient men. With the providential arrival of the Ghilzais from Afghanistan in November the situation was saved. They took orders for 5,000 men—double the requirements—who most unexpectedly arrived, causing considerable congestion.

Lengths of road were given to their contractors at the rate of 100 r. ft. per 25 men. Four thousand five hundred men were camped at Damdil, and Jefferis and his excellent S.D.O., Rahmatullah, moved there to settle the almost hourly disputes of such a heterogeneous mixture. Work was concentrated on hill portions, since, these vital links finished, vanettes could always traverse the plains stretches on diversions.

Meantime Glazebrook had taken charge of the Engineer Store Park at Idak, which was growing in size, fed by lorries from Bannu. Endless streams of carts, camels, and donkeys carried the gear forward to Tal and beyond. Four road rollers had been got across the River Tochi for the second section, and others arrived from all parts of India, until there were no less than twenty, all in varying

ISHA RAZMAK ROAD. (Sheet. 1)



ISHA RAZMAK ROAD.

Section 1. The commencement of the Road at Isha.

Section 2. Tochi Causeway looking towards Tal

Section 2. A corner above Tal.

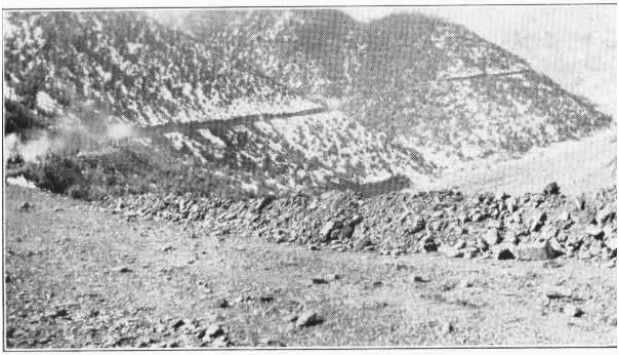
ISHA RAZMAK ROAD

Section 3A. View from Dizh Narai looking North.

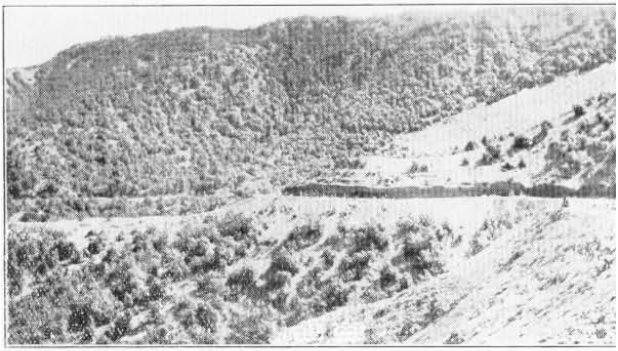
Section 3B. View down Damdil Narai looking East

Section 3C. Lakki Kula Algad

Section 5. Near Tamre Oba.



Section 8. Lower portion looking South.



Section 8. From the Razmak Narai.

TAMRE OBA

Khaisora Zigzag showing centre dividing wall.

A typical Jirga.

KHAISORA ZIGZAG

states of repair, and of different makes, rendering the acquisition of spare parts extremely difficult. Darling, the E. & M. Officer, was kept very busy with this heterogeneous collection. Two rollers were retained to provide spare parts for some of the others, but even so, age and the evil machinations of the drivers, successfully kept several out of work. Matters were improved by a system of bonuses to the roller crews, tempered by fines for avoidable stoppages.

A cleverly staged Mahsud raid at Asad Khel caused a loss of 160 donkeys to the contractor on the fourth section. Evans, of the Signals, rode through the ambush seeing nothing, but Dickson, inspecting work, had to run for it, and the Mahsuds kept up a barrage for an hour to get the booty clear away. This raid eventually cost the Government Rs. 9,600 in compensation.

In November Colonel C. H. Haswell came to live at Idak as C.R.E. All along there had been great need of someone to fight the " superior " battles and to give practical orders and helpful counsel in the many perplexities.

Owing to lack of water, most of the road from Chinakai to Damdil Narai was consolidated dry with soft shale chippings. Rain during, and vanettes after, consolidation, naturally helped matters, but that part of the road became very slippery in rain. This construction was found to last well even under heavy M.T., which was allowed over it after the vanettes had been running for a month.

By November 16th the 3rd and 5th Coys. K.G.O. S. & M., 20th and 21st Coys. Royal Bombay S. & M., 13th Co. Q.V.O. S. & M., together with the 32nd and 34th Sikh Pioneers, were all at Tal and at work on various portions of the road. No. 5 Coy., under Greenwood, improved a difficult corner a mile south of Tal by means of some very fine dry stone revetment walling.

Dickson had now practically completed the earthwork on the fourth and fifth sections and the ascent of the Girdai Raghza, but the stretch behind Khani Ziarat graveyard was untouched. There was great trouble here, as the locals alleged that the thorny acacias on the hillside alignment behind it were as sacred as the olives in the graveyard itself. After three heated *jirgahs*, and the slaying of some goats to propitiate the spirits, work was allowed to proceed, but progress was hopelessly slow.

The cause of the anxiety to get this portion completed was the fear of spates in the Khaisora River, the bed of which was at that time the only route available for the vanettes which would supply Asad Khel when the troops moved there. Finally, an inferior alignment, lying farther back, was arranged only just in time to avoid the floods.

The progress of the work received a very severe blow on December 12th, 1922, by the murder of Dickson. He should have come down to Idak that day, but, having made arrangements for guards,

etc., he was allowed first to get data for the seventh section estimate, of which the reconnaissance had already been made. On his return he somewhat outstripped his guards, and fell riddled with bullets, while his assistant, Lieut. Bromhead, 32nd Sikh Pioneers, had a miraculous escape at his side.

Throughout Dickson had done amazingly. He was out daily on his long charge, with little or no protection, and only his dauntless courage could have carried him over the countless difficulties, dangers, and discomforts he had faced. Long after, it was said that the Mahsuds had vowed to get the three original officers on the road, since it was due to their efforts that the security of the Mahsuds was threatened. Greatly to their credit, the staff at Tamre Oba did not lose confidence, and the S.D.O.—one Abdur Rahman, a permanent M.E.S. subordinate,—carried on the work, but as a result of Dickson's murder, work beyond Tamre Oba was forbidden pending the arrival of regular troops.

The 5th Brigade, which had reached Tal on December 15th, proceeded to Asad Khel the next day, and on the 17th the first vanette convoy ran from Tal to supply them. Early in January the 7th Brigade, designated for the Makin operations, advanced through the 5th Brigade to Razani.

From Razani, the road had to rise 1,400-ft. or so to the Razmak *narai*—the bulk of the way through thick vegetation of holly oak and fir. Jefferis, profiting by the protection afforded by a reconnaissance by the 7th Brigade on to the Razmak plateau. reconnoitred, in deep snow, the alignment of this eighth section, The trace of this section was not cut when the composite 7th Brigade made its march on to the plateau in a snowstorm, and only a small and very steep ice-covered path had been cut for the troops and camels to follow. How this march was accomplished in a blizzard in January, 1923, and what befel the 7th Brigade before it finally established itself in a wonderfully sited camp near the Shuran Algad, on the grassy slopes running down to the Tauda China stream, is another story. Suffice it to say that the true soldier struck the canvas in Lazani before the rain came, so that there was not their weight wet to carry—also that much mud, sweat, and curses pushed the last camel over the slippery *narai* on to the " promised land " at about eight p.m.—long after dark.

Vanettes were now running through to Razani, although improvements and final touches were still being made behind.

The alignment of the 9th section presented no natural difficulties, but, owing to trouble with contractors, it took five months to complete, and vanettes did not get to Razmak camp until June 15th. It must, however, be stated that there was no urgency for this section, as brigade stores were being sent up by camel convoy.

The next item of note was the erosion, for the second time, of

the right bank of the Tochi adjoining the causeway. To combat this a heavy bell bund, formed of boulders in wire crates, was run out from the bank and upstream. A wired stone boulder apron was given on both sides. This bund had immediate effect, the dead-water area silting up 6-ft. in two floods, inducing secondary shoals up-stream, which diverted the stream away from the right bank altogether.

The eighth section was well in hand, and much valuable work had been done on it by various S. & M. companies. Both the 20th and 21st Coys. had worked on the three-span girder bridge across the Paitopangi, whilst Greenwood's No. 5 Coy. had made another fine retaining wall round a zigzag. The work can almost be described as monolithic, since boulders, requiring 30 sappers to bring them on to the site, were built in.

At the end of March all companies, except the 13th and 20th, left for the Takki Zam. The 13th Coy., belonging to the 7th Brigade at Razmak, worked on water supply for Razmak Camp, whilst the 20th Coy. remained to finish work in the eighth section. The road was finally opened to heavy M.T. on August 10th, 1923, thirteen months after the cutting of the first sod at Isha, though vanette convoys ran to Razmak from the 12th of June.

A cause for congratulation was provided by the fact of the accounts panning out with a small saving, in spite of many heavy unforeseen items, such as the "entertainment of *jirgas*" (no detail given) ranging from Rs. 5,000 to Rs. 10,000; extra *badraggas* employed to look after labour on operation works, with their camp expenses, water, ration carriage, etc.; extra rates and bonuses for completing vital links quickly; compensation to contractors for losses; and the cost of cutting so-called "trees" along the alignment.

Casualties, in addition to Dickson's murder, included eight of the M.E.S. staff and some 40 coolies killed. In the coolie camps between Razmak Narai and Pariat, where during the winter for two months there was always a foot of snow on the ground, 50 coolies died of pneumonia due to exposure, and at no time was it usual for a returning camel convoy to pass without bringing at least one white covered *charpoy* lashed to a camel's back bearing some corpse back to the plains.

To the fine work and devotion of the officers and staff, and also of the Sappers and Miners and Pioneers, all too briefly mentioned, was due the successful conclusion of the work.

SOME UNEXPECTED PROBLEMS WORKED OUT BY THE ROYAL ENGINEERS DURING THE 1914-18 *WAR.*

A Lecture delivered at the S.M.E. Chatham, on 12th March, 1925, by MAJOR-GENERAL W. H. GREY, C.B., C.M.G., D.S.O.

When accepting the invitation to lecture I informed your Commandant that I am not an engineer and, therefore, any remarks I may make concerning engineering work and its results can only be taken as applying to management and control and not to technical and scientific work for which scientific training and practical experience are essential.

Amongst the unexpected problems the Royal Engineers were called upon to solve during the 1914-1918 war were two transport problems. The first big one I was connected with was the re-organisation of transport services on the Tigris and Euphrates in Mesopotamia. Some time after the fall of Kut the War Office decided to take a greater share of responsibility for the forces in Mesopotamia, and in July, 1916, I was sent out to report upon the Water Transport service then being done by the Royal Indian Marine. The War Office, on receiving my report, instructed me to take on the work myself and carry out my own recommendations.

During an exchange of cables with the War Office, London, I agreed to take on the responsibility for the re-organisation of the Port and River transport if the War Office would agree to convert the Royal Indian Marine services in Mesopotamia into Royal Engineer services by giving the Royal Indian Marine officers temporary commissions in the Royal Engineers and the temporary Royal Indian Marine officers, temporary General Service commissions, also to transfer control to London instead of to India.

Officers of the Royal Indian Marine hold no commissions, and, although their status in the Army and Navy had never been questioned, I believe it is a fact that legally they ranked as camp followers with the Army, and so far as the International Sea Law was concerned if a Royal Indian Marine ship had fired at an enemy ship the Royal Indian Marine ship's act would be that of a pirate. When the War Office and Indian Government had agreed that the Royal Indian Marine officers should transfer to the Royal Engineers, I informed the officers that if any of them did not wish to remain in Mesopotamia under the new conditions they could go back to the Royal Indian Marine in India; only one officer elected to return to India, and he asked permission to reconsider his decision the day

before he sailed. A man could not wish to meet a finer set of men or more loyal men than the Royal Indian Marine officers who served with me in Mesopotamia. The work done in Mesopotamia under the control and in the name of the Royal Engineers consisted of building wharves, building a dockyard, workshop, slipways, barges and river steamers and doing all the river transport for the Army and Civil authorities, a great deal of river conservancy works and water supplies. Practically the port of Basrah was constructed.

Colonel Symons, the present C.R.E. Mesopotamia, wrote to me the other day and said that almost every civilised work in Mesopotamia to-day had been done by the British Army—water supplies, electric light plant, ports and railways. He is not a man to exaggerate, and the British Army in this case means the Royal Engineers.

Before the Royal Engineers undertook the work there was no wharf at Busrah alongside which a ship could lie, except the old German Baghdad Railway wharf, where there was accommodation for one vessel. In a few months accommodation for 10 ocean steamers to lie alongside wharves was put up, slipways capable of taking the heaviest river steamers were built, repair workshops and a large wet basin constructed. One hundred 300-ton barges were built and numerous river steamers constructed. Workshops and wharves were made up river at Amara and Baghdad. Permanent floating bridges at Amara and Baghdad were built, and, when the advance to Baghdad commenced, 6 months after the Royal Engineers took over the river transport, there was not the slightest hitch and the work was done to the satisfaction of General Maude.

From information gained whilst doing the work as Director of Inland Water Transport in Mesopotamia I came to the conclusion that the failure in Mesopotamia in '15 and '16 was due to ignorance of conditions in the country, on the river, and of the supplies possible to obtain in India and Burmah suitable for the Tigris and Euphrates. When I was sent to Mesopotamia in 1916 I was informed that India had been combed dry of all craft suitable for use on the Tigris. I was informed that for half a year the draught of water from Basrah to Baghdad was only 3′ 6″, and that the current at times and in places over long stretches of river ran up to 6 knots per-hour. I was informed that the only site suitable for constructing barges and ships was at Abadan, below Basrah, where land was difficult to obtain. I found in practice that the current was about 2 knots per hour, and only around various bends at flood time was a current of more than 3 knots per hour ever experienced and then only for a day or so, that by shewing the channels in the river by proper buoys and survey marks vessels drawing 5 feet could get up to Baghdad practically all the year round. Think what that means, a difference of 40% in the carrying capacity of a fleet. When I went up river the first time to make my report there was not a single buoy or survey

mark on the Tigris proper from the junction of the Tigris with the Euphrates to the trenches at Sheik Said near Kut, 250 miles. All vessels used to run aground and lose days every voyage on unmarked sand banks, and in consequence the river service was only doing half the work it should have done.

I found that by sending my own officers to India materials and river steamers from the Ganges and from Burmah, most suitable for Mesopotamia, could be obtained, in fact, after we captured Baghdad I obtained permission from General Maude to send an officer, Colonel Ratsey, of the famous family of Ratsey's, the sailmakers of the Isle of Wight, to India and he was able to get 10 magnificent river steamers, each of them capable of carrying from 500 to 1,000 men. These vessels came round India and were eventually used between Basrah and Baghdad.

I found that practically the whole country from Basrah to Baghdad, 500 miles, was suitable for building yards for constructing barges and river boats. Slipways for taking the heaviest river vessels were built, excavations and filling up of land for the slips was done by hand labour and the excavation for a wet basin at the back of the dockyard, together with its connecting river channel, was also done by hand labour owing to no machinery being available. The labour used consisted of part of an Egyptian Labour Battalion and Indian labourers recruited as lascars for work on the river steamers; there being not sufficient river steamers requiring the services of the lascars they were persuaded to do the necessary mud shifting.

The various specimens of river steamers and barges shown on the screen will give you a very good idea of the fact that for river work almost any kind of vessel not exceeding the necessary draught can be used. The idea that special vessels have to be built for rivers like the Tigris and the Euphrates is an exploded one. One of the vessels shown is the old Thames steamer "Brunel," one of the so-called penny steamboats which used to run from Richmond down the Thames. A number of the vessels, including the "Brunel," were sent out to Mesopotamia from England under their own steam, although they only drew 3′ 6″ to 4′ of water. The Admiralty would not take responsibility for sending the vessels, and they were manned by Royal Engineer enlisted men and flew the Royal Engineer flag. They were not entitled to fly the White Ensign and were not merchant vessels. As the Royal Engineer Flag was not known to the Italian and French Patrol vessels in the Mediterranean the vessels caused something of a sensation when they passed through.

The second problem was due to the German Submarine campaign, which caused the British Government to decide to send troops and supplies for the Mediterranean and Eastern theatres of war through France and Italy. The best port the French Government could place at the disposal of the British Government was that of Cherbourg,

and at this port only the small harbour, really a harbour suitable for coasting vessels, was available. The Great Naval harbour was kept by the French for their own naval purposes. Ordinary necessary constructional work, railways, warehouses, and camp, was done partly by coloured South African Labour battalions and partly by contract with French contractors. The plans were drawn up by the War Office and there was little or no difficulty or trouble in getting them completed. Rest camps were formed at various intervals between Cherbourg and Taranto, as it was not thought advisable from a health point of view that troops should travel in trains for such a long distance without having opportunities for exercise and a general clean up. There were difficulties in obtaining building materials at the various camps and *halte repas* places. At one camp in the middle of Italy the officer in charge found material enough to write a book on his experiences. The main difficulty as regards accommodation for troops was at Taranto. I was sent along the Cherbourg-Taranto route to inspect it, on my return from Mesopotamia in July, 1917, and in my report I referred to the conditions at Taranto, where there were hundreds of men without any tents, and there was absolutely no accommodation for officers, who were arriving by various steamers, and were told at Salonika and Egypt that as soon as they arrived in Taranto they would be put on the international sleeping carriages straight through to Cherbourg; consequently they did not bring their kit, and one steamer arriving with about 200 officers presented a difficult problem to the Camp Commandant who had no funds available to purchase any necessary articles for the table, such as cutlery, chairs, etc.

I returned to London and advised the War Office to take away from G.H.Q. the control of the Cherbourg-Taranto Route, because I was convinced that any officer who became responsible for the work, and had to depend upon G.H.Q., France, for supplies of men and materials, would find it impossible to get the work done in a reasonable time, and if attempts were made to use the line under existing conditions serious trouble would ensue. The officers of the G.H.Q., France, had more than enough work and worry nearby and could not be expected to worry much about a place 2,000 miles away. I sent in my report one Friday evening and at eleven o'clock next day, Saturday, the War Cabinet agreed to transfer the Mediterranean Lines of Communication from G.H.Q. Branch to direct War Office control, and I was told to take charge of the organisation abroad; my headquarters would be at Lyons. Lyons is in the middle of France and is not on the direct road from Cherbourg to Taranto, but it was thought that headquarters in Paris might interfere with the prestige of others handling the war in France. However, in about a week I was able to convince the War Office that if any good was to be done at all,

Paris had to be the headquarters. All arrangements for trains had to be agreed to by the French, and Paris was the best place where one could get into communication with both the French and British War Offices, also when necessary with G.H.Q., France.

One of the troubles at Taranto was malaria, and this had to be attacked by insisting upon mosquito nets being issued and the area round the camp properly drained. Eventually Taranto was made into almost a model camp, but it was a very worrying job. The transport of troop trains the whole length of Italy and France could only be carried out with the goodwill of the French and Italian officials and people in the districts near the rest camps. The only serious trouble occurred with some of the coloured troops who were sent to Taranto to labour some months after I had severed my connection with the route, but in every other way the experiment of using the land line, instead of sending supplies and men by sea, was a success, and if the war had continued it would have been found to have been the only method by which it would have been possible to keep the Eastern Armies supplied without running unfair risks. The cost of transporting men and materials by the line was very small. Real constructional work did not commence until July, 1917, yet in October, 1917, the line was actually transporting more cargo than ships were available to take at Taranto.

The original War Office scheme for the construction of wharves at Taranto had to be altered owing to the difficulties of obtaining materials, and it was decided to build barge jetties and wharves instead of a wharf suitable for ocean going steamers. The general idea that vessels can always be loaded more quickly when they are lying alongside a wharf than when in midstream and loading from barges is not always correct. It is possible that loading by man power may be at times more expeditious, also, if ships have plenty of derricks and can load from barges on both sides, it is possible to load more quickly than on one side of a quay. The decision to build only lighter wharves was taken after due consideration of the difficulties of obtaining machinery, and the question of being in a position to load more than one steamer at a time.

One of the great difficulties in constructional work at Taranto was that of obtaining material, particularly timber. The Italian General Staff sent down a General of engineers to investigate our requirements, and when it was explained to him the amount of air space considered necessary for the accommodation of the British Tommy, when making estimates for huts, he was horrified. He said that in the Italian Army the huts used by the British would be made to hold just double the number of men we put into them, as beds would be built up in tiers, one above the other, as on board ship. This idea does seem to me to be a sensible one for putting

into force at any rest camp where a man has to be one or two days at a time, but the medical authorities are all against it, and housing accommodation at any British camp becomes, in consequence, a very expensive item.

Although the Cherbourg-Taranto Line of communication represented a problem not thought possible in pre-war times the whole problem was really worked out by officials in the War Office, and to them more than anyone else is due the credit of the work. Their plans both for construction and time tables for the trains were practically worked to. The alterations in constructional work necessary owing to various changes of plan at different times were all submitted to the War Office first for approval, and the advantage of being able to consult with the War Office officials over any difficulties cannot be too highly appreciated. General Mance was really responsible for the War Office control and carrying out of the Cherbourg-Taranto scheme, and I cannot call to mind a single instance of a request for assistance not receiving prompt attention. Sir Guy Granet, who was Director General of Movements and Railways, was always sympathetic, gave one every support, and one was not worried over petty affairs. My experience on the Cherbourg-Taranto route was that, provided one kept the War Office fully informed of progress and difficulties, one received every assistance and support both with advice and materials.

As an instance of the difficulties of working in Allied countries I should like to point out that on the Cherbourg-Taranto route it was necessary, for a time, to arrange for the troops to change trains at Modane, the frontier station on the Italian-French frontier, because the Italians did not like their waggons being run into France, and the French did not like their waggons being run into Italy. They both said that they never got them back if once they crossed the frontier. A certain number of officers and nurses travelling over the route went by the ordinary passenger train, which followed the route, Genoa, Rome, Naples, Taranto, whilst troop trains followed the East Coast Route, Genoa, Bologna, Ancona, Bari, Brindisi, Taranto. The traffic via Rome was very annoying to the Italians, as it meant that the limited accommodation in their reduced passenger train service during the war was, so far as they were concerned, further reduced through the increased British traffic. Many instances of officers and nurses causing trouble with Italian railway officials by endeavouring to retain more than one seat in a compartment were brought to my notice, and at one time it was seriously considered issuing orders to stop officers and nurses travelling by the ordinary passenger train. Fortunately, by the help of having R.T.O's at the principal Italian stations, supported with the moral support of the military police, the nuisance was to a great extent mitigated, but there are in the files of the Embassy in Rome some

rather amusing complaints of the conduct of some of the British passengers. Of the many thousands of officers and men who travelled by the troop trains we had practically no complaints.

Generally speaking, communication between the Navy and the Mediterranean Lines of Communication officers was always most cordial, and at Taranto, where we had quite a large naval force, the work could not at the commencement have been properly carried out without a great deal of assistance from the Admiral in Command.

To those who may have to do similar work to that I had, I would say: If your work is in an Allied country you will find that all the things you want for your work will also be the very things required by the Allied Army, which naturally has first call, and you will get more by doing things unofficially than is at all possible through official channels.

A matter of most importance in connection with expenditure is the keeping of accounts for any work undertaken. Each officer in charge of work must necessarily have an Imprest Account, unless it is possible to control expenditure from a Central Office, and this latter is what I recommend, and in practice did, whenever possible. The ordinary Army Accounts are sufficient for small works, but when great undertakings have to be carried out, as in Mesopotamia, I am convinced the ordinary Army Accounts are not sufficient; in fact, when in Mesopotamia, I opened a set of books on the double entry system for all the work I carried out there, and had in charge of the books an officer who in private life was a Chartered Accountant. To suit the convenience of the Indian Government Auditor I also had kept the ordinary Indian Army Accounts. The advantages of double entry are that the accounts can be presented to the officer in charge in a compact proved form, and the books can be balanced and records kept in a manner which is admittedly superior to the Army single entry system.

Before making up your mind to build any works to any particular design talk things over with the R.E. Officers of your unit; don't be too shy to go to R.E. Officers outside your unit for advice and help. I was greatly helped in Mesopotamia by Brig.-General Stokes-Roberts, the C.R.E., Works, a very great gentleman, who died out there. If you have in your unit N.C.O.'s who have had practical experience of the type of work you have in mind don't hesitate to take them into your confidence before you tell them what you want them to do. This applies particularly to temporary war-time N.C.O's, as you may easily have in your unit an experienced workman who can set your mind at ease on matters which otherwise may only be known to you from a theoretical point of view or book knowledge.

When ordering supplies in an Allied country don't expect to get them unless you have your own men continually worrying suppliers, and don't pay for any goods until your own men have them in their

charge. If you have to send or go to an allied or foreign district outside your working area for supplies of materials go to the nearest British Consular Officer and get the assistance of the Consular Staff in any bargain you may make. You may need the Consul's evidence later on to prove that no mistakes in contracts have been made and also for the necessity of any prices you may have to pay. Don't risk laying yourself open to charges of negligence, or even worse, in dealing with Government money. Many officers have had a great deal of unnecessary worry and trouble over both their imprest accounts and contracts they have had to make with suppliers in foreign and allied countries. You may be sure all your expenditure will be scrutinised by people who do not know the why or the wherefore of anything you may have to do. It is most necessary when handling Government money to see first that authority for expenditure is correct, and, secondly, that expenditure can be proved in more ways than one. When dealing with foreign suppliers in either Allied or Foreign ports one must always bear in mind that the custom of the district may be one of *backsheesh* or bribery, and an officer cannot be too careful to keep his name clear of any suspicion of getting mixed up with the customs of the country.

When doing work of the nature above mentioned it will be found necessary to use the labour of the country or Army troops of the country, and it will be found that handling foreign people is somewhat different to handling people in England. My experience is that foreign troops or civilians work better and more satisfactorily when they are supervised by their own officers or nationals than when they are under direct control of English officers. There are exceptions to this, as some English officers got infinitely more work out of foreigners than their own officers, but as a general rule I think the wisest policy is to work through nationals of the party doing the labour. When labourers or Army troops are not being supervised directly by English N.C.O's or officers it is most important that all orders and instructions should be given through the foreign officers or civilian foremen who may be supervising the gang, otherwise misunderstandings and jealousies will flare up. Any complaints an English officer may have concerning the work of foreign labour should be tactfully put forward, otherwise he may find they are taken very seriously, and the men, if Army troops, severely punished, and if civilians a strike may occur. Formal complaints against the work or capacity of foreign army troops are often worse than useless. One must put up with the men one is given and be thankful to get any at all, consequently soft soap and tact have to be used, and more good can be done by talking to an officer over a drink at the camp or a town café than any number of official complaints or rude remarks on the job itself. A sense of humour in handling foreign men is often of more importance than a scientific knowledge of what ought to be done.

Officers of engineer corps in other armies are usually very scientific and sound engineers. The regular engineers I met in the Italian and Serbian Armies were certainly first-class men used to working with poor material and getting clever work done cheaply. They look upon English methods as wasteful and unnecessarily expensive, they also consider work done by English engineers to be of a too permanent character. When dealing with the foreign engineer officers it is advisable to let them know one is aware of their sound qualifications, and if circumstances suit be guided by their views both on work to be constructed and materials to be used. Accommodation for foreign labour does not have to be on the same scale as for British labour troops, and their feeding is a simple matter compared with the food of British troops. I found there was no difficulty when British N.C.O's had to control Serbian Troops or Italian workmen.

When controlling, temporary R.E. Officers remember they are not in the Army for fun, or because of a career; they most of them want to get the job over as quickly as possible and get back to their own work. They appreciate any kindness or advice a regular may give concerning Army Rules and Regulations, and it is not reasonable to expect temporary officers to know the Rules, Regulations and various Routine and General Orders as intimately as regulars, consequently it is not cricket to attempt to injure temporary officers by catching them on Rules and Regulations. Royal Engineer officers get to be more experienced men of the world during the course of their career, and can see many things from a different angle to that of officers in other branches of the Army. They are respected by other branches and can exercise great influence on the tone of a division or army when on active service.

In war time it is of the greatest importance for engineers to get work done quickly, and consequently peace time practice is not necessarily the best method for war time requirements. In peace time, the cost of work and scientific standards have to be taken into account before and during constructional work, consequently it is often possible to cut down costs and put up better structures by leisurely consideration of plans and delays in construction or placing orders for construction. In war time it may not be practicable to give sufficient time for consideration of plans and estimates. Speed of construction is the greatest factor to be taken into account, risks must and can be taken which, if taken in peace time, would end up in the criminal court, and practically the only point to bear in mind is the utility of the completed work.

In war time it is not wise to depend upon machinery being available for the execution of engineering work, and when planning work which has to be done quickly, it is advisable to consider what classes of plant and labour will be available to carry it out, as these two considerations are of more vital importance to the success of any

work than all other considerations put together. Much work can be done without machinery, and, when native labour is available, the amount of constructional work which can be done with manual power and ordinary spades, saws, hammers, etc., is astonishing. Heavy weights can be moved, docks dug, wharves built and slipways erected by man power as quickly, or more quickly, than can often be done by machinery when it is available, and if at any time an officer has reason to think there is a possibility of machinery not arriving, my advice is, if man power is available, use the man power and don't depend upon getting the machinery. Ships carrying machinery can be sunk by submarines, and in war time overseas one cannot be sure of receiving any machinery until it is actually landed and erected ready for use.

In handling temporary officers who have engineering qualifications it is as well to bear in mind the fact that the ordinary civilian engineer, when doing his practical work in peace time, has to remember that his living and reputation depend upon work being done properly, consequently he must satisfy himself that the materials and work he is putting into his job are sound and scientifically correct. The result is that in war time, when scientific principles cannot always be followed, and the best materials required are not available, the civil engineer may be apt to prefer delay whilst waiting for proper materials to come along, instead of finishing off the work quickly with bad material, and in consequence it is advisable that the engineer officer responsible for decisions should encourage the temporary officer by taking responsibility from him and advising or instructing him to use the bad material to get the job done, provided, of course, he is of opinion that bad material will last long enough, until better material can be obtained, or if, as is often the case, the temporary work will last until the work is no longer required for military purposes. I remember when building the first wharf at Mahgil, Basrah, the temporary officer responsible for the construction objected strongly to using certain old timber piles which were certainly most unsuitable for constructional purposes, and it was only after he had had it explained to him that either the unsuitable piling had to be used, or the work would be delayed for an indefinite period, he put his heart into the work and made the best job he could. I have no doubt that sooner or later someone responsible for the upkeep of the wharves at Basrah will write a long report damning the military people for using such poor materials in some of the sections of piling. They may even go so far as to say that someone must have made money out of it. The real reason for the use of bad material for this particular work will not be known.

At Taranto, although there is an established port—in fact, two ports, an inner and outer port—the facilities for handling supply ships were very poor, consequently it was necessary to construct

necessary wharves, and, owing to the difficulty of obtaining supplies from outside Italy, it was necessary to construct wharves, warehouses and camps out of local material as much as possible. Fortunately, underlying the whole of Taranto district is a bed of sandstone, and consequently it was possible to use the stone for constructing the jetties, wharves, warehouses and camps. Skilled Italian workmen were available for stone-cutting, and it was found that to build warehouses and huts of stone was cheaper and quicker than if they were built of timber. The Italians, upon seeing everything being constructed of stone, asked us how long we thought the war was going to last; but many of the British who passed through the camp, not knowing the reason for the great number of stone structures, were rather mystified, as they imagined the buildings of stone in Italy cost what similar buildings would cost in this country. It is a fact that in addition to the many advantages gained by being able to build the principal works of local material, they were actually built more cheaply than if they had had to be built from timber. It must also be remembered that it would not have been possible to obtain timber in Italy. Italy is not a timber-growing country, although in Calabria, near the Taranto district, there are timber forests. The difficulties of getting the timber from Calabria to Taranto were impossible to overcome in war time. The Italian army had to import timber from Switzerland for its own use; in fact, for any timber for housing or warehouse work in Taranto, it would have been necessary to send to England; only rough scaffold poles about 6" diameter were procurable after much trouble in Italy itself.

One lesson to be learnt from the working of the Cherbourg-Taranto route is that in war time one's Continental allies are so occupied looking after their own interests that it is not reasonable to expect them to be of service to British troops, except in extreme cases.

I think it is agreed that the regular Army forces of Great Britain in the event of a war with a first class or second class power will have to be considered only as the backbone of the land forces required to carry on the war, and that so-called temporary forces will have to be recruited to form the remainder of the body of the Army, and, as history repeats itself, so we may take it that the 1914 to 1918 problems which had to be solved will crop up again whenever any war of importance occurs. The maintenance and success of an army depend to a very great extent upon supplies of expert professional men and materials, and one most important problem which, so far as I know, was overlooked prior to 1914, and may still not be attended to, is that of knowing the positions and records of men who in civil life have the practical knowledge and experience of technical and professional work and of districts, countries or places possessing the

necessary machinery, craft and appliances. As an illustration of what I mean I can state that I am convinced that if it had been someone's duty in 1914 to keep a list of river steamers and barges in British India and Burmah suitable for use on rivers such as the Tigris in 1914, the Army which attempted to relieve Kut would have had every chance of success, as the whole difficulty of relieving Kut was simply due to lack of means of getting the army up to the front and maintaining it efficiently whilst there. It is not reasonable to expect human beings to do their work on half rations or with the knowledge that medical services have broken down and that guns and ammunition cannot be brought up as required.

Men who join the Royal Engineers have special qualifications, consequently if the best work is to be got out of them they have to be handled somewhat differently to ordinary troops. During the late war many of the temporary R.E. troops received practically no military training. They were to all intents and purposes civilians in uniform and had to some extent to be treated accordingly. I had at times N.C.O's who were Master Mariners, Civil Engineers, Mechanical Engineers, Electrical Engineers, all men who in their particular professions were capable of keeping their own end up in general competition. The opinion of such men had to be taken and considered whenever they were given a job of work to do. The officers of the R.E. recognised this, but officers of other Corps and Regiments very seldom took this factor into account, and when, as in the above mentioned instances of work, I was brought in close touch with officers of Allied Armies, French, Italians and Serbians, I found it practically impossible for these allied officers to realise the work of the R.E. N.C.O's. I found Continental allied officers very touchy concerning their dignity, and they expected to always have to deal with a commissioned officer in the British Army whenever any conversations of any kind had to take place. One difficulty in dealing with allied officers and getting satisfaction when a job of work has to be done is the rule that communications with foreign staffs should be through the staff officers of our own headquarters. This can best be got over by getting the Foreign Staff to attach to the R.E. officer an officer who can deal direct with the Foreign Staff. In small Missions, where only junior officers of the R.E. are attached, the usual thing is for an allied officer to be attached to the English Staff, and as the officer is usually a man chosen more for his tact or knowledge of English, than for knowledge of R.E. work, it simply means additional delay if everything has to go through the Staff, consequently my advice to any one undertaking work in connection with foreign armies is to do your utmost to get attached to your unit a special allied officer, and moreover get him to act unofficially 99 times out of 100.

If my experiences in the War have any lesson to teach it is that of preparation. I think that if the Royal Engineers are to be responsible in future for the work they were responsible for in the 1914 to 1918 war, then they must add to their present training and gain greater knowledge of the construction and working of ports and rivers transportation. A war in the Far East or Near East would entail a great deal of water traffic. The Navy will always have its own work to do, and I think it has been found in practice that an army must be self-contained.

THE EARLY YEARS OF THE ORDNANCE SURVEY.

(Continued).

VII.—Thomas Colby.

Thomas Colby.—Mudge was fortunate in his successor. It is difficult to imagine that any officer can have been more entirely fitted to direct the survey of this country than Thomas Colby. He had joined the department as a young subaltern in January, 1802; he became Mudge's right-hand man and took a large share in the general conduct of the operations during Mudge's life-time; and on Mudge's death, in 1820, he was appointed by the Duke of Wellington to succeed him: but not until the Duke had thoroughly satisfied himself that Colby was the right man.

Mudge died on the 17th April, 1820, but Colby was not appointed until the 10th July, by a letter from the Office of Ordnance of that date, signed by Lord Fitz-Roy Somerset:—

"I am directed by the Master-General to acquaint you that His Grace appoints you to succeed the late M.-General Mudge in the superintendence of the Ordnance Trigonometrical Survey; and the requisite notifications have been made accordingly."

During the three months' delay, Colby, not unnaturally, became a little restive, and wrote to His Grace on the 20th June a somewhat lengthy letter, in which the following passages occur:—

"I have used no interest, I have solicited no one of your Grace's noble friends to paint my character or conduct on the Survey in glowing colors; but I have had a firm but humble reliance that your Grace would, when the press of more important business allowed opportunity, enquire how far my conduct and character would render me deserving of confidence and enable me to conduct the Survey with efficiency and credit to the country."

He then mentions, as men qualified to give an opinion on his work, "Dr. Charles Hutton, of Bedford Row, the late very eminent Professor of Mathematics at the Royal Military Academy; Professor Bonnycastle and Dr. Gregory, of the Woolwich Academy; Dr. William Pearson, of East Sheen; the Professors of Natural Philosophy and Mathematics at Edinburgh, Aberdeen and St. Andrews."

This letter produced an immediate answer, which, judging from its style, was perhaps dictated by the Duke himself:—

Office of Ordnance,
21st June, 1820.

"Sir,

"I am directed by the Master General to acknowledge the receipt of your letter of the 20th instant, and to acquaint you that His Grace is

now making enquiries, and will let you know whether he will appoint you permanently to conduct the Survey or not. In the meantime, the Master General begs you will continue it, in like manner as General Mudge would have done.

" His Grace at the same time desires me to inform you that he entirely approves of your not having urged any of your Friends to apply to Him; and that you may rely upon it that neither upon this, nor upon any other occasion, could a private application be made to the Duke, without diminishing the favourable opinion which His Grace might entertain of the person in whose behalf it should be made.

" I am, etc.,

FITZ ROY SOMERSET."

His Grace proceeded to consult various scientific men as to Colby's fitness to take charge of the Survey, and amongst others he wrote to Sir Humphrey Davy, who replied that not only was Colby the officer best fitted for the appointment, but that it was in a sense his right, as he had been so long in charge of the greater part of the work. The Duke also sent for Dr. Hutton, and the story of the interview is told in several ways. The doctor, on entering the room, was at once asked by His Grace if Colby was the best man to take charge, and began a speech, " No man more so, My Lord Duke . . . " when the Duke cut him short with, " Thank you, Dr. Hutton, that is all I want to know; my time is valuable, and yours, I know, is not less so." And so Colby was appointed.

He was then a captain, and the Board of Ordnance paid him, on appointment, £1 7s. 8½d. a day, or about £500 a year.

He remained Director of the Survey until his retirement from the Army in 1846. He was, thus, continuously employed in the Department for 44 years, and during 26 of these he was in control of it. Like Mudge, he was devoted to his subject. Like him, also, he had many official difficulties to contend with, and had to put up with the same indignity of an official enquiry into his work. But, before he retired, he had the satisfaction of seeing the Ordnance Survey firmly established in public and official estimation, and he had succeeded in greatly expanding the scope of its activities and in increasing its usefulness to the country.

According to Portlock, whose *Memoir of Major-General Colby* is the principal source of information with regard to Colby's early life,

" The grandfather of General Colby was Mr. Colby, of Rhosy Gilwin, Newcastle Emylin, South Wales, a gentleman of considerable landed property. His father, Thomas Colby, was an only son, and an officer of Royal Marines. For many years he appears to have been attached to the Chatham Division of Marines, and at that station most, if not all, of his children were born, the births of four being recorded in the registry of St. Margaret's *next* Rochester."

Captain Colby was severely wounded "at the glorious battle of the 1st of June," 1794.

Colby's mother was Cordelia, sister to General Hadden, R.A., a distinguished soldier. Thomas Frederick Colby, the future Director of the Survey, was born on the 1st September, 1784, at Rochester, and his early years were passed either at Rochester or Chatham; but, when his father again went to sea, he was put under the care of his father's sisters at the family seat, Rhosy Gilwin, and by them brought up until sent to school at Northfleet in Kent. From Northfleet he went to the R.M. Academy, Woolwich, and was commissioned as second-lieutenant of Engineers on the 21st December, 1801.

In the following January he was posted to the Survey under Mudge, whose letter to the Master-General reads:—"I find him, on examination, well grounded in the rudiments of mathematics, and in other respects perfectly calculated to be employed in this business. I beg to point out to your lordship the expediency of Lieutenant Colby being attached to me with some degree of permanency, and to request you will assign him to my orders on that principle." He was posted to the Survey on the 12th January. There cannot be any doubt that General Hadden, then Surveyor-General of the Ordnance, was the prime mover in his nephew's appointment, but it is equally certain that Mudge was satisfied that young Colby was fitted for the work. In after years he had every reason to be pleased that the Surveyor-General's nephew had been chosen. As to the "degree of permanency," we have seen that Colby remained "in this business" for 44 years.

Although Colby was christened *Thomas Frederick*, he never seems to have used the second name, but always signed himself T. Colby or Thomas Colby.

In 1803 Colby suffered an accident which materially affected him for the rest of his life. He was engaged on a tour of inspection, and was examining Mr. Dawson's work on the interior survey of Cornwall, and that of his first batch of pupils, when the accident occurred.

Mudge thus describes it in a letter to General Morse, dated Liskeard, December 16th, 1803:—

"I am extremely sorry to announce, for your information, a most unfortunate occurrence. On Monday last Lieut. Colby, in the act of placing an overloaded pistol on the ground, was severely wounded from its going off unexpectedly: his left hand grasped the barrel and was so violently injured that amputation became necessary: it accordingly was taken off just above the wrist the same evening. The loss of his hand is not the only misfortune to be deplored, as his skull received a violent blow, producing a fracture in the forehead. . . . The brain, it seems, remains free from any injury; nor is any future evil apprehended, beyond a scar.

" Mr. Dawson, with whom Lt. Colby was living, and to whose house he was brought, took every proper step, and amongst others immediately sent to me. I consequently came with all possible speed. It is . . with a degree of satisfaction proportionate to my regard for this most excellent but unfortunate young man that I have to state the confident expectations entertained of his recovery, without the smallest injury to his intellects."

Colby was a man of unusual strength of constitution, and he recovered; but for the rest of his life his forehead bore the mark of the accident. He accustomed himself to observe with the large instruments, though he had only his right hand. Portlock, who knew him well, wrote in the *Memoir* that it was " impossible not to recognise in the injury inflicted on his skull a sufficient cause both for subsequent bodily ailments and for a reluctance to enter on long continued mental exertion." However that may be, there is abundant evidence that the injury did not, in later years, materially affect his activity either of mind or body, though we may, perhaps, attribute to it a certain unwillingness to tire himself with controversy.

It has been seen how much personal work Colby carried out during Mudge's directorate. The following letter from Colby to Mudge describes some of the conditions of work in Scotland :—

Benclach, near Alton,
24th July, 1818.

" The country which we have now to deal with is so extremely wild and destitute of accommodations of every kind, and the mountains are so high and difficult of access, and, moreover, seem at such long distances, that they require larger objects than those that were wont formerly to be erected, in consequence I have been compelled to send two men together instead of one alone to erect the objects, and the allowance of 2s. 6d. each object heretofore granted is become obviously too small. I have, therefore, to request that you will sanction me in raising it to 3s. 6d. each object. . . In this, as in everything else which regards the Survey, I have paid the utmost attention to economy, and I am willing to try the effect of what I consider as a minimum allowance. . . In the western part of Scotland, from the want of roads and carts, and the extreme height of the mountains, no station can be visited without very considerable expense, and I shall, therefore, endeavour to perform the Survey of it with as few stations as possible by the intersections of objects on the mountains, which will serve all the requisites of the map. . . "

Portlock includes in his *Memoir* an account, written in 1852, by Major R. K. Dawson, of a season spent under Colby's command in the Highlands. This account, from which the following paragraphs are extracted, gives an excellent picture of Colby's manner of life when at work, before he became Director of the Survey :—

" In the month of May, 1819, Lieutenant Robe and myself were appointed assistants to Capt. Colby on the Trigonometrical Survey,

and on the 5th June following I embarked in charge of a selected party of artillerymen, the instruments, and camp-equippage, for Aberdeen. . .

" We were joined at Huntley by Captain Colby, he having travelled through from London on the mail coach. . . . This was Captain Colby's usual mode of travelling, neither rain nor snow, nor any degree of severity in the weather, would induce him to take an inside seat or to tie a shawl round his throat; but, muffled in a thick box-coat, and with his servant Frazer, an old artilleryman, by his side, he would pursue his journey for days and nights together, with but little refreshment, and that of the plainest kind—commonly only meat and bread, with tea or a glass of beer.

From Huntley, Captain Colby proceeded with us on foot, and on the second afternoon we reached the base of the mountain [Corrie Habbie] in Glen-Fiddick, near to a hunting lodge of the Duke of Gordon. Here, by partially reducing the loads on the cars, and by the application of guy-ropes to support them, and with the men's shoulders to the wheels, we climbed up as far as we could; and, having unloaded the cars, made an irregular kind of encampment for the night. It was a fine evening; and we had need, therefore, of but slight covering; and anything like luxury was, of course, out of the question. A marquee was pitched for Captain Colby, in which he slept, in his clothes, on a bundle of tent-linings; and I, knowing no better, was content to put up with the like accommodation; but Robe, who had recently been with the Army of Occupation in France, like an experienced campaigner, set to work with his Portuguese servant, Antonio, who had also been with him on the continent, and soon put up his camp bedstead, and made himself much more comfortable—a lesson which I did not fail to profit by in my after-experience.

" On the following morning the really laborious part of the business commenced, that of conveying the camp-equippage, instruments, and stores to the top of the mountain. Horses were hired for the purpose and made to carry the packages slung like panniers over their backs, so far as the ground proved tolerably even and firm; but when it became broken and hummocky, which is commonly the case with peaty soils, or springy and wet, there was then no alternative but to unload the horses and carry the things on the men's shoulders. . . Captain Colby went on, taking Robe and myself with him, to the summit, where he selected a spot of ground for the encampment as near as practicable to the station, and also for the watch-tent, at a point much nearer still. He then selected a suitable place for a turf-hovel, to be built on the sloping face of the hill, with a tarpaulin roof, in which to make a fire for cooking, and for drying the men's shoes and clothes, and to serve also as a place of shelter and warmth for the men in tempestuous and severe weather. When some of the tents had been brought up, and one or two of them pitched for present use, a party of the men were withdrawn from this duty, and employed in pulling down the conical pile of stones built round the station-staff, and in setting up in its place the observatory-tent. The requisite steps were then taken for securing the table or stand, for the great theodolite; and the theodolite itself was then brought up with special care and fixed in its position. . . .

"When the arrangements in the observatory had been completed, and the summit of the hill was free from clouds, every moment favourable for observation was anxiously caught by Captain Colby, and devoted to that service, from sunrise to sunset. At other times he imparted to Robe and myself a knowledge of Ramsden's great three-foot theodolite, and of its adjustments, as also of the mode of working and entering the computations. . .

"29th of June.—Captain Colby took Robe and a small party of the men on a 'station hunt,' or pedestrian excursion, to explore the country, along the eastern coast of Invernesshire, Rosshire, and Caithness, and to erect objects upon some of the principal mountains, and select those which from their position and circumstances should be preferred for future encampments. . .

"21st of July.—Captain Colby and Robe returned to camp, having explored all the country along the eastern side of the counties of Inverness, Ross, and Caithness, as well as the mainland of Orkney, and having walked 513 miles in twenty-two days.

"23rd of July.—Captain Colby took me and a fresh party of soldiers on a station-hunt, to explore the country to the westward and northward of west."

The first day they walked 39 miles, having "crossed several beautiful glens" and avoided the beaten track as much as possible. In the middle of the second day Dawson thought that he really could not stand any more of it, and "petitioned strongly" to be excused from accompanying Colby. But the latter would not listen to his subaltern's petition and Dawson had to limp along. But he soon got broken in, and in a day or two was able to walk with the best of them. They got back to the top of Corrie Habbie on the 14th August, having walked 586 miles in twenty-two days.

Dawson (junior) says that on Sunday, 1st August, 1819,

"I so far forgot the sacred nature of the day as to commence whistling some light air. Captain Colby very properly checked me in so doing, explaining to me the deep sense of veneration with which the people of that country regard the Sabbath, and the next day I was informed, while on the march, by one of our men, that he had been urged by the landlord to come to me and beg me to cease whistling, dreading that some judgment should otherwise fall upon his house."

The Duke of Gordon helped in every possible way whilst the party was in the neighbourhood of Glen Fiddick, and came up the hill frequently to see Colby. He took no small interest in the work and carried out some of the barometer observations himself. The observations with the great theodolite were finished on the 28th September. After the instruments had been safely packed, Colby gave the men *carte blanche* to provide themselves a farewell feast.

"The chief dish on such occasions was an enormous plum-pudding, the approved proportions of the ingredients being—a pound of raisins, a pound of currants, a pound of suet, etc., to each pound of flour; these quantities were all multiplied by the number of mouths in camp, and the

result was a pudding of nearly a hundred pounds weight." This gigantic pudding was suspended by a cord from a cross-beam and boiled for twenty-four hours in a brewing-copper. "A long table was spread in three of the marquees, pitched close side by side and looped up for the purpose, and seats being placed also for Colby and his subs., we partook of the pudding, which was excellent, and withdrew, after drinking '*Success to the Trig.*'"

R. K. Dawson says that, after Colby was appointed Director, he was out with Vetch, Drummond and himself, in 1821, in the Orkneys and Shetlands, and in the solitary islands of Faira and Foula. In 1822 Colby was with Vetch and Dawson exploring the whole range of the western islands of Scotland. In 1825, the scene having shifted to Ireland, he camped on Divis, and in 1826 on Slieve Donard; and was not again in camp for any length of time until the resumption of the Survey of Scotland in 1838.

As the result of the report of a Select Committee of the House of Commons, the Survey of Ireland on the scale of six inches to one mile was commenced, under Colby's direction, in 1825. But the Tower of London still remained the Survey headquarters, although all but one of the officers were transferred to Ireland; Richard Mudge only, with a few engravers (and perhaps one or two of the surveyors engaged on the English detail work) remaining at the Tower. Colby himself led a migratory existence, being sometimes in Ireland and sometimes in London. The triangulation of Scotland was stopped, and no further work was done on it until 1838.

The last winter that all the officers were present at the Tower was that of 1824-25. Portlock says that Colby's "ardent zeal and craving for improvement spread quickly amongst the young officers serving under him, and setting them also thinking and working," rendered the winter memorable in the annals of the Survey. The officers were:—Richard Mudge, Robe, Drummond, Murphy, Dawson, Lacom and Portlock. Drummond's quarters in Furnival's Inn "became a laboratory and workshop." Everyone who knew Colby in those days "must remember how rapidly he moved or ran through the streets, rarely relapsing into a simple walk; and it was thus that I met him rapidly descending Tower Hill, when he took my arm, and with the usual, "Come, my boy, I have something to talk to you about," carried me back with him to the map office in the Tower, which was not only the office for the business of the Survey, including the engraving of the maps, but also contained the private apartments allotted to Major Colby as director of the work."* Portlock had dinner there with Colby, who explained to him his idea of compensation bars for base measurement, it being certain that a base would shortly have to be measured in Ireland.

* Portlock's *Memoir of General Colby.*

In 1828 Colby married Elizabeth, the second daughter of Archibald Boyd, of Londonderry, and took a house in Mountjoy Square, Dublin. In 1830 he rented Knockmaroon Lodge, close to one of the gates of Phœnix Park, and a few minutes' walk from Mountjoy House, which had become the headquarters of the Survey of Ireland. He had four sons and three daughters. Two of the daughters, Anne and Cordelia, survived until within a few months of the writing of this paragraph; they died at Clifton in the autumn of 1924, within a few weeks of each other, having lived to a great age, and to the last were keenly interested in the memories of their father's life. They entrusted to the present writer a great number of letters and documents which had been collected by their father.

In the collection above mentioned is a bundle of (copies of) letters written by Colby to his wife, between 1830 and 1844, covering a great part of the period of Colby's administration of the Survey of Ireland. In a letter written on the 8th May, 1830, from Liverpool to Knockmaroon Lodge, Colby says :—

" We went in a fly to the railroad and walked about a mile, where stupendous excavations through rock are in progress. We then got upon the steam carriage and went a mile with a dozen wagons fastened to our rear. The perfect ease with which these carriages can be managed is really beautiful—not like the pulling and hauling with horses. We could run up to a thing, and push it along in the most gentle manner without the slightest concussion, and stop or go backwards or forwards with equal ease. As the steam had got low and no experiments were in progress, we only went at the rate of 16 miles an hour."

On the 28th May :—

" On my arrival [in London] I found things in somewhat of a new train and that my influence in society was not in the least improved by my having been bottled up in Ireland for the greater part of a year. The Civil Engineers Club has almost ceased to exist. The Astronomical Society have got a little bad feeling among them. The Royal Society have a similar evil to contend with. The Athenæum are not in the most thriving possible state, and the Geological alone remains uninjured by folly or party feeling. . . A new Geographical Society is started and I am one of the provisional committee for its management. It bids fair to do well. Lord Aberdeen and all the leading people in his department, Lord Melville and the principal Naval characters, and, indeed, most of the Ministers, are in it. . . I have paid £5 to the Charter fund of the Astronomical Society; £3 12s. to the Geological Club, and £2 8s. to the Royal Society Club; £1 for silk stockings and 16s. 6d. for shoes—you see I am not extravagant."

June 3rd, 1830, Tower to Knockmaroon :—

" . . . I dine with Lord Hill, the Commander of the Forces, on the Saturday after next, and I have a Member of the House of Commons on the look-out to assist me in getting at those I want to aid in carrying my public objects in relation to the Irish Survey. I mean to be a little

more independent of the good or bad will of the Master General when I return; at least things are getting into train. The Member I allude to is not in office, but he is a personal friend of the Duke of W., Lord F. Somerset, Sir H. Hardinge, and of Peel and the other leaders of the Ministerial party. I am also at work through another channel to secure the support of Lord Lansdowne and that party. I am not asking personal favours, and therefore no interested motive can appear to operate against me. I have also taken further steps to secure the Survey against any unpleasant observations from Mr. Hume and his party; and I have also a promise of a committee next session for the Survey if I want support. You see, I have been on the look-out here."

23rd June, 1830:—

" . . . I have been working away for Ireland at a great rate, to get the bogs drained, etc., but the difficulties are enormous. I was yesterday first with Lord Downes (who, by the way, is turned civil and asked me to lunch at his house) and Colonel Rochfort about it. Next I went to the Irish Office to push the matter with Sir Charles Flint and the Irish Government, then to Sir Thomas Towlins, who is drawing the Bill for the drainage, and then to the House to get Brownlow and Sir H. Parnell rather to let the Bill pass with clauses which may impede its working than to throw it out altogether. It is uphill work and I would rather be at home, but I believe that I have saved the Bill from being thrown out. . "

December 2nd, 1831, London to Knockmaroon:—

" . . . You would have been amused if you had heard the *odd* speeches at the Royal Society Dinner. The Duke of Sussex evinced much good humour. When he gave the Queen's health, he told us that 'she contributed to the King's comfort,' and he called the Royal Society the 'Mamma' of the new societies, and he designated himself the Husband of the old Mamma.' He told us it was difficult to find men who would tell princes the truth, and that he could only get at it now and then by stealth. He drank wine with a few individually at dinner, and with the remainder in parties of six or seven. There were few great men there, and I was included among those who received the individual compliment. . ."

February 14th, 1832:—

" . . . Our new clerk, Mr. Kennedy, seems a sensible, straightforward, intelligent man. He is to be with me at the Tower on Thursday."

February 28th, 1832:—

" . . . When I am no more, I trust those I leave will not think it necessary to pay any pompous respect to the worthless remnant of what once was me. The tribute of sincere affection is all I desire, and the cheerful belief that my conduct below has not rendered my removal a matter to be regretted on my own account. But while I am here, it is my duty to do the best I can for those I love. I, therefore, take as much care as I can to prolong my existence."

December 4th, 1832, Tower to Knockmaroon:—

" . . . I dine to-day with Sir James South and on Thursday with

the Master General. But my official duty is very uphill work, though we are all personally on the most friendly terms."

May 9th, 1833 :—

"I have had a long private audience with the King to-day. He was very gracious, and looked over the whole atlas of Derry very carefully, sheet by sheet, asking questions about them and the Survey, and expressing his approbation, not only of the maps, but also of his Corps of Engineers and Artillery and of the Ordnance Department under which the work was executed. When Sir James Kempt introduced me, the King said,' he ought to have been ashamed of himself for not immediately remembering Colonel Colby '— that he thought I had belonged to the Artillery, and did not recognise me in the Engineers' uniform.

"It is gratifying that the first Irish map has been so well received."

In January, 1834, Colby suggested to the authorities that Captain Richard Mudge should carry on the English Survey independently, in order that he, Colby, might devote his whole attention to the completion of the Irish work. This is a proof that the English survey was still being slowly proceeded with, although the survey of Scotland had been stopped. It appears that the authorities still left Colby in general charge of the English work. "I had made up my mind to the sacrifice of my salary for the sake of advancing the Irish work." In later years he did undoubtedly sacrifice a large part of his salary for the same object, but it does not appear that this happened in 1834.

In September, 1835, he says that he has been down to Woolwich with Sir H. Vivian to see "the new Pontoon Bridge of Major Blanchard's invention. . . I returned with Sir H. to London . . . went straight to the Tower, did my business, and dined with Robe close to the Tower."

May 29th, 1837 :—

"Babbage has published a new book on Natural Theology, and his parties are crowded to excess. He gives one every Saturday, and as I came home past his door last Saturday, I am sure there were more than a hundred carriages waiting."

May 26th, 1837 :—

". . . My having been in London is most fortunate, for poor Dawson's complete failure in the tithe commutation business would have cast a sad damp upon all our work if I had not been here to avert the evil. The Scotch are coming forward for their Survey in good earnest. The Societies have petitioned, and some influential men see the Chancellor of the Exchequer to-morrow about it. A more powerful mass of noblemen and gentlemen are coming forward on that point, and it is quite necessary that I should be here to guide and prevent such blunders as have happened in the tithe commutation business. There is nobody that I could trust to put in charge of the Scotch Survey, and I suppose I must make it part of my business. All the leading movers of the matter are my personal friends."

May 7th, 1838 :—

" . . . Left the Tower about ½ past 3 o'clock, and went to the Engineers' Office. All gone but Colonel Wells. Went into the Ordnance Office, had a long conversation with the Master General ; asked to dinner on Sunday. Went to the Club. Murchison kept me a good while talking about geology."

May 19th, 1838 :—

" . . . I breakfasted to-day with a party at Mr. Baily's, lilies, tulips, etc., in the middle of the table—broiled salmon, roast pigeons, cold fowl, ham, plovers' eggs, prawns, and a party of philosophers : Sir John Herschel, who has just returned from the Cape of Good Hope, the Editor of the Nautical Almanac, Captain Smyth, the Professor of Natural Philosophy from Edinburgh, two Cambridge professors, Baily and I. Sir John enquired after you. . ."

June 5th, 1838 :—

". . . Jervis and Lock, the Director of the E.I. Company, took my time yesterday at the Tower."

June 6th, 1838 :—

" . . . I dine at Mr. Baily's to meet some of the foreign astronomers. These dinners are sad hindrances. We had a very good dinner at the Greenwich Observatory Visitation on Saturday and a very pleasant party of about 16—Mr. Baily in the chair—the astronomers of Greenwich, Cambridge and Edinburgh, Oxford, etc. Healths drunk, speeches, etc. Colonel Pasley has succeeded in blowing up two wrecks, and he is quite happy."

July 9th, 1838 :—

" . . . On Saturday the Duke of Wellington came to the Tower to present the new colours to the 20th Regiment, and after the presentation he did me the favour to call at the office, with Lord Hill, Lord Fitz-Roy Somerset and several other general officers, and I had the honour of shaking hands once more with my old and much esteemed Commander."

Writing from Perth, where he had gone to make arrangements for the resumption of the Survey of Scotland, Colby says :—

" Sir Charles Gordon told me that if I wished to have introductions to any of the proprietors, that the members of the Highland Society would be happy to give them to me, and they have put a paragraph in their report, expressing their wish that every assistance shall be given to the persons employed on the Survey throughout Scotland."

December 5th, 1838 :—

" . . . Jervis is working away to get my system introduced in the Indian Survey ; but as yet he is violently opposed by all the East India underlings."

May 8th, 1840 :—

" . . . I had a very long conversation with Sir Hussey yesterday morning about the proposed survey of Scotland. . . I have had heavy work to face all opposition, but the Engineer Office are now very civil to me—and everything is apparently smooth. The Inspector General has recommended the instruction of the young officers of Corps, and

non-commissioned officers on the Survey. This is complimentary, but what will Pasley say to it? . . . We are friends now, and both Ellicombe and Fanshawe are on my side. When I was buried in Ireland I had no opportunity for meeting difficulties."

In 1842 the headquarter offices of the Survey were established in Southampton, and Colby's letters from this date are mostly written from that town or from London. On October 31st, 1842, he says that he has seen Lord FitzRoy Somerset and Sir Henry Hardinge about the new scale of the English survey. On November 4th he writes that he left Southampton at 11 and got to London at 2.

On the 5th November :—

"The Engineer Office and the Ordnance Office were very civil to me to-day—perhaps they think it as well to be so as the Master General does not agree with them against me."

November 10th, 1842 :—

"Not many years since the value of a knowledge of Latin and Greek with a good flow of language for public speaking were so great that a man possessing them was allowed a high station in society, and supposed fit to govern others; though he might have been profoundly ignorant of everything but *words*. These times are changing. Men who learn to think aright, and to know what is going on both in the natural and moral world are rising in importance. The conceit which is engendered by ornamental or unsubstantial knowledge is giving way."

November 17th, 1842 :—

"My base apparatus has returned from the Cape of Good Hope, and I am in daily expectation of its coming here."

November 28th :—

"Yesterday was a fine morning and I walked to Romsey, where I heard a good sermon in the church there."

December 4th :—

"I am still in the dark as to what is to be done with the Survey, though I have just had a long conversation with Sir George Murray, the Master General, who is well disposed to me about it."

From an undated letter :—

"The little strip inside are penny postage stamps; by wetting one of these and sticking on the back of a letter not weighing more than half an ounce, you save sending a penny to the post office."

February 11th, 1843 :—

"I stand alone, with all the Surveyors in the kingdom against me—with the desire of the Inspector General's office (under whom I act) to take every opportunity of opposing me—with the Board of Ordnance mostly against me—the Master General neuter, and the Treasury desirous of putting the money spent under my direction under some one who will be less honestly inclined to prevent their exercise of patronage in appointments; and, my only chance of standing alone against this opposition, is that everything done under my direction shall be quite unimpeachable in every respect, for I have neither money to bribe

by good dinners, or health or leisure for political intrigues. . . During the last 12 months I have refused 65 applications for employment—many of them recommendations by noblemen, and influential members of the House of Commons; and several by the Master General and Members of the Board of Ordnance." . . .

November 12th, 1843:—

"My department is so powerful that I can (if they will allow money enough) carry on the American boundary, the Hong Kong Survey, the London Survey and the Scotch Survey, without checking the English or Irish Surveys."

December 12th:—

"Yesterday evening I went to the Geographical Society, where they had more of Dr. Beake's account of Abyssinia. But certainly we knew no more about its geography when we left the room than we did when we came into it."

10th February, 1844:—

"I had a very complimentary note from the Foreign Office last night, about Captains Robinson and Pipon and my sappers that I sent from the Survey to settle the American Boundary."

And on February 21st:—

"I have just been reading two very amusing and cheerful letters from my officers, Captains Robinson and Pipon, who are at work with some of my soldiers on the American Boundary. They cannot tell the degree of cold because the mercury is in the bulbs of all the thermometers. It is, therefore, more than 32 degrees below freezing; and they are obliged to keep all the chronometers in a room with a fire, and a sapper to repeat the *ticks* loud for them to hear in the observatory, because it is too cold in the observatory for the chronometers to go."

Colby was a man of religious temperament and took a lively interest in church affairs. He deplored the state of things that then existed in Wales. Being also a man of science, he had no patience with those ecclesiastics who ignored, decried, or derided the conclusions of organised knowledge; and it may be remembered that in his day the new teachings of geological discovery were beginning to be appreciated by the public. On February 27th, 1844, he writes:—

"I met a gentleman who has property at Cheltenham yesterday evening. He was giving me an account of the ignorant bigotry of Close, and his violent attacks on science."

On March 25th:—

"Wales will be improved *in spite* of the Welsh [Colby was himself Welsh].

Again, with regard to the church in Wales:—

"I feel convinced that the whole government of the Established Church requires a change, and regret that the clergy are the last to see the necessity for a reform."

Whilst the Survey of Ireland was in full swing, Colby's permanent house was Knockmaroon Lodge, although he was, for long intervals, in London, looking after the interests of the work. In 1838, when the survey of Scotland was resumed, Colby left Ireland and lived in London. In October, 1841, the Survey offices in the Tower of London were burnt down, and in 1842 the headquarter offices were removed to Southampton. From this year until his retirement in 1846 Colby lived principally at Southampton. Colby's retirement took place at the moment when the last of the Ordnance maps of Ireland on the six-inch scale had just been completed and published.

It appears from a letter written by Sir John Burgoyne that Colby voluntarily retired, after being promoted to the rank of Major-General. It was not the case that he left the Survey on account of his promotion, but rather that he thought it time to take a rest from the prolonged labours of forty-four years. After leaving the Survey he took his family to Germany and Belgium, in order to educate his sons. He was not well off, but had taken the unusual step of relinquishing his salary for the last five years of his active employment. It is said that :—

"Colby did not hesitate, year after year, to take upon himself the responsibility of exceeding by large sums the rates sanctioned by Parliament, rather than diminish the rate of expenditure and progress by discharging qualified assistants. To keep down current expenditure, Colby for some time did not draw his own salary. When he subsequently applied for arrears they were refused and never paid."*

This statement is borne out by a letter from Richard Mudge of the 20th July, 1848 :—

"MY DEAR SIR,

"If anything has given me more surprise than for a very long time, it is the fact you mention, and which I learned for the first time from your letter that the Board of Ordnance had withheld your salary for the Survey of Ireland for the last five years preceding your quitting the Survey. It is so unjust and absurd that I am sure it must eventually be paid, although it may require the interference of some person of weight and influence with the present Government to obtain it. I think that your claims are of a much greater amount. . . The Survey of Ireland is one of the most important and successful undertakings of late years and was conducted throughout and to what may be termed a conclusion by a continuation of firmness and perseverance which I assure you always impressed me with pleasure and admiration. I knew a great deal of what you had to contend with and of some of the difficulties and impediments that were thrown in your way." . .

However, he never got the whole of his money back, though it appears that he was repaid a small fraction of it.

* *Dictionary of National Biography. Article, Thomas Colby.*

One of the many advantages of Colby's long residence in London was that he became very intimately connected with the various scientific societies which have their headquarters in the metropolis. He was a Fellow of the Royal Society. He was an original member of the Royal Astronomical Society, and helped to draw up its rules. He assisted at the formation of the Royal Geographical Society, and was a Fellow of the Geological Society. He was an Honorary Member of the Institution of Civil Engineers and frequently attended the meetings of that body. He was given the honorary degree of LL.D. by the University of Aberdeen. But, except for promotion to Major-General, he never received any recognition from the various governments that he had served.

Colby had a wide circle of friends and correspondents. Amongst soldiers, Hardinge, Fitz-Roy Somerset (afterwards Lord Raglan), and Burgoyne, Pasley and Everest; amongst sailors, Raper, Hurd and Beaufort; amongst men of science, Banks, Faraday, Airy, Kater, Brewster, Murchison, Herschel, Baily, Hutton, Sheepshanks, Sir W. Hamilton, Sedgwick, De la Beche, Peter Barlow and Gregory; and in the larger world, Rowland Hill, Robert Stevenson, the engineer, Lord Macaulay, and Sir Thomas Brisbane. He was clearly happiest in the atmosphere of learning, and never more at home than when in the company of his friends of the learned societies, at the various dining clubs to which he belonged, or when taking part in the proceedings of these societies.

The unsettled state of affairs on the Continent induced him to return to England with his family in 1848, and a few years later "with little or scarcely any warning, the spirit, yet active, was summoned from the body, yet firm and hale, and on the 2nd October, 1852, in the 69th year of his age, whilst amid his loving and mourning family, at New Brighton, near Liverpool, he passed from the scene of so much bodily and mental exertion to rest and peace eternal." * Portlock goes on to say that he learnt to appreciate Colby's "accurate knowledge, his sound judgment, his untiring energy and consummate skill, and, above all, his unbounded liberality in imparting to me and others the stores of his own knowledge."

One more tribute to Colby's memory may be given: that written by Sir George Airy, the Astronomer Royal. Airy and Colby were friends and had been in close touch for a great number of years. Colby knew how to value Airy's great gifts, and Airy was ever ready to help the Survey. There is no trace of the hard and unpleasant side of Airy's character in his relations with Colby or the Ordnance Survey. Airy writes in 1869 to Mrs. Colby:—

"We both were members of the Board of Longitude, which was dissolved in 1829 (I think). . . At one of my Irish visits I had the happiness

* Portlock's *Memoir of General Colby*.

of enjoying the hospitality of Knockmaroon Lodge; and in later years, when Colonel Colby was for a long time fixed in London, I and my family had the gratification of receiving him very often at our Sunday dinner at Greenwich. We can all bear testimony to his kind and social disposition; his appearance was always a source of friendly pleasure to us. I was often struck with the peculiar adaptation of Colonel Colby's talents and habits to the great work which he directed and the great system which he principally created. With the scientific geodetic problem before him he was familiar. On the grand points of execution, such as the large scale triangulation (I may well use that epithet for a triangulation which described the length of Ireland in three steps and its breadth in two), he was clear in his own judgment and decided in his provisions for carrying them out. . . The order of his offices was admirable. His attention to the accuracy of instruments of every kind was very great. And all this devotion of himself to his great work appeared to be wholly unselfish. I never heard a word from him which implied that he was looking abroad for personal glory, or for any expression except the recognition of his results as producing a scientific survey superior to any that had ever been made, and a cadastral mapping to which no other, I believe, can be compared."

Major General Thomas Colby

MODERN HEAVY OIL ENGINES.

By CAPTAIN R. M. H. LEWIS, M.C. R.E.

In view of the probable adoption of the "airless injection cold starting heavy oil engine" ("loosely termed" the cold starter) for army purposes in place of the old Hornsby type of slow speed horizontal paraffin engine, this article has been written (*a*) to attempt to make clear the differences between the semi-diesel, the diesel using air blast injection and the cold starter; (*b*) to compare briefly their relative merits; and (*c*) deal with the main points in cold starter design.

Although official definitions for the semi-diesel and diesel engines have been got out by the Diesel Engine Users Association, no definition of a "cold starter" has yet been devised: mainly because the cold starter, although now an economic proposition, is only just emerging from the experimental stage. The various attempts at getting a true cold starter were too diverse for a definition to be devised which would cover them all and yet exclude the semi-diesel and the air blast diesel.

Cold Starter design, however, has now settled down into two main channels: (*a*) The marine type, not found in small sizes, which has been evolved from the air blast injection diesel (hereafter called the diesel for short); (*b*) The land type, found in sizes from 10 h.p. up to 950 h.p., which has been mainly evolved from the semi-diesel.

While the general design and principles of the diesel and semi-diesel can be found in any text book, it is necessary to summarise briefly here their relative advantages and disadvantages for comparison purposes with the cold starter, about which last, so far as the writer is aware, there is no extensive literature available except the makers' catalogues.

The semi-diesel engine is an engine working on the constant volume cycle designed to use the lighter types of residual oil.

To make ignition possible the oil has to be split up or atomized into a fine spray. This is done by means of a fuel pump which forces the oil, under varying pressures, up to 1500 lbs. per square inch, through one or more fine holes in what is known as the pulverizer, into the engine vaporizer.

The resultant mist of fuel is then ignited by means of the heat of compression *aided by the heat of an uncooled portion* of the cylinder head.

Herein lies the root of semi-diesel troubles.

(*a*) External heat has to be applied to the engine to start it, i.e., it is not "cold starting." In the past this heat has usually been

supplied by heating up the uncooled portion of the head with a blow-lamp. This operation takes up to twenty minutes to do, and a blow-lamp is a messy affair and increases the fire risks.

This difficulty has been largely got over by the use of quick starting devices, e.g., heating up a coil of wire electrically or burning a patent cartridge in the cylinder head. These devices supply the necessary heat for starting and enable the engine to get away in about two minutes. They, however, usually entail auxiliaries such as a battery or a supply of cartridges.

Some semi-diesel makers are doing jackal to the cold starter lion and describing engines fitted with one of these quick-starting devices as "cold starters" Such a description is intentionally misleading, as the engine in question has all the characteristics and efficiencies of a semi-diesel.

The true cold starter starts solely on the heat of compression, which is sufficient to ignite the charge with a cold engine.

(*b*) The semi-diesel suffers from either cooling off of the hot bulb at light loads or overheating of the hot bulb at full loads, according to the compression pressure that the engine was designed for (150-250 lbs. per square inch).

Both these faults can be met by special devices which, however, all entail *hand adjustment* by the engine driver for efficient running. This is always an undesirable feature.

The prevailing modern type of semi-diesel is the two-stroke vertical, usually using crankcase compression. (The old 4-stroke type has deserted practically *en bloc* to the cold starter camp).

This type of engine, until the advent of the cold starter, kept its market, not by its efficiency as compared with the diesel, but by its simplicity, low first cost and light weight. It is only found in the smaller sizes from 5 h.p. up to 6 cylinder 480 h.p., 80 h.p. per cylinder marking the limit at which it is possible to use the air-cooled piston.

Up to date no two-stroke cold starter has been evolved from the corresponding semi-diesel 2-stroke in this country, but the manufacturers of the latter are at last realizing that they must move with the times in face of intensive cold starter competition. One of the leading two-stroke semi-diesel firms has announced that it is building an engine with a higher compression pressure (280-300 lbs. per square inch). The engine is fitted with an electrical quick starting device and the higher compression pressure enables the head to be entirely water-cooled. It is not a cold starter but is a step in that direction.

As regards running characteristics the principal points are summarized below.

(1). *Range of fuels.* The semi-diesel will run most satisfactorily on the light residual oils of about .88 to .9 specific gravity. Although

the makers claim that their engines will run on fuels up to .95 specific gravity they are careful to avoid stating that their maintenance troubles will probably be doubled thereby.

(2). *The fuel oil consumption* of semi-diesels is poor as compared with its rivals, ranging from .48 (exceptional) to .55 lbs. per B.H.P. Hour with oil of approximately .88 to .9 specific gravity and 18,500 B.Th.U's per lb.

By substituting a separate scavenge air pump for crankcase compression (big diesel practice invariably has the separate pump) both the fuel and lubricating oil costs are cut down, at the expense of simplicity and first cost.

(3). *The lubricating oil consumption* is very high, especially in those types using crankcase compression without forced lubrication. The consumption varies from $1\frac{1}{2}$ to $2\frac{1}{2}\%$ of the fuel oil consumption.

(4). *The first cost* is very low, lower than either the diesel or cold starter.

(5). *The maintenance and attendance.* Provided too cheap and heavy an oil is not used, maintenance of these engines is simple. The engines are easy and safe to handle with moderately skilled attendance.

Fig. (1) shows the cylinder head of the Tangye semi-diesel.

Leaving out the intermediate types of engine, it is found that the land type of cold starter is a four stroke semi-diesel which has been altered as follows :—

(1). The cylinder head is entirely watercooled and the compression pressures raised to 380 to 420 lbs. per square inch. At these pressures no quick starting device is necessary, as the heat of compression is sufficient to give reliable starting under all conditions.

It should be noted that 380 lbs. per square inch is the limit, and as a precautionary device with engines working at that pressure it is quite usual to find a hot tube in the cylinder head which in an emergency can be heated up.

(2). At the same time, if the plain constant volume cycle were retained the maximum explosion pressures developed would be excessive. The timing of the fuel pump cam is therefore set a little later than in the semi-diesel, so that the fuel is burnt partly at constant volume, up to about 560 lbs. per square inch in the land type, and the remainder at constant pressure, which explains the rounded top to the indicator diagram. Even so there is a marked thump in these engines on heavy loads.

(3). The same principle of injecting the fuel by fuel pump and pulverizer, known as solid injection, is retained, but improved to

give finer atomization, using in the land type fuel oil injection pressures of 1500-3000 lbs. per square inch.

(4). Whereas semi-diesels are not usually fitted with compressed air apparatus for starting under 15 h.p., the apparatus is common with all types of cold starter. Engines can be got away with air pressures of 60 lbs. per square inch, but 250 lbs. per square inch is the normal pressure used.

Fig. (2) shows the cylinder head of a Blackstone cold starter. Comparing with Fig. (1) it will be noticed that the protuberance on the piston head has been retained. This is known as a "turbulence block" and is a feature of all land type cold starters except in some of the larger sizes.

Its object is to provide a state of turbulence in the ante-chamber at the moment of injection of the fuel. Air, trapped in the spaces AA, is forced at high velocity into the ante-chamber at the end of the compression stroke, thus attaining this object.

The greatest disadvantage of solid injection is that, unlike air blast fuel injection, it does not provide good turbulence. Hence it is usually found that the turbulence, and therefore efficiency of combustion, falls off as the piston starts to move out, i.e., during the constant pressure portion of the combustion. This probably accounts for the coloured exhaust of a cold starter, which gets more pronounced as the load, and, therefore, the constant pressure period of combustion, increases.

Two questions naturally arise on reading the foregoing. (1) Why the variation in fuel oil injection pressures from 1500-3000 lbs. per square inch? (2) Why the variation in compression pressures from 380 to 420 lbs. per square inch? (1) The oil when issuing from the pulverizer comes out in one or more fine jets which split up into a mist at a distance from the pulverizer, which depends on the pressure with which it is forced through the pulverizer. For the marine cold starter pressures up to 9000 lbs. per square inch are used. In that case the oil spreads out in a mushroom shaped mist immediately on leaving the pulverizer holes. With pressures of 1500 to 2000 lbs. per square inch the oil will travel as a jet some distance before spreading out as a spray.

The aim is to spread a mist of fuel out all over the combustion chamber and not localize it round the pulverizer nozzle nor let it impinge as a jet or jets on the combustion chamber wall.

The pressures used, therefore, are designed to suit the shape of the combustion chamber.

As regards the compression pressures these are mainly governed by the manufacturers' own ideas as to what will give reliable cold starting. The lowest pressure possible is used to simplify construction and lower bearing, etc., stresses.

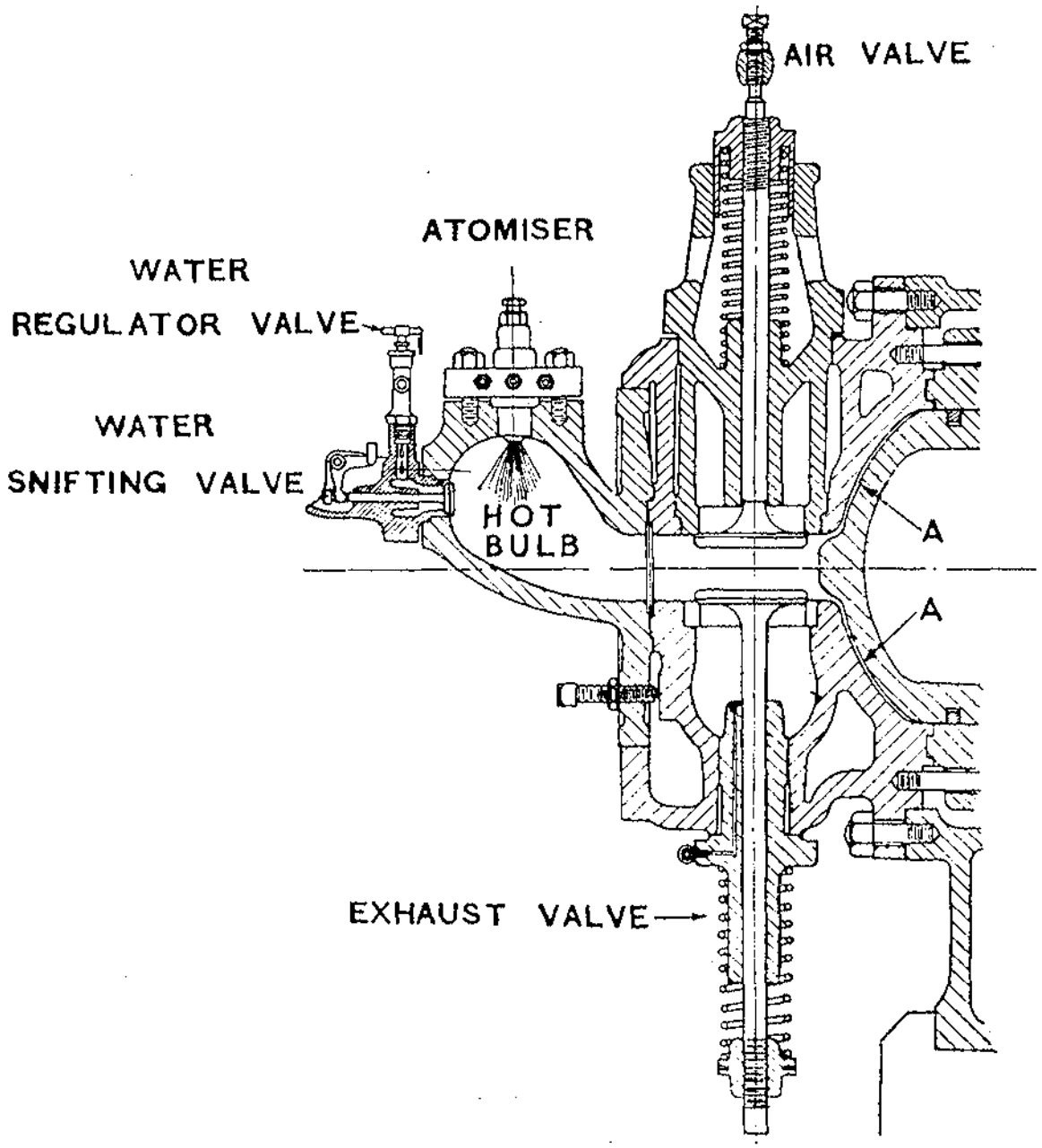


Fig. 1.—Tangye Semi-Diesel Engine.

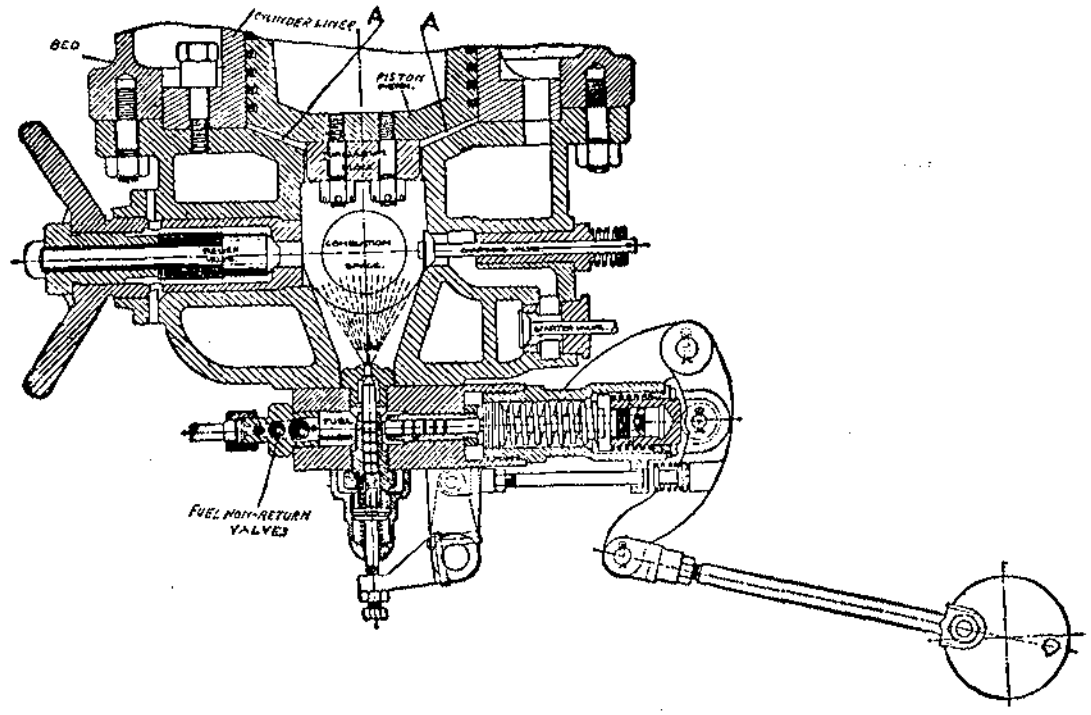


Fig. 2.—Blackstone Cold Starter.

The facts and figures regarding the cold starter are enumerated under the heading of Marine Cold Starters.

Turning to the diesel engine, as is well known, this engine uses a compression pressure of 450 to 500 lbs. per square inch. The normal method used for injecting the fuel is by means of a blast of air at 600 to 1000 lbs. per square inch pressure.

It is on account of the cooling effect of the air blast that a diesel has to use a higher compression than a solid injection engine of the cold starter type, in order to compensate for the loss of temperature.

In order to avoid excessive pressures the fuel is burnt approximately at constant pressure.

The diesel engine is made in a large number of different types on both the four-stroke and two-stroke cycles. It is made multi-cylinder double acting, single acting, opposed piston and many other special types from 35 h.p. up to 7200 h.p. Orders have just been placed for an 8,000 h.p. 8 cylinder marine diesel. With air-cooled pistons the limit of B.H.P. per cylinder is 175. With water-cooled double acting pistons 750 S.H.P. has already been obtained.

The diesel engine is now slowly but surely ousting the reciprocating steam engine from marine work up to 10,000 H.P. Over this size it cannot compete with the steam turbine. The whole problem before diesel makers now is (1) to simplify and (2) to lighten their engines. (1) will be dealt with later. As regards (2) the limit of development has now probably been reached with the four-stroke single acting engine. Future development of high powers with low weight for power undoubtedly lies along the lines of the double acting two-stroke with supercharging.

Apart from marine work there is a certain scope for this type of engine for stationary purposes.

The diesel engine using air blast fuel injection has the following characteristics. *Fuel oils used.* Diesel engines can use the heaviest oils, up to tar oils, with the aid of pilot ignition. Engineers, however, are generally in agreement that the increased maintenance troubles are not worth the increased economy of using the heavier and cheaper oils.

When the heavier oils are used, a practice known as "centrifuging," for getting rid of the solid impurities in suspension in the oil prior to its use, is advisable.

In all cases the heavier oils have to be preheated in order to get them to flow to the fuel pump.

Fuel oil consumption. This is extremely good. A fuel oil consumption of .37 lbs. per S.H.P. hour has been recorded with a very large marine diesel. More normal figures range from .42 to .48 lbs. per B.H.P. hour with fuel 18,000 to 18,500 B.Th.U.'s per lb. *Lubricating oil consumption* is much lower than in the semi-diesel, being in the nature of .0002 to .0006 lbs. per B.H.P. hour—approximately

½ to 1½% of fuel consumption. *First cost.* The diesel first cost is very high. It is difficult to give actual figures, but Kemp's pocket book gives £25 to £30 per B.H.P. at makers' works. *Maintenance and attendance.* For the engine to be run with safety and economy highly skilled attendance and very careful maintenance are necessary. It is, therefore, not suitable for general army purposes.

As mentioned before, the chief problem before the diesel manufacturer was to simplify his engine.

The obvious point of attack was the high pressure air blast used for injecting the fuel.

While producing an excellent condition for combustion in the cylinder head, it has the following drawbacks.

(1) Its cooling effect necessitates a very high compression pressure. These high compression pressures necessitate heavy construction and, therefore, low mechanical efficiency, to cater for a possible pre-ignition and consequent high explosion pressure.

(2) The air blast necessitates a compressor running continually and a blast air storage bottle. These both add to the first cost and overall weight and bulk, and the former is a source of danger and lowers the mechanical efficiency.

(3) Unskilled or careless attention to the fuel valve and blast air arrangements have resulted in more than one disastrous explosion.

(4) The air blast pressure for economic running requires continual regulation with the load and engine speed. This leaves the efficient running of the plant largely at the mercy of the engine driver.

Some diesel manufacturers, therefore, now make both air blast and solid injection engines. Many more are experimenting with solid injection.

This type of cold starter having been developed from the diesel is very often known as the "solid or mechanical injection diesel." As far as constructional detail goes it follows diesel practice in everything except the fuel valve, even to the flat top or concave diesel piston head. It does not use the turbulence block in favour with the land type of cold starter and injects the fuel straight into the cylinder head, as in diesel practice, and not into an ante-chamber as in land cold starter practice.

In consequence, as already mentioned, fuel oil injection pressures of 4000 to 9000 lbs. per square inch are used, which pressures are very hard to deal with as far as pump packing, etc., is concerned.

Whereas with the air blast compression pressures of 450 to 500 lbs. per square inch are necessary, owing to the cooling effect of the blast, with solid injection the pressure is dropped to 420 to 450 lbs. per square inch. The fuel, as in the land type, is burnt partly at constant volume only up to higher pressures, in some cases, pressures from 560 to 650 lbs. per square inch being met with.

The efficiencies of both the land type and marine type cold starter are about the same, and the following facts apply to both.

Range of sizes. Marine types are only made in fairly large sizes. The Vickers firm make from 450 S.H.P. up to an 8 cylinder 2700 S.H.P. type. They are made 4-stroke or 2-stroke. Land types are only made from 10 H.P. single cylinder up to 950 H.P. 6 cylinder (the limit with air cooled piston 4-stroke cold starter or diesel is 175 B.H.P. per cylinder); only the single acting 4-stroke type has been developed at present.

Fuel oils used. Identical with the diesel.

Fuel oil consumption. Test bed consumptions on a land type engine have been got down to .365 lbs. per B.H.P. hour with fuel of 18,500 B.Th.U's per lb. A more normal consumption ranges from .4 to .48 lbs. per B.H.P. hour. This compares very favourably with the diesel.

Lubricating oil consumption. Identical with the diesel.

First cost. Intermediate to the diesel and the semi-diesel.

Running costs. Taking into account everything, including depreciation, the balance is in favour of the cold starter as against either the diesel or the semi-diesel.

Maintenance and attendance. The engine is simple and safe to handle with unskilled labour. Its maintenance troubles are very little, if any, more than a semi-diesel's and much less than a diesel's.

The foregoing should prove that the oil engine future lies in the cold starter type.

Three new fields of use have been opened up to heavy oil engines by this type.

(1) Aero engines. Little has been done in this line at present. Messrs. Beardmore and Co. exhibited a 6-cylinder 600 B.H.P. 1300 r.p.m. cold starter at Wembley, the weight working out at 3 lbs. per B.H.P., but this is still experimental.

(2) Automobile engines. Continental manufacturers have tackled the problem and obtained speeds up to 2,500 r.p.m. and maintained them. The difficulty is in this case to obtain sufficient flexibility, and the great advantages are the enormous saving of fuel costs and the absence of fire risks.

(3) Railway locomotives. Experiments are being made in this direction, but the only field of application would appear to be in tropical countries where water and coal are scarce, e.g. East Africa. Also they would appear to have possibilities for active service use.

To conclude, while no more improvement in blast air injection can be looked for, there is still room for improvement in solid injection.

The brake thermal efficiencies of the air blast diesel and the cold starter are about the same. The diesel mechanical efficiency is

73 to 75%, due mainly to the work absorbed by the compressor. The mechanical efficiency of the cold starter is 85%. The indicated thermal efficiency, therefore, of the cold starter is some 10% worse than that of the air blast diesel, showing that *per se* solid injection is not yet comparable to air blast injection. Experiments made in an endeavour to raise the mean effective pressure of heavy oil engines at high speeds have demonstrated that a much higher M.E.P. can be obtained at present with air blast fuel injection than with solid injection.

As it is desirable for instructional purposes to find some simple definition of a " cold starter " the following definition, on the lines of those got out for the semi-diesel and diesel by the Diesel Engine Users Association, is suggested.

A " cold starter " is a prime mover actuated by the gases resulting from the combustion of a hydro-carbon oil. A charge of oil in a fine state of subdivision is injected into the engine cylinder at or about the time of maximum compression, the oil being injected by the pressure exerted on it directly or indirectly by a cam-operated fuel pump.

The heat of compression is the sole means of igniting the charge at all times. There is no uncooled portion of the cylinder head. The engine is capable of starting on residual oil of .9 S.P.G.

Combustion takes place partly at constant pressure and partly at constant volume.

Fig. 3 shows comparative indicator cards of the semi-diesel, cold starter and diesel.

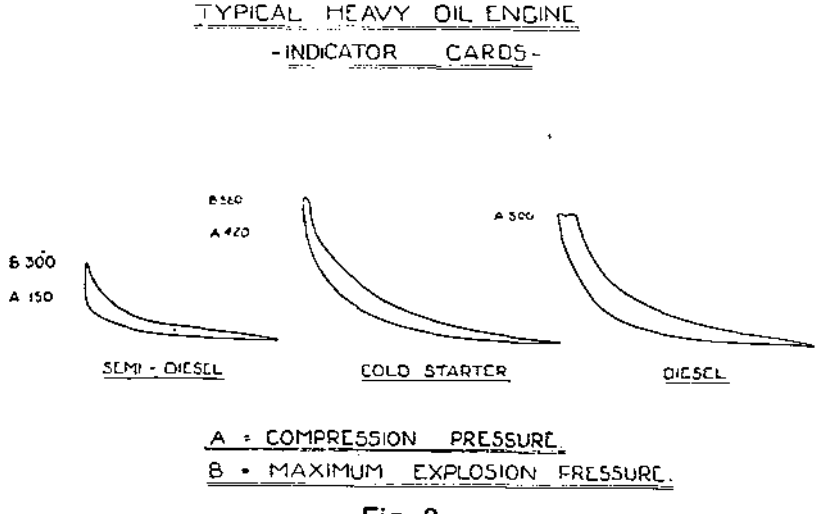


Fig. 3.

NOTES BY A CHIEF ENGINEER DURING THE GREAT WAR OF 1914-1918.

By BRIGADIER GENERAL W. BAKER BROWN, C.B.

ALTHOUGH much has been written about the details of the various campaigns which made up the Great War of 1914-18, little has been published about the work which was done almost unnoticed in the Commands at Home and in the Colonies. This work in preparing the components of the Field Armies and in holding the bases used by our Fleets was essential to the efficiency of the mobile forces afloat and ashore, and will have to be done over again if we are ever faced with another war of the same magnitude. A record of such work may, therefore, be useful as well as interesting.

The outbreak of war in 1914-18 found me employed as Chief Engineer in the South China Command and stationed at Hong Kong, where I had joined in January, 1914. The G.O.C. of the station was Major General F. Kelly, C.B., late R.E. (and no one could have wished for a better chief). The station was well known to me as I had served there in command of the submarine mining company from 1901-1904, and on the outbreak of the Russo-Japanese War in 1904, I had been employed for two months on the staff of Major General Villiers Hatton, C.B., in revising the defence scheme. One of the outcomes of this revision had been a recommendation for a considerable increase in the Light Gun and Electric Light Defences and in the provision of military roads to the passes on the Kowloon hills. The station's recommendations were adopted by the War Office and were in full progress when there occurred the violent swing of the pendulum which accompanied the transfer of the mine defences to the Navy in 1904 and 1905, and which culminated in the appointment of the "Owen Committee." This Committee, which was perhaps the most iconoclastic of any of the long series of Committees which has studied the question of our defences, adopted the extreme naval view that the advent of submarine boats would render all our harbours liable to underwater attack and would thus render useless all the anti-torpedo boat defences. In pursuance of this view, the Committee recommended the withdrawal of all guns smaller than 6 inch, and many of the defence lights. At the same time they considerably increased the heavy armament. During the years following 1905 the various alterations and additions recommended were carried out.

But by 1913 it had been found that the development of submarines had not followed the lines anticipated by the naval experts of 1904,

and that so far from small submarine boats being developed for transport on board parent ships, the tendency was to make these boats larger and larger, so that they should be more seaworthy. In fact, their development followed very closely that of the torpedo boat, which, begun as a small armed pinnace carried on board ship, has developed into the present sea-going "destroyer." Coupled with the increase of size of the submarine, it was found that ample depth of water was essential for safe navigation, with the result that in harbours like Hong Kong, which has a maximum depth of only five fathoms at low tide, it would be impossible for a submarine to enter and manœuvre except on the surface.

The attack was thus compelled to revert to the old surface methods, trusting to high speed and darkness to get home. In short the pendulum was on the reverse swing and steps were being taken at all ports to introduce again a close defence of 4.7 in. and 12 pr. guns combined with obstacles. The first half of 1914 was thus taken up in preparing schemes for new batteries or for alterations of old ones, and the outbreak of war found us with several new batteries just commenced.

One of these was of a rather unusual character, and as it was never completed may be described as a sample of the jobs which occasionally have to be tackled by a military engineer. This battery was one for two light guns which had to be mounted on the south end of Kowloon peninsula to cover the approaches to the dockyard from the west. This end of the peninsula had been only recently reclaimed from the sea and was a dead flat site at a level only a few feet above high water—mark. The guns had to be mounted 45 feet above high water mark so that automatic sights might be used, while the War Office had calculated the energy of the recoil as equivalent to a dead load of 1,000 tons for each gun applied at right angles to the centre line of the towers which were to carry the guns. As this far exceeded any strain which could be produced by the dead weight of the building or the guns, the calculations for the towers were the same as for a cantilever 45 feet long with a weight of 1,000 tons at the end. The foundations gave some trouble; the first suggestion was to put the towers on the edge of the reclamation, but investigation showed that the whole site which had only recently been reclaimed was enclosed by a wall of "pierres perdues" or large blocks of natural stone piled in a loose heap, and that behind this there was a filling of soft soil which was 30 feet deep. It was thus necessary to bring the towers back some feet from the front, and after some consideration, the only available site which gave the necessary area of view was astride of the main road and close to the pier used by the ferry boats. To comply with these conditions the final design of the battery took the form of an ornamental gateway across the road. On each side was a tower

with a gun on the top and with three storeys below; the shells being heaviest were put on the ground floor, the cartridges over and the gun stores above. Between the two towers was placed a two-storey gateway which formed living quarters for the gunners, with cooking and ablution, with an observing post for the officer on top. Ample head room was left underneath for a double line of traffic in the roadway and two footpaths.

The foundations were made on a series of piles, each 36 feet long, of a species of timber obtained from the Straits Settlements; the tops of these were to be joined by a cross lattice of steel girders to which were attached a series of steel rods for reinforcement of the walls of the towers and a steel framework to support the centre. The tops of these foundations were to be bedded in a heavy raft of concrete and the towers built up of concrete so as to be homogeneous, a proportion of the reinforcing rods being turned in at each floor. Loopholes were to be provided for close defence. Such a form of construction would not only have been impervious to bullets, but even to light gun fire. Before the construction had risen above the foundations the altered situation, created by the withdrawal of the German Fleet, made further progress unnecessary.

Besides these defence works which were in hand, the special measures taken on the outbreak of war which affected the R.E. were accommodation for the garrison at their war stations, a camp for war prisoners and the preparation of the field defences. The accommodation for the garrison was not a difficult job, as the Chinese are past masters at erecting the "mat shed" hut, and all details for this had been threshed out in the defence scheme. The accommodation of war prisoners gave more trouble. No great number of these had been expected, but provision had been made in the defence scheme for forming a small camp for about 50 prisoners on Stonecutters Island, which is about three miles by sea from the headquarters and is occupied solely by the military. It was thought that not only would the prisoners be safe here, but that they could be guarded by the local garrison of artillery and infantry. These forecasts proved wrong.

In the first place the number of prisoners was much larger than we had expected, and thereby hangs a tale.

In the long controversy which accompanied the growth of the submarine mining service*, one of the objections often made by naval officers to the use of mines was that they would unduly restrict the entrance of ships and cause an accumulation of shipping outside a port. The answer to this was that there is no free entrance or exit for vessels in and out of a port even in peace time, as strict rules are always enforced to regulate the use of anchorages and to enforce quarantine. The examination of vessels in war time would therefore

* For details of this see *History of Submarine Mining in the British Army*, chap. V.

only differ slightly from the examination necessary to enforce quarantine laws, the only important difference being that it would be necessary to carry out the first inspection of vessels in selected areas outside the defences but within the limits of gunfire.

To get at the facts, when revising the defence scheme in 1904 I analysed the traffic entering Hong Kong Harbour in 1903 with the assistance of the Harbour Master, and got the following rather astonishing data, considering that Hong Kong handled at that time more traffic in and out in a year than any port in the world.

As regards steamships, we found that an average of 18 steam vessels entered the port daily, of which 6 used the eastern or deep water entrance and 12 used the western or shallower entrance.

There were also about 50 junks entering daily exclusive of fishing boats.

It was obvious that the inspection of this amount of traffic offered no particular difficulty, and so it proved when we had to put the procedure in practice. Among the appointments made in the defence scheme was that of an Assistant Provost Marshal, for which a retired officer living at Hong Kong was selected. This officer accompanied the harbour officials on the visits to ships arriving and inspected all the passengers, throwing on the latter the onus of proving that they were not Germans. The result was that we picked out a number of German reservists from Manilla and other places, and this caused a steady movement into our prisoners' camp from all vessels arriving, necessitating the opening of an extra camp on Stonecutters Island and an addition to the infantry garrison to find the necessary guards. As the water supply on this island is entirely dependent on rainfall on a small catchment area, we were at once somewhat anxious about water supply. At the same time the A.P.M. found the distance of the camp from Headquarters was very inconvenient. I therefore obtained the approval of the G.O.C. to make a new camp on the mainland at the end of the Kowloon peninsula, close to the barracks and landing pier and readily accessible from all parts. To provide for all contingencies, I laid out this camp of a size to take 1,000 prisoners and erected huts to accommodate 500. This was fully justified when a few weeks later we got orders from home to intern all German residents of Hong Kong who were physically fit and to expel their families. This order resulted in an addition of nearly 300 prisoners to our numbers, or about 350 in all.

The field defences of Hong Kong have been the subject of much controversy, on account of the large perimeter to be covered. The harbour is situated between the mainland of China and the Island of Hong Kong, and has a length from east to west of about 10 miles. The backbone of the island is a line of granite hills with heights of from 1,000 to 1,800 feet rising steeply from the south shore of the

harbour. On the side of the mainland there is a similar line of hills rising to over 2,000 feet and about 4 miles from the harbour. Adding the width of the openings at each end, the perimeter of the whole was about 30 miles, of which 4 miles was water and the rest rough hills covered with boulders and trees. To facilitate movement along these hills a system of military roads had been gradually constructed, giving access to all the principal gaps and also forming a link along the line of hills on each side. The garrison of Hong Kong, which included five infantry battalions and some mobile guns, was large as such garrisons go, but was obviously insufficient to hold such a perimeter in force. On the other hand, the German forces in the East were quite insufficient to attempt any attack in force, and the most we had to meet were raids by small landing parties, directed against important points such as the defences of the entrances. Such attacks might have had the effect of keeping our naval force in the East tied to those waters, but would not seriously affect the final result of the war. If such attacks were contemplated it was obvious that they would be most effective immediately on the outbreak of war, so that in the defence scheme at all defended ports provision was made to commence selected defences immediately on the commencement of the "preliminary stage." With this in view schemes were kept prepared, tools and materials were held in readiness by the A.O.D. and the resources of civil contractors in the matter of civil labour and materials were reviewed periodically.

We received the preliminary telegram announcing a probable war against an enemy "unnamed" on Thursday, 30th. July, 1924, and the defence scheme was put in force at once, accordingly to plan and with very little trouble. The principal difficulty was to persuade the infantry portion of the garrison to take the work seriously, two commanding officers suggesting to me that as the men had moved to their posts on Friday, and Saturday was a half day and Sunday a holiday, it would be sufficient to commence digging on Monday.

The only detail which gave me any anxiety was the close defence of the heavy batteries recently constructed, many of which were quite open on the land slide. There had been considerable discussion about this, and there was a definite conflict of opinion as to whether such defences must be pushed out so as to keep attackers at a distance; or whether a close defence would not be more effective, especially at night. No decision had been reached by the War Office on this, but personally I plumped for the close defence with a short field of fire as requiring less garrison and being well within the limits of the tools and materials available, and work on these lines was put in hand at once.

We received official notification of the Declaration of War against

Germany on Wednesday morning, 5th August, and thenceforward were in daily communication with London, getting orders and instructions and a summary of the fighting intelligence as if we were in an English fortress. The full scheme of defence then started into full life, and the garrison settled down to war routine. At headquarters, except that a staff officer was on duty night and day, there was little change from our ordinary routine, as all officers lived so close to headquarters that the G.O.C. did not consider it necessary for officers to sleep in their offices except in the event of an attack.

The military telephone lines had all been got ready beforehand, and the only details to be carried out on mobilization were the distribution of instruments and operators to the outlying stations and look-out posts, a matter which took only a few hours.

The manning details of the electric light defence to supplement the local detachments also went out at once and all electric lights were run continuously.

Hong Kong was in the happy position of possessing a strong and efficient Volunteer Corps which included Engineers, Artillery and Infantry. These were called out. It was, however, found necessary to give a number of exemptions, as motives of patriotism had caused all the leading English officials to join the Corps, including the Colonial Secretary and Chief Justice. It was obvious that these gentlemen would be more usefully employed at their ordinary occupations. As time passed it was evident also that it was not in the interests of the Colony to keep the best of the business men permanently at military duty. Arrangements were therefore made to work a system of relief.

In the case of the manning details for the electric lights, advantage was taken of an offer made by certain residents to give partial service, and under this over 50 very useful recruits were enlisted who undertook to take a "watch" of 8 hours every third night. Most of these had some technical qualification and easily picked up the work required from them. When, later on, the bulk of the regular R.E. were withdrawn from the Colony, this local force maintained an efficient service of lights.

Some exciting and amusing incidents occurred in connection with the control of traffic. Among the first vessels to attempt to enter the port after the declaration of hostilities was a Chinese gunboat from Canton, which steamed gaily in towards her usual anchorage. As she disregarded all signals she had to be pulled up in the historic manner by a shot across her bows. The first shot was rather wide and produced no effect, but the second shot dropped so close in front of her bows that the vessel ran into the splash produced by the shot. The cold douche was effective. Another incident had a tragic ending. A Japanese cargo boat arriving about a week after war commenced took no notice of three shots fired across her bows,

so the officer responsible put a plugged shot through the fore part of the vessel. The shot went right through, doing little structural damage. Unfortunately, one of the seamen was in the line of the shot, and suffered accordingly. At the subsequent Court of Inquiry the Japanese Captain explained that he had left his last port before he heard war had been declared, and apologised for the trouble he had given.

All this time the centre of interest was our Fleet, which was under the command of Vice-Admiral Sir T. Jerram, K.C.B., who had the reputation of being one of the best tacticians in the Navy. On the outbreak of war the Fleet was up at Wei-hai-wei for the usual summer exercises, being fully equipped, as was always the case, with ammunition and fuel, and ready for immediate service. As Wei-hai-wei was usefully placed for co-operation with our allies the Japanese, and for watching the German port of Kiauchau, the Admiral proposed to stay where he was, leaving the military garrison to hold Hong Kong; but orders were received from the Admiralty for the Fleet to return to its base to pick up the battleship "Triumph," which was held in reserve at Hong Kong. In order to man this ship, and also some merchant ships which were commissioned as auxiliary cruisers, it was necessary to recall to Hong Kong the numerous river gun-boats which are maintained by us for police duty on the Chinese rivers. And as these did not give the numbers required, some R.G.A. and Infantry were drawn from the garrison, reverting to the practice of the Napoleonic wars. This preparation took some time, and meanwhile touch was necessarily lost with the German fleet. Subsequent events, however, showed that this fleet had never any intention of challenging our forces, and with the exception of the *Emden*, all the German ships crossed the Pacific to take part later in the battle of Coronel and to be annihilated at the Falkland Islands. It is rather difficult to see what they could have hoped to gain by this concentration, while the career of the *Emden* showed what damage could be caused by a free-lance on our lines of communication. Once our fleet left the harbour the fog of war descended and covered their movements, and I next saw Sir T. Jerram at Singapore in January, 1915, in command of a fleet composed of two French, two Japanese, two Russian vessels and a small British gun-boat, all the larger ships of his fleet having been withdrawn for service elsewhere.

With the large German element in the Colony, the enforcement of an adequate censorship was unusually difficult. For obvious reasons I cannot dwell on this. But I may mention that we had ample proof that the German missionary organisations in China were largely used in the dissemination of military intelligence. When, as explained above, we got orders to expel or intern all Germans, all their missionary organisations were compelled to leave.

The defence once secured, our thoughts naturally turned to offence and to possible action against German forces in the East. These forces centred in the port of Kiauchau, which was held by the Germans since 1898 and had been carefully fortified on both the sea and land fronts. In addition to the garrison of this port the Germans had an armed force in the town of Tientsin, where the German concession lay alongside that held by ourselves. In the same town there were military garrisons maintained by the British, Japanese and Russian forces, our own force being commanded by a Major-General under the direct control of the War Office. At Shanghai, the port for the centre of China, where there is a large European settlement, there are no regular troops, but there is a strong volunteer force of mixed nationalities, including German and Austrian. This force was commanded by a regular British officer, and was inspected annually by the G.O.C. in S. China or an officer deputed by him. A few days before the outbreak of War all the German Reservists in the East were ordered into Kiauchau, and those from Hong Kong and ports in North China succeeded in getting there, though, as related above, we succeeded in catching many of those from Manilla and neighbouring Islands. The regular German garrison of Tientsin also moved by train to Kiauchau, their concession being occupied by the British. This increased the German garrison of Kiauchau to a strength estimated at 7,000, rather too much for the united garrisons of Hong Kong and Tientsin to tackle unaided, but not an impossible proposition if a little help could be obtained from India. The entry of Japan into the war changed the entire situation, and when she expressed her intention of dealing with Kiauchau, nothing was left for the discussion except details. It was early decided that Hong Kong would have no part in the coming operations, much to our disappointment, but in order to emphasise our alliance with Japan, the G.O.C. Tientsin joined the Japanese force with an "armed escort" of one British battalion and a wing of Indian Infantry. This force had no artillery and was entirely dependent on the Japanese for transport. The British fleet was to co-operate by keeping the sea defences busy, and one of the first things we heard of the operations was the arrival of two torpedo boat destroyers in Hong Kong who had ventured too close to the German guns and had to return to their base to repair damages.

When operations commenced, the Japanese, who had sent a completely equipped force, naturally dominated the operations, and when the German outposts were driven in on the line of defences the little British force was allotted a portion of the line near the centre, between two of the German forts. On the night of the main attack, the British force was ordered to advance against their portion of the line, were held by the Germans and sustained some casualties. The G.O.C. then called on the Japanese for assistance

from the guns and held on to what he had got. Meanwhile, the Japanese had launched their attacks all along the line, had captured all the German forts and occupied the town. The British force marched in a few hours later.

Just before the main attack, the German steamships in the port tried to escape. Seven of them were picked up by our fleet and sent as prizes into Hong Kong.

The capture of Kiauchau confirmed the fact that the German fleet had left the West Pacific, and henceforward the centre of interest was the *Emden*, which played a sporting game with great skill and some luck, until she met her fate at Cocos Island. She had managed to sink some of the ships with supplies for Hong Kong, but not enough to seriously interfere with our routine.

Once she was dealt with, the War Office began a systematic weeding out of all the British officers and men in the Eastern garrisons, replacing them by retired officers and by territorial and Indian units.

In November we sent home the 25th Coy. R.E. and a large draft of the N.C. officers and men and individual officers and men left every week for England. My own turn came in January, and I left on a P. & O. steamer with many officers and men of the regular forces and a large contingent of Volunteers for service drawn from all the Eastern ports.

At Singapore, we took on more, including the G.O.C. and his staff, and at Ceylon we all transferred to one of the largest P. & O. steamers which had on board the officers and crews of the flag-ship on the Australian station and also a large group of volunteers from Australia to join the Army at home.

At Aden we heard of the mutiny of the Indian troops at Singapore, and at Suez we heard of the first naval attack on the Dardanelles. I ventured to remark to a Captain R.N. that in attacking land defences without the assistance of a land force the Navy were running counter to all professional opinion of pre-war days, and on arrival at Port Said he told me that troops were coming out and that some of his officers were being left behind to act as landing officers. Together we considered what sort of force was coming out to fight the whole Turkish Army, as they would inevitably have to do. On arrival at Marseilles we heard that the British force was to be composed of three Divisions with some French troops, and I concluded that the latter would include at least an Army Corps of French Colonial troops, a very inaccurate assumption as it turned out.

We arrived at Plymouth on the 8th March, 1915, to be met with the news that two german Submarines had been seen in the Channel and that all military personnel and their families were to proceed to London by train.

To be continued.

THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914-19.

EXPERIMENTAL SECTION (*concluded.*)

CHAPTER 12. METHODS OF DESTROYING WIRE ENTANGLEMENTS.

FROM the earliest days of the war endeavours were made to devise some method of destruction of wire entanglements, so as to form a passage for attacking troops.

Many inventions were submitted to the G.H.Q. Experiments Committee from time to time. One suggestion consisted of spraying different acids from special containers. The reports of the inventor showed that it required 36 to 48 hours of spraying with mixed sulphuric and nitric acid to affect the wire, and the idea was not developed.

A wire cutter attached to the nose of the rifle was a more practical suggestion, and was occasionally used.

Some means of removing the entanglements in bulk was really needed, and experiments were undertaken with various forms of rocket apparatus. A cable with grapnel attached was thrown, and caught in the wire, which was then removed by a winding arrangement, either from the trench or by means of an armoured car.

Another method tried was to throw a charge of high explosive into the wire with a time fuze for firing.

Rocket apparatus was found too unreliable, just as it was for other purposes requiring accuracy of range and direction, and experiments were soon given up.

The Bangalore Torpedo proved the most satisfactory solution, and was used in large quantities. Various patterns were made by R.E. units, but the commonest was that designed in the First Army workshops. The Experimental Section had little to do with this, with the exception of advising on minor modifications which were introduced when, during 1918, manufacture in England was arranged for. Supplies had not begun at the time of the Armistice, so that all those used during the War were of local manufacture. At different times various mechanical devices for propelling the torpedoes forward from a trench were suggested, but no practical method was ever evolved, and torpedoes were almost invariably placed in position by hand under cover of darkness.

In June, 1917, the Experimental Section made trials with a French pattern of torpedo, but this showed no advantages over the usual type and was dropped.

Experiments were carried out in the autumn of 1916 by the Section with a grapnel device suggested by an Officer of the Engineer-in-Chief's Staff. The apparatus consisted of a steel box with a pointed nose containing a winding gear. This was worked by a winch placed behind in the trench, and caused the apparatus to move outwards from the trench after the grapnel had been thrown on to the wire. The box could haul several lengths of torpedo behind it, and would wind itself into the wire, when it could be fired. The device, although it could traverse very rough ground with remarkable ease, did not work its way far enough through the wire to carry the torpedo where it was required, and experiments were eventually dropped in the spring of 1917.

Chapter 13. Aeroplane Height Finder Instruments.

The experimental Section made two instruments which were called for by the Lewis Gun Schools for reading heights of aeroplanes. The two patterns of Height Finder were as follows :—

(i). The pattern illustrated in Photos (4) and (5), which was introduced into the Service during 1918 for use at the Schools.

The instrument was designed to aid Instructors in Anti-aircraft Machine Gun work in estimating the heights and ranges of various types of aeroplanes. It consisted essentially of a base piece (A), at one end of which was a removable brass eye-piece (B) and at the other end a wooden frame (C). The eye-piece was capable of both vertical and horizontal movement.

The wooden frame was connected to the base piece by hinges so that it could be folded down on to the base piece for transport, or opened out at right angles to the base piece while in use. When in the latter position two hinged steel bars (E), one on either side of the instrument, automatically locked and maintained it in that position.

Six flat bars (F) were screwed to the frame. These bars were four inches apart from centre to centre. Along the top and bottom of each bar was cut a series of notches of different widths.

At the base of the frame and immediately opposite the eye-piece, in a plane parallel to the top of the base piece, was a Clinometer in a brass case (G).

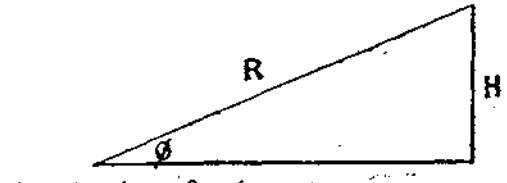
The head of the tripod (H), which was secured to the bracket carrying the legs by means of a screw, was provided with a recess into which fitted the spindle of a forked bracket (J), in which the base piece was mounted in such a way that it was thereby capable of movement in both a horizontal and a vertical plane. The spindle was secured in the recess by a thumbscrew (K).

The principle of the instrument was as follows:—

At any given range, an aeroplane subtends a certain definite angle at the eye.

If a bar is placed at a certain distance from the eye and at right angles to the line joining eye and the aeroplane, the imaginary lines joining the eye to the outer edges of the aeroplane will cut the bar at two fixed points. If the distance apart of these two points is represented by a notch, the width of the notch represents the apparent width of the aeroplane at that range.

For a given angle of elevation for each range, there is only one height at which the aeroplane can be, as is obvious from the figure.



Ø = Angle of elevation.
R = Range.
H = Height.

Therefore a notch which is correct for a given range is correct at the angle of elevation φ for one height only (H).

Therefore, for one angle of elevation, a series of notches of different widths can be cut in the bar and each of these notches will be correct for one height only at that angle. Therefore, for any angle of elevation, notches can be cut which, for one type of aeroplane, will be correct for heights of 3,000, 2,500, 2,000, 1,500, 1,000 and 500 feet, and for those heights only.

For another angle of elevation, a similar series of notches can be cut, though these notches will be of different width from the corresponding notches at the first angle of elevation.

In the instrument under consideration, for practical reasons, only six angles of elevation were considered, and therefore only six bars were provided, but it was found that, if when viewed through the eyepiece the height of the aeroplane was measured on the nearest bar, the results were sufficiently accurate for all practical purposes.

The notches on the top of each bar were to be used for an aeroplane coming or going or crossing diagonally, and the notches on the bottom of the bar for aeroplanes flying directly across the front.

Conversion Tables were also prepared to enable the instrument to be used for various aeroplanes.

Certain of the notches on the instrument were coloured red.

When using the instrument, if the notch which was found to be the correct one for use was red, the aeroplane was in, or just coming into, machine gun range.

If the notch was coloured black, the aeroplane was out of range.

The same applied also to the Conversion Tables, figures being shown in red, when the aeroplane was within range, and black when out of range.

In the Conversion Tables there were two rows of figures against each bar. The upper row represented the height in feet for an aeroplane coming or going or crossing diagonally (i.e., the top row of notches), and the bottom row represented the height in feet for an aeroplane flying directly across the front (i.e., the bottom row of notches).

(ii). A Telescope Pattern was made and demonstrated to an Anti-aircraft Committee to show that a simple type of instrument could be evolved for instructional purposes.

As it was not developed till the Autumn of 1918, no further action was taken with it, and for instructional purposes, the other pattern was simple and satisfactory. This telescope instrument was rather outside the scope of the Experimental Section's work, but was an interesting device. An ordinary Signal Service Mark IV telescope was used, and the instrument introduced at a point in the focal plane of the object glass. The principle was well known and recognised to be unsatisfactory for correct readings at heights above 6,000 feet, but was considered suitable for the purpose of correcting and instructing Machine Gunners to read heights for observation.

The Machine Gunner was hardly interested to know the height exactly, but only as to whether the aeroplane was within range or not, and 1,000 yards was considered the limit of range, i.e., 3,000 feet vertically overhead.

Owing to the various shapes and sizes of aeroplanes, practice in reading heights was difficult unless the type of aeroplane was recognised and an approximate height read off for verification.

For the purposes of the instrument, aeroplanes were divided up into four classes, and height curves were plotted and reduced to scale for each class. Two wires let into the body of the instrument carried on sliding bars could be moved towards or away from each other by rotation of the wheel on the spindle carrying the bars. Mounted on the rotating spindle was a sliding drum carrying the four graphs. A fixed pointer at the other end of the instrument was carried on a clinometer, and indicated directly the height of the aeroplane by its position in relation to the curves on the drum. The clinometer gave the angle at

which the instrument was held, and the sliding drum indicated the distance apart of the two hairs on the width of the aeroplane, i.e., when the angle and the width had been both read, the height was given direct on the curve. By measuring the width of the aeroplane, as it flew, the heights were read off directly by the positions of the pointer on the drum. A damper was fitted to the clinometer to lock it after reading the width, so that it should be held at the angle at which the width was read. The drum could be rotated independently to bring the desired graph into place, after reading the width, and observing under which class the type of aeroplane came. A few feet in error in reading made very little difference to the height recorded, and, if the target was flying diagonally, the width was approximately the same as the forward view. For machines flying at right angles, where a side view was presented, similar curves in red were used for reading off the heights.

Investigation of the instruments for height finding led up to the development of a system of Automatic Sights and a large number of drawings and plans were prepared. These were only finished in 1919, and do not come within the scope of this work.

Plate No. XXIV shows the general arrangement of an aeroplane target made by the Experimental Section for use at Lewis Gun Schools.

The model target could be pulled round the octagonal track by hand, while the gunners at a fixed range would be instructed to sight on the target, the eight-sided figure giving eight different directions which the gunner would have to cope with. By rapid change of direction, the gunner would have to swing quickly over on to the forward sight, which gave excellent practice in the use of the sight.

CHAPTER 14. LEWIS GUNS.

WORK in connection with Machine Guns was outside the scope of the Experimental Section during most of the War, but in June, 1918, they took up the question of a mechanism for slowing down the rate of fire of the Lewis Gun; any such mechanism had to be capable of being rapidly disconnected should the normal rapid fire be required.

Experiments were carried on simultaneously by the Ordnance and the R.E. Experimental Sections, and at first both worked on similar lines. The device consisted of a catch, which held up the cocking handle at the end of its stroke, and connected to a rocking lever, which worked against an air cushion in a piston. Various difficulties were met with, and after considerable experiment the R.E. Section abandoned the air apparatus, and finally evolved an oil device, which proved entirely successful. This is shown on

photograph (6) and Plate XXV. The development of this mechanism led naturally to the idea of single shot firing, which proved to be an altogether simpler and more satisfactory device. By means of it the heating up of the barrel became naturally slower, and experiments showed that the radiators and casing of the heavy Lewis Gun could be taken off and the weight reduced by 10 lbs. This ultimately developed into the light Lewis Gun, of which a number arrived for trial in March, 1919.

The Experimental Section produced a neat single shot mechanism in the shape of an auxiliary trigger, which could be clamped to the standard Lewis Gun. All the parts were pressed and stamped, and fitted in such a way that it should be possible for armourers to do the work in the Field. It was never generally introduced, owing to the Armistice. This mechanism is illustrated on photographs (7), (8) and (9). It consisted simply of an auxiliary trigger pivotted on a fulcrum pin, which was carried on two outside plates gripping the main trigger guard and kept in position by two screws; the auxiliary trigger carried the rocking stirrup, which worked over the end of the main trigger. By pulling the auxiliary trigger the stirrup was set to fire one round, and then slipped off the main trigger, so releasing the nose of the sear in time to catch the piston on its return stroke. In order to get continuous fire, it was only necessary to hang on to the auxiliary trigger, and pull it right back, as it then came in contact with the main trigger, and held it back.

The only other work done in connection with machine guns was a light folding anti-aircraft mounting; this was made with an old rifle for the stem, fitted with folding legs. When opened up, it gave a firm mounting, and it folded up very neatly. This pattern was sent to the Lewis Gun School in the Autumn of 1918, but no reports as to its employment had been received before the end of the war.

Chapter 15. Periscope and Hyposcope.

The work of the Experimental Section as regards optical instruments was almost entirely of an advisory nature, and very little was done in the way of experiment.

Trench Periscopes of all varieties were made during the earlier days of trench warfare in Army workshops, and were gradually developed on better lines by civil optical firms.

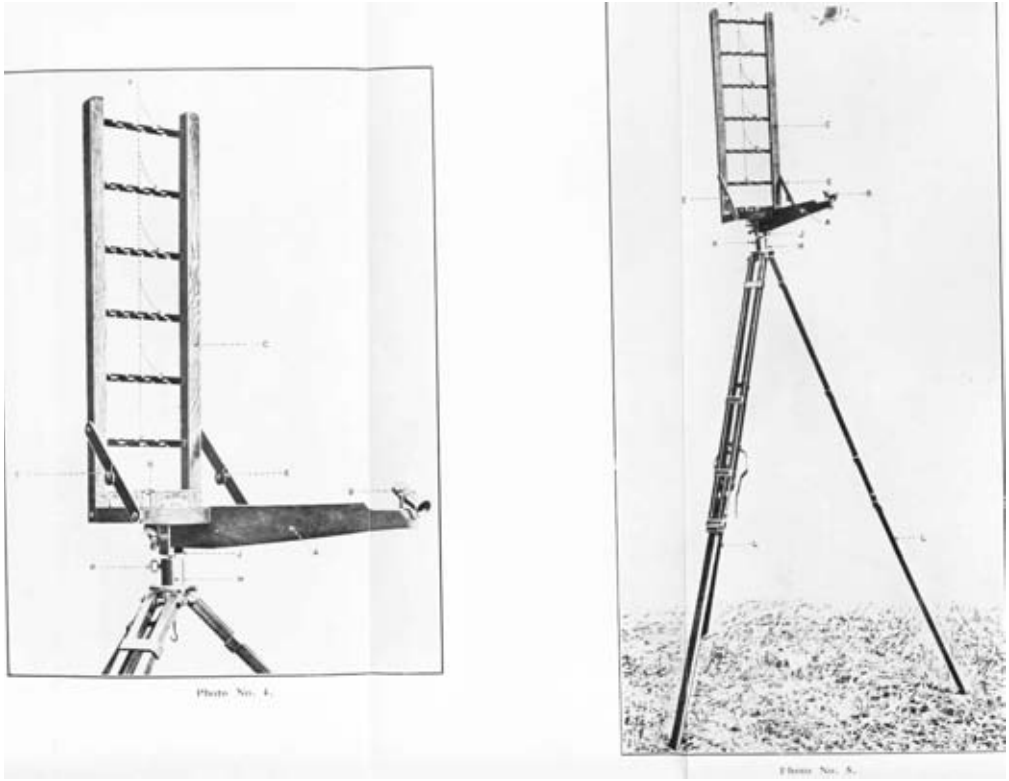
The superior patterns, more especially for Artillery work, were taken over later by the Special Works (Camouflage) Park, and were no longer referred to the Experimental Section.

The development of Hyposcopes, for use both with rifles and machine guns, went on in much the same way. The chief difficulty in the design of a hyposcope was to make it fold easily, so that it

could be conveniently carried as part of the rifle, and at the same time be easily put in position for use. Its use was never encouraged in the British Army, except for special snipers, as it undoubtedly led to lack of confidence when firing over open sights.

Probably the best pattern produced during the War was the German one, of which, as a matter of interest, an illustration is given on Plate XXVI.

Various improvements of detail in the design of the Camera Obscura were evolved by the Experimental Section. The instrument was only introduced in France towards the end of 1917, and about twenty were received during the Summer of 1918, which embodied these improvements. Good results could not be obtained with the Camera Obscura, except in fine weather, and with good visibility. Under these conditions, objects were clearly visible up to a range of 2,000—3,000 yards. The instrument was very useful for observation purposes, in positions where it was possible to erect it. The whole view was projected on to the table without strain to the eye of the observer, and it was also easier to set up and move about than the giant periscopes which were developed by the Camouflage Park.



PICTURES 1 & 2

Photo No. 6.

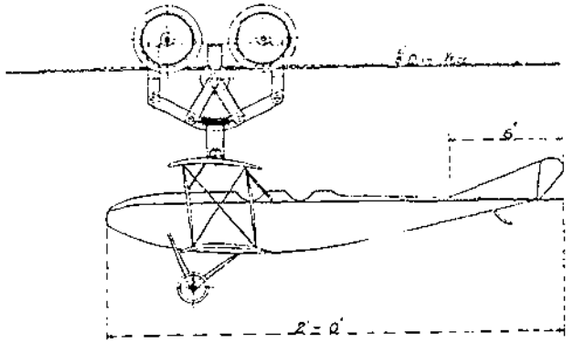
Photo 6 & 7

Photo No. 8.

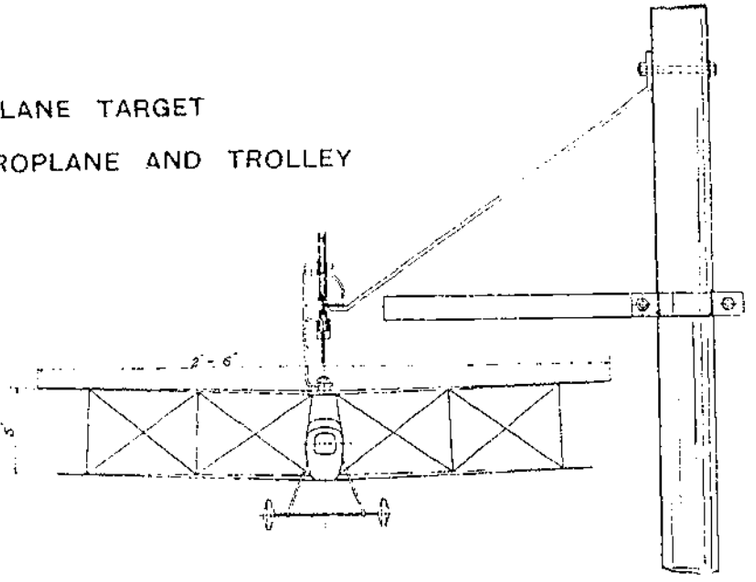
Photo 8 & 9

HAND-OPERATED AEROPLANE TARGET

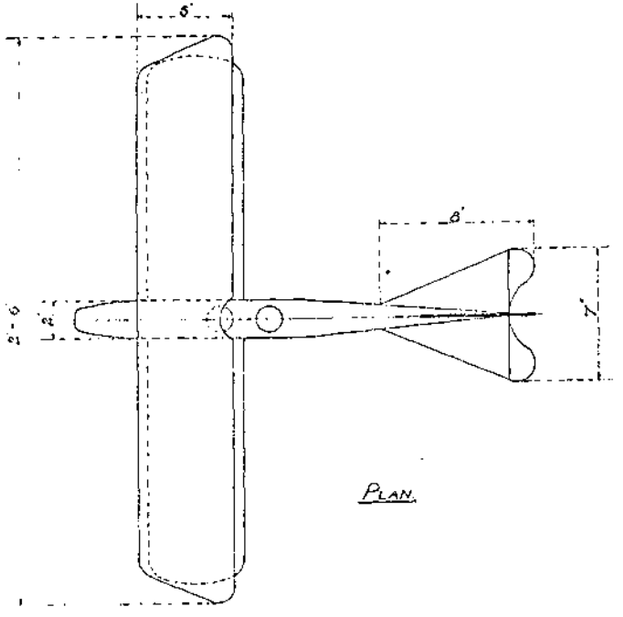
GENERAL ARRANGEMENT OF AEROPLANE AND TROLLEY



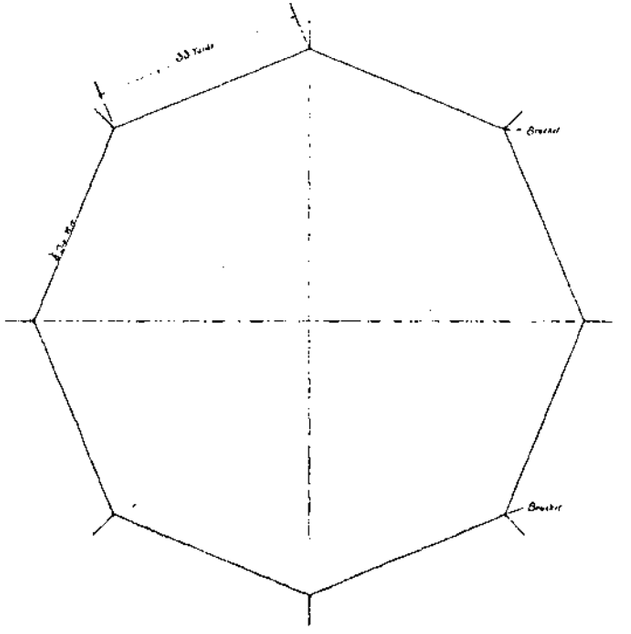
ELEVATION.



END ELEVATION SHEWING BRACKET SUPPORTING WIRE.



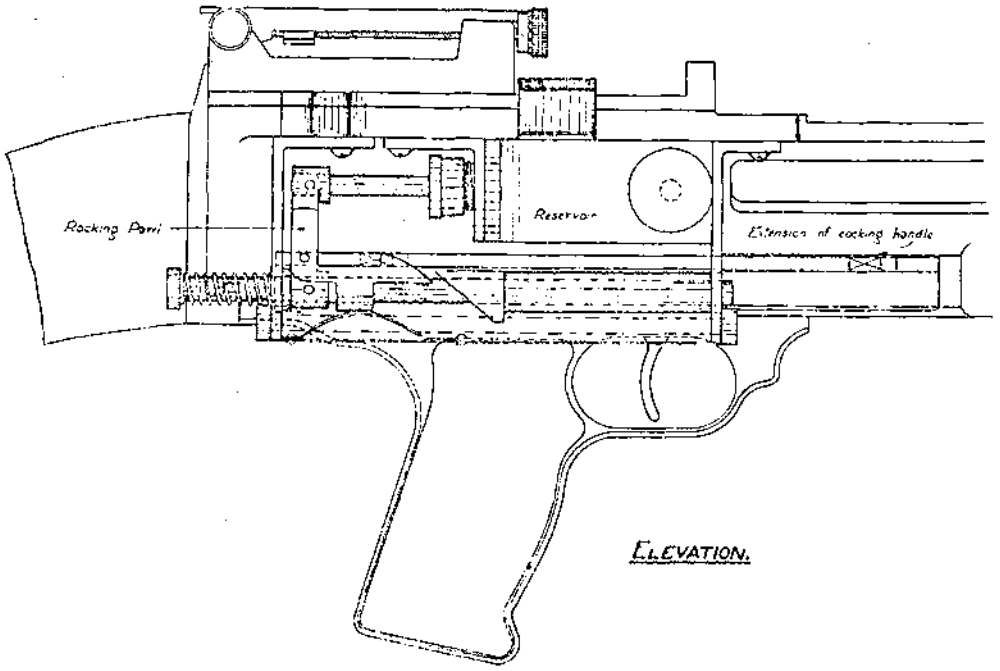
PLAN.



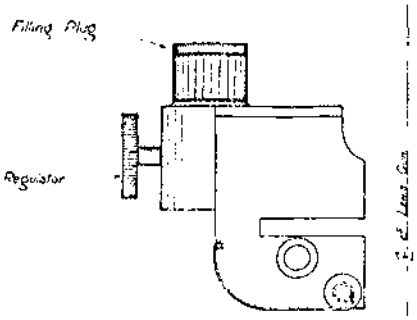
PLAN OF TRACK.

Scale ½" = 9 Feet.

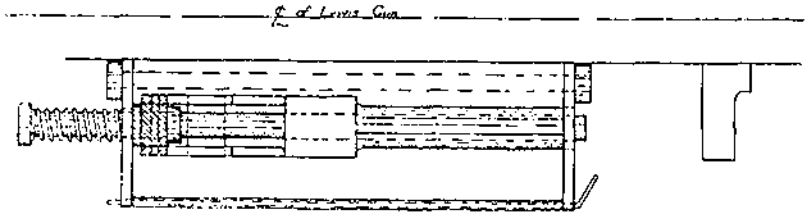
MECHANISM FOR SLOWING-DOWN RATE OF FIRE FOR LEWIS GUN.



ELEVATION.



END ELEVATION.



SECTIONAL PLAN.

GERMAN HYPOSCOPE AND PERISCOPE.

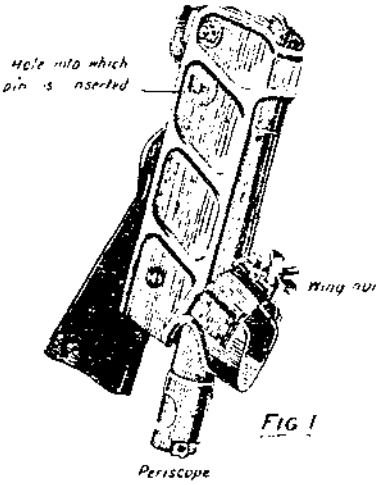


FIG 1

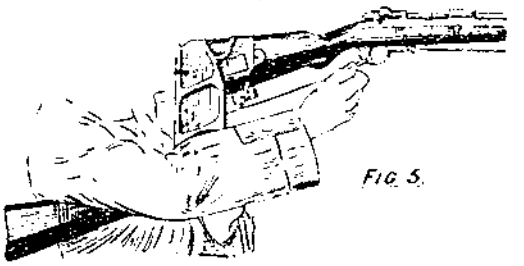


FIG 5.

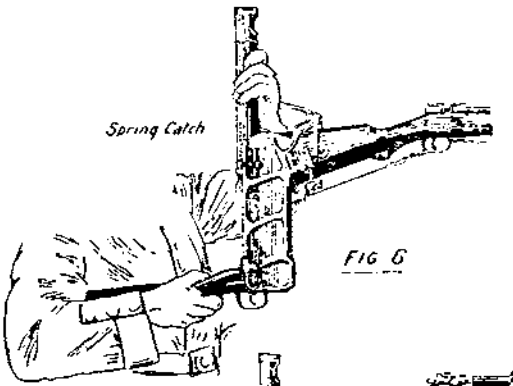


FIG 6

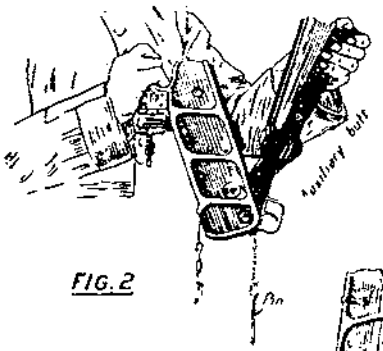


FIG. 2

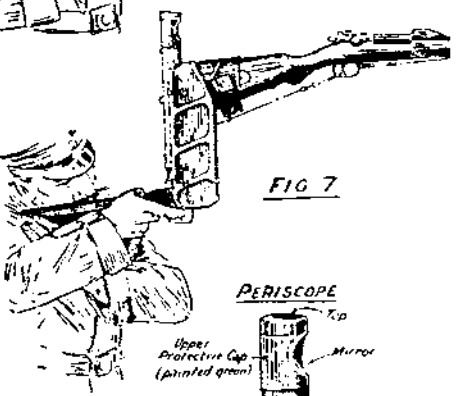


FIG 7

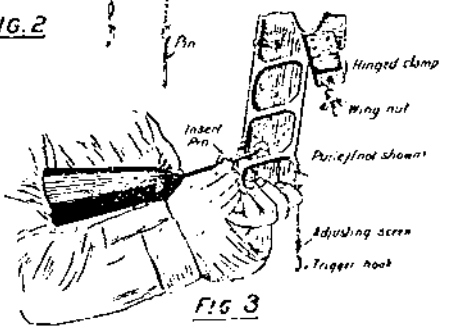


FIG 3

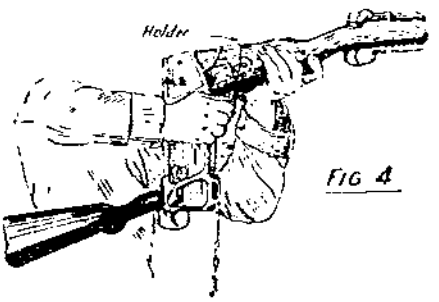


FIG 4

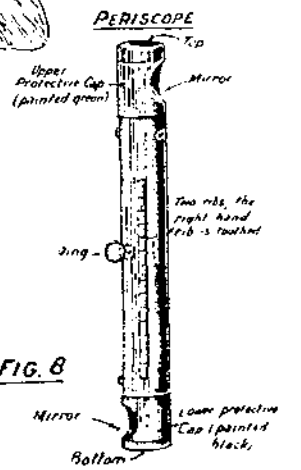


FIG. 8

A MINOR OPERATION.

The Capture of Infantry Hill—June 14th, 1917.

By Bt.-Major I. S. O. Playfair, D.S.O., M.C., R.E.

Monchy-le-Preux marked the eastward limit of the objectives of the Arras offensive of April 9th, 1917. It stood up as a "cock-shy" for miles, and was referred to as an important tactical feature. Its north-western enclosures were reached on April 10th, and the village itself was captured on April 11th by the 37th Division, who had to repulse several counter-attacks to retain it in their possession. The 29th Division who relieved them were strongly attacked on April 14th but stood their ground. By April 15th, says the official despatch, "our front had been rolled 4 miles farther east, and all the dominating features forming the immediate objects of my attack, which I considered it desirable to hold, had passed into our possession." The offensive was, however, continued to assist the French, whose intended attack on April 9th was delayed by bad weather until April 16th.

Early on April 23rd the 29th Division gained the Western slopes of the rising ground known as Infantry Hill (see map). The attack was renewed at 6 p.m. "Very appreciable progress has been made east of Monchy-le-Preux." Further attacks were made on April 28th and May 3rd "with shallow objectives."

The British front was now roughly the line of Hill. The enemy held Hook, Long and Devil's trenches and the fortified shell-holes in and around Bois des Aubepines and between Tite's Copse and Stirrup Lane.

Towards the end of May the 76th Inf. Bde., 3rd Division, which had just been withdrawn from the Monchy area into "rest," was ordered to prepare an operation for the capture of Infantry Hill. This was looked upon by those immediately concerned as a fourth attempt to achieve what had already failed three times. The previous attacks were carefully studied. Each had been delivered after a bombardment and under a barrage, which had drawn from the enemy a vigorous reply on to all the trenches in the forward area. Hill, Dale, Shrapnel and the communication trenches Vine and Canister received particular attention, and heavy machine-gun fire developed from Bois des Aubepines and the shell-holes east of Tite's Copse. It seemed that as soon as our fire became intense the enemy opened on the above targets and rendered the handling of our supports very difficult.

Further, a study of the hours of attack showed that the enemy had every reason to be particularly alert at dawn. For example,

on April 9 the Zero had been at 5.30 a.m.; on April 11th, 5 a.m.; on April 23rd 4.45 a.m.; April 28th, 4.25 a.m.; and on May 3rd at 3.45 a.m. Other points which received the attention they deserved were:—(1) There was as yet no wire in front of Hook, and (2) that in spite of heavy shelling the No-man's-land between Hill and Hook allowed of comparatively good "going."

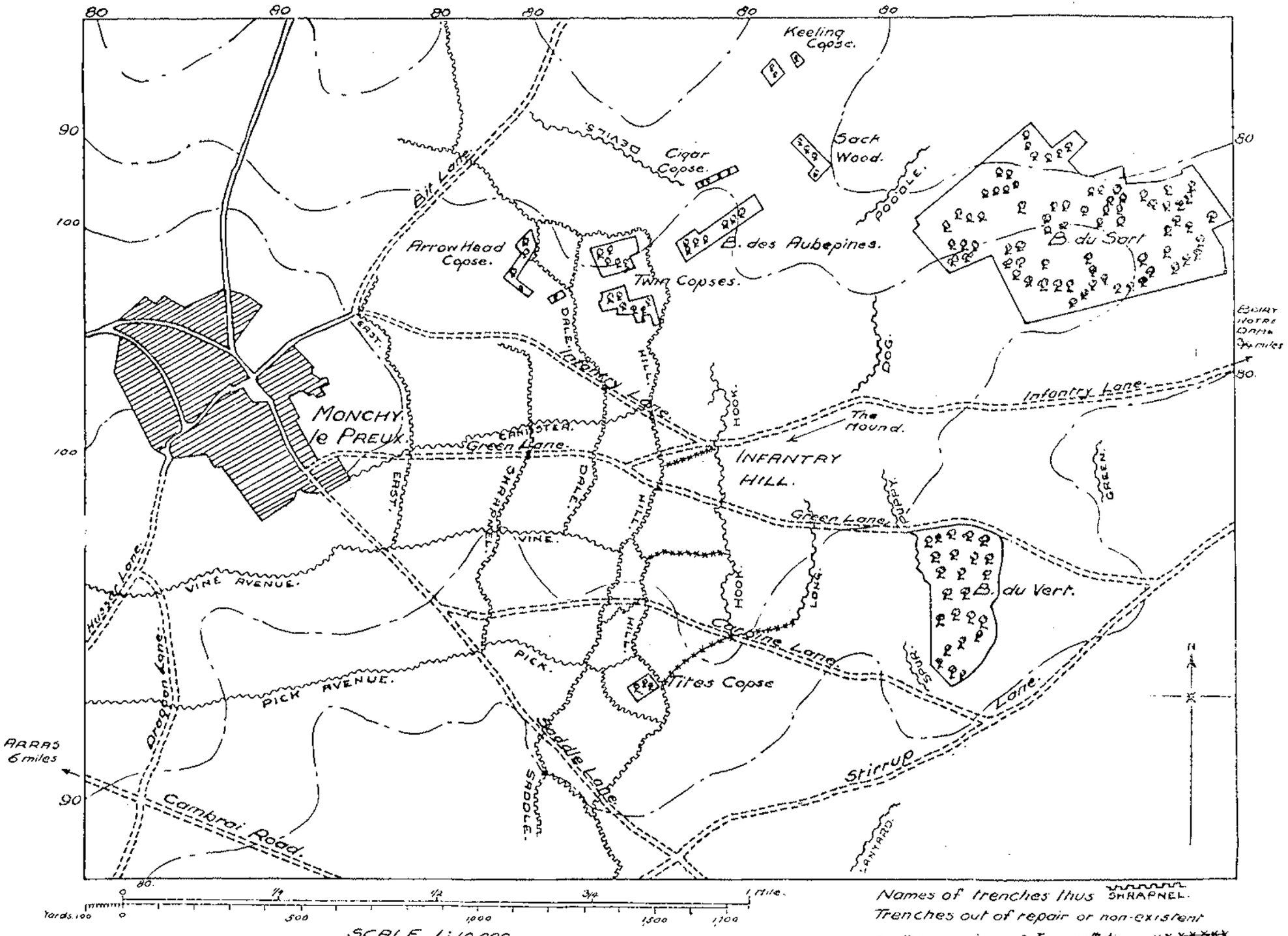
The plan was as follows. There was to be a slow continuous bombardment by all calibres for 5 days, increasing in intensity each night when it was to be severe (see Artillery Programme). It was to be assisted by frequent bursts of machine and Lewis-gun fire during the night to prevent the enemy from putting up any obstacles in front of his line, and generally to keep the forward area so swept with fire that the bringing up of rations, water, stores, etc., would be very difficult, the relief of the front-line troops well-nigh impossible, and visits by senior and staff officers extremely unlikely. Particular attention was to be paid to the location and registering of hostile batteries. Fire of all kinds was to cease from 5 to 9 a.m. daily. The enemy infantry were known to be occupying shell-holes and isolated positions where supervision would be difficult; men *must* have sleep, and the only possible time to have it would be during those four peaceful hours.

The attack was to be unheralded (one can hardly say unprepared) by any fire. The attacking troops would assemble in Hill. At a given moment they would emerge and double to Hook. A proportion of men were to be "skirmishers," *i.e.*, good sprinters carrying only rifle, bayonet, 2 bombs and 20 rounds. They were expected to reach Hook before the enemy could put up any more than a spasmodic defence. It was thought that after 1½ minutes he would be awake to the situation so that a barrage was arranged to precede the advance to the second objective (The Mound and Long). The enemy would presumably open on his usual S.O.S. targets, which were well-known and therefore to be avoided. The troops advancing from Hook to Long should be clear of any artillery fire, while Hill would be practically empty.

THE ARTILLERY PROGRAMME.

Open 9 a.m., June 9th. Targets by day: Communication trenches, known and suspected machine guns, occupied and fortified shell-holes, trench junctions and headquarters. By night: General harassing fire and gassing of batteries. All fire to cease from 5 to 9 a.m. daily.

June 14th, at Zero plus 1½ minutes, intense bombardment of Bois des Aubepines, Cigar Copse, Devils Trench, Bois du Vert and The Mound. Barrage along a line north and south through the junction of Green Lane and Long. The Heavy Artillery was to neutralise batteries and fire on selected areas, assisting the Field Artillery to


Keeling Copse.
Sock Wood.
Cigar Copse.
Arrow Head Copse.
B. des Aubepines.
Twin Copses.
B. du Sart
Bit Lane.
DEVILS
POODLE.
DOG.
DALE.
EAST.
HILL.
HOOK
Infantry Lane.
The Hound.
MONCHY le PREUX.
Green Lane.
INFANTRY HILL.
CHARING
PUPPET.
GREEN.
VINE.
VINE AVENUE.
Hussar Lane.
Dragoon Lane.
PICK.
PICK AVENUE.
B. du Vert.
Cactus Lane.
Tires Copse
SPUR.
Lane.
Saddle Lane.
SADDLE.
Stirrup
LANYARD.
Cambrai Road.
ARRAS 6 miles
EQUIRY NOTRE DAME 9½ miles
80
90
100
0
1/4
1/2
3/4
1 Mile.
Yards. 100
500
1,000
1,500
1,700
SCALE 1:10,000
Names of trenches thus SHRAPNEL.
Trenches out of repair or non-existent on the morning of June 14th thus

deal with certain suspected machine-guns and routes of approach. Barrage to lift at Zero plus 5 minutes on to the line Spur-Puppy-Dog, which would then be the S.O.S. line if required.

The artillery available on the front of attack and in co-operation on the flanks consisted of 5 divisional artilleries, eighteen 6 inch howitzers, eight 60 pdrs., one 6 inch gun, one twelve and one fifteen inch howitzer, three 8 inch and three 9.2 inch howitzer batteries. It was organised into 4 groups, each of which synchronised several watches with Inf. Bde. H.Q., at 10 a.m. and 10 p.m. on June 13th.

Machine Guns.

Thirty-two Vickers guns assisted the Artillery with harassing fire during the preliminary phase. At Zero plus 1½ minutes (taking the signal from the artillery) fire was to be opened on the area between Bois de Vert and du Sart, Green and Lanyard. Twenty-four guns were employed on this task, firing *intense* (1 belt per gun per 2 minutes) until Zero plus 12 minutes, and then *slow* (1 b.p.g. per 15 minutes) until Zero plus 2 hours. Four guns were to move up after the attack into Hook.

Trench Mortars.

The Light T.M. Battery (3 inch Stokes) had 3 mortars registered for 'S.O.S.' work on the flanks of the attack.

R.E. and Pioneers.

One Section 529 (East Riding) Fd. Co. and 1 Company 20th K.R.R.C. (Pioneers) were allotted definite tasks to assist consolidation.

The R.E. were to convert a derelict trench from Tite's Copse to Long into a fire trench. The Pioneers were to dig two communication trenches from Hill to Hook in prolongation of existing saps. Both were to move up to their work on receipt of orders from Bde. H.Q.

Training.

It was obviously vital to have a good start. Various forms of signal were considered, but it was decided to rely upon practice with carefully synchronised watches.

As the attack was to be launched between 5 and 9 a.m. the assembly would have to be complete before dawn or the unusual movement in the trenches would attract attention. Low-flying aeroplanes were in the habit of coming over early every morning and the increased number of men might be noticed. An officer of the Divisional staff was sent up to report upon the effect of ordering the men in a trench to keep perfectly still and not to look up. Acting on his report arrangements were made to keep the men still and quiet,

for them to crouch and not look up when aeroplanes came over, and for certain detailed men only to open rifle fire to give the impression that normal conditions prevailed.

Runner traffic was to be reduced to a minimum.

The attack was delivered by 2nd Bn. The Suffolk Regt. on the right and 1st Bn. The Gordon Highlanders on the left. Boundary between battalions—Green Lane. 8th Bn. The King's Own Royal Regt. and 10th Bn. The Royal Welch Fusiliers became involved shortly afterwards and took over part of the line.

BRIEF DIARY OF EVENTS.

June 2nd & 3rd. Practice ground chosen among old trenches near Arras, measured up and marked out from air-photos; necessary filling-in, clearing and digging done during the night.

June 3rd. Battalions begin training.

June 6th. Battalions train separately on the practice ground.

June 7th. Reconnaissance by Officers and N.C.O's., final recognition of landmarks, determination of frontages and boundaries.

June 8th. First rehearsal by both battalions together.

June 9th. 9 a.m. Artillery programme begins.

June 12th. "Dress rehearsal," attended by G.O.C. 3rd Army.

12th-13th. Bde. takes over the Monchy sector. Enemy quiet.

June 13th. 7 p.m. Heavy shelling of Monchy.

June 14th. 2 a.m. Assembly reported complete.

5 a.m. Preliminary bombardment ends. Very quiet. Typical fine hazy summer morning.

7.20 a.m. Zero. Synchronization good.
The two battalions appeared from Hill as if by magic. Enemy in Hook completely surprised. A little bombing, then all quiet. Hook found to be only 3 feet deep and much damaged. Work of deepening and reversing parapet begun.

7.20½ a.m. One German field battery opened fire on Hill!

7.21½ a.m. Barrage. Enemy reply spasmodic at first.

7.25 a.m. Advance to Long and the Mound. Objectives quickly reached. About 90 prisoners taken. One Officer gave Boiry as the Reserve billets; our 9.2 inch howitzers informed.

5.30 p.m. Brigade on the right reported much movement just south of Bois du Vert. Excellent work done by 60 pdrs. Enemy dispersed. Subsequently found to be an attack by 2 battalions; no co-ordination, lost direction.

June 14th-15th. Some shelling.

June 16th. 1 a.m. Enemy opened "trommelfeuer" over the whole forward area.

2.15 a.m. Barrage on Hook and Long.

2.17 a.m. S.O.S. from the Mound. All the occupants of the 1st Gordon Highlanders' posts became casualties, and their shell-holes were occupied by the enemy. Enemy found to have employed 1 battalion.

10 a.m. Three unsuccessful bombing attacks made to recover one of the lost posts. A fourth made under a shower of rifle grenades succeeded.

June 17th. 1.45 a.m. Unsuccessful attempt to recapture the 2 lost posts. Enemy not surprised. Enemy aeroplanes very active all day, observing for the artillery. Balloon up in a new place. Suspicious.

June 18th. 1.15 a.m. Bombardment of our whole area and gas-shelling of battery positions.

1.20 a.m. "S.O.S." from the Mound. Enemy attacked and in places reached Hook. The garrison of Long was over-run but held out. At 5 a.m. the O.C. 2nd Suffolk Rgt. reported Long still in his hands, and the 529 Fd. Co. helping him to repair it. (This Company's casualties were 1 Officer and 11 o.r. killed, 1 Off. and 20 o.r. wounded).

This attack was found to have been made by some 1000 men of 3 different battalions. During the day the Trench mortars did excellent work, "putting up" enemy out of shell-holes to be dealt with by small-arm fire. Men's spirits raised accordingly.

10.15 p.m. All posts (except one obliterated) re-occupied with slight opposition.

June 19th-20th. Brigade relieved.

The total captures were 4 officers and 197 o.r. Prisoners spoke highly of our artillery and m.g. fire. One officer smiled when asked why they had no wire in front of Hook. He replied, "For the same reason that we have had no rations for three days."

Lessons learned :—None, unless the value of surprise is new.

THE EXPERIMENTAL PONTOON EQUIPMENT.

(Concluded).

Contributed by the R.E. BOARD.

SUPERSTRUCTURE.

Meanwhile, assuming the distribution as far as calculable, figures were prepared and examined showing the strength required for varying numbers of joists for heavy and medium bridge, based upon an impact of 40 per cent. for lorries and fast traffic and 12½ per cent. for tractors and nil for tanks—also a safe working stress for a steel of 12 tons.

At the same time certain non-standard joists were considered which gave a saving of weight on a 9-in. x 4-in. mild steel joist (400-lbs.), *e.g.*, lattice joists weighing 270-lbs., pressed steel built up or fish bellied joists weighing 280-lbs. and finally 6-in. x 3-in. nickel chrome steel joists weighing 252 lbs.; the latter material entailed using seven joists for lorry bridge and 11 or 12 for heavy bridge, based upon 24 tons per square inch stress as against 12 for the others.

The use of nickel chrome steel had been under consideration for some time, but the provision of a small number of joists for trials had hitherto proved a serious obstacle, but eventually firms who were more encouraging were found and definite estimates obtained.

Meanwhile some rough tests of distribution of loads were made by laying joists over a bed of soft mud—the bearings being firmly supported. The results may be interesting in comparison to the assumed distribution.

The table appearing on next page shows the comparison between the assumed distribution of loads on joists and the distribution found by experiment.

As a result of these experiments it was decided to obtain 6-in. x 3-in. nickel chrome steel joists on the basis of five for light, seven for lorry, and eleven or twelve for heavy bridge.

To carry out more accurate tests for distribution of load a special gap was constructed which enables joists of any length from 15-ft. to 21-ft. to be tested. It is provided with a rigid structure under the joists for carrying instruments for measuring the deflection.

For the 21-ft. joists, which were expected to yield an ample deflection under live loads, no very accurate measurements were

Loads.	No. of joists. 9″ x 4″	Maximum percentage of ½ Total Load on any one joist. Assumed.	Found by Experiment.		
2T Axle Load.	5	100%	66.6%	Using 1½″ chesses.	
			Decking.		
			Two 1½″ Chesses.	3″	4″
3T Lorries.	6	90%	60.8%	62.4%	65.4%
	7	80%	62%	61.8%	60%
	8	70%	56%	52%	52%
	9	60%	56%	52%	52.4%
Tractor	8	40%	38%	.. Using 4″ decking.	
	10	33%	34.8%		
	12	30%	32.4%		
Tank.	8	40%	48%		
	10	33%	37%		
	12	25%	32.6%		

necessary, and a simple device was provided in the form of a plunger graduated in fractions of an inch, provided with a self-registering cursor and held up against the underside of the joist by a stout elastic ring.

Seven joists (nickel-chrome steel) were spaced at 1-ft. 7-in. centre to centre and double chessed with service 1½-in. chesses Ribands of 6-in. x 4-in. were racked down by chains.

A loaded 3-ton lorry (5½-ton axle load) was used. Tests were carried out under the following conditions:—

(*a*) Lorry stationary and centrally with rear axle over centre of span.

(*b*) Lorry stationary with one wheel up against the riband and with its rear axle over centre of span.

(*c*) Lorry moving centrally at five to eight miles per hour. (The driver could not be persuaded to drive at this rate with his wheels close up against a riband).

The maximum deflection on any one joist (1.75-in.), which was obtained under (*c*), indicated a maximum stress of 13.3 tons per square inch, and an impact effect at 10 m.p.h. was deduced as 25 per cent.

An 8-ton axle load gave a deflection 2 9/16-in., which equals 18 tons per square inch, when passed over this bridge at 1 m.p.h. with one wheel against the riband.

Corresponding tests for light bridge with five joists spaced 2-ft. 8½-in. centre to centre and single chessed, with ribands as before—loaded with a 2-ton pontoon wagon and four mules, maximum speed 8 m.p.h., gave a maximum percentage of load on one joist of 28.4, maximum deflection 1.09-in., stress 8.3 tons.

Other tests with different spacing of joists clearly demonstrated that the limiting factor was the strength of the chess and not that of the joists. Equally spaced joists were, therefore, adopted for light and lorry bridge.

It appears at first sight that the size of joists might be reduced, but owing to the whippiness of the 6-in. x 3-in. joist, such a course is not considered advisable.

The next problem was the saddle and the method of attachment of the roadbearer thereto.

The claw hitherto in use in the wooden roadbearer had various drawbacks, among others liability to bend and get in the way generally, and it was further anticipated that such a claw would be difficult to secure to a nickel chrome steel joist.

It was consequently decided to try the single pin now introduced. The obvious difficulty in its use was to find a means of securing it to avoid all risk of its coming adrift, particularly in view of the method adopted of ending the joist. This was achieved after various means had been tried and pins, secured by the present method, *i.e.*, welded into holes drilled in the joists, have been submitted to very severe trials without yielding.

The shape of the end of the joist had now to be dealt with. The alternatives of meeting butt-ended or overlapping had to be considered. A plain overlap was rejected for lack of space on the transom in heavy bridge for the 24 joists required, and for difficulty in racking down.

Butt-ending was clearly impossible owing to the gap in the roadway that would have to be left open to enable the pontoons to immerse without jamming the joists.

A halved end overlapping was, therefore, adopted after satisfactory evidence of a method of fixing the pin had been obtained.

Tests were made to detect any tendency of the joists to jam or to overturn. A 25-ton pontoon was floated by a 4-knot tide into a bridge without an upstream anchor. The bridge stood the shock without any disturbance.

It was found later that a tank, when making slight alterations in direction on a bridge, produced a distinct wobble in the roadbearers; this was rectified by the use of stiffening transoms, which are referred to later.

The saddle presented no serious difficulties; when the decision as to the shape of the ends of the roadbearers and the method of fixing the same had been made, several patterns of saddle were made and tried out.

The question as to whether it was advisable to use a stiff saddle or one with relatively little strength against bending, was solved by a somewhat crude experiment. This experiment evolved ascertaining the stress in each case on the lower coupling.

Two pontoons, butted together, were supported on two rollers. The bottom coupling was replaced by pulley ropes which were rove crossways to holdfasts with a dynamometer interposed.

The pontoons were loaded with various weights. Two saddles were used—one continuous, made up of two steel channels 11-ft. long x 3-in. x 1½-in., the other of wood in two parts, each 5-ft. 6-in. long, butting over the line of contact of the two pontoons.

The lower corners of the pontoon were kept together by means of a winch, the tension on the ropes being measured by the dynamometer.

The strain due to a dead load of 7.9 tons, representing a lorry and superstructure, was 3 tons 6 cwt. for the stiff steel channel saddle and 3 tons 3 cwt. for the splitwood saddle.

This result bears out the theoretical conclusion that, so long as the rigidity of the saddle is less than that of the coupled pontoon, there is no relief to the couplings to be gained by the use of a stiff saddle.

The first pattern considered was wood, 6-in. x 4-in., with a top plate of ¼-in. steel the edges of which were rounded, with slots to enable the joists, both in light and medium bridge, to be equally spaced. The length was 10-ft. 10½-in., enabling the ends to rest upon the cross frames of the pontoon in light bridge.

Under test this type of saddle was not found satisfactory as the wood did not provide sufficient resistance to the pins in the slots in case of any tendency of the joists to overturn. It was decided, therefore, to make the saddle of two channels on edge, resting on a wooden bedplate; between the channels steel castings, which contain the slots for the reception of pins, are bolted where required. This saddle also serves as a shore transom.

Under test these saddles have been found quite satisfactory. Owing to the heavy loads which come on to the pontoons in lorry and heavy bridge, it has been found necessary to reinforce with angle iron the wooden runners on the pontoon between which the saddle rests.

Having settled upon the saddle, the next problem was the racking down of the decking.

To enable the same joists, ribands and racking to be used for single and double chessing, and also for the 3-in. decking recommended for the heavy bridge, involved considerable experimental work.

The rope lashings hitherto in use for racking are too quickly destroyed by the edge of the steel joist, and they cannot be made to develop sufficient holding power, so experiments were carried out on hooks, girder clips, wire rope and on chains, etc. Hooks, unless unduly heavy, deform to such an extent as to require very frequent tightening, and ultimately deform so much as to be useless—wire rope stretches too much and is also liable to fraying.

An early experiment with a ring bolt, fixed in a hole made for the purpose in the flange of a roadbearer, was thought to be effective, but subsequent tests in which a lorry was passed many times over a bridge showed that this was not so.

In fixing the roadway there are two problems involved—

(*a*) Preventing the chesses moving parallel to their length under the constant vibration; this necessitates buttons of some sort, either on the outer roadbearer or on the ribands.

(*b*) Preventing creeping of the whole roadway; this necessitates a very tight racking attachment.

It was found at first that the most effective way of preventing movement was by hook bolts pinned through the ribands, and fastening to special cast steel buttons rivetted to the outer roadbearers: or engaging in small projections rivetted to the outside of the joists.

Girder clips which slipped over the top flange were also tried and found to be effective.

It was considered, however, that the disadvantage thereby entailed, of providing two special roadbearers for each span was such that this idea was abandoned.

Various forms of chain and wire rackings were tried, both with screw and lever tightenings, and the pattern finally selected is a slight modification of the commercial "scaffixer."

Extended trials indicated that eight of these per bay were sufficient.

The original intention as to decking was to use single chessing for light bridge, double chessing for lorry bridge and 3-in. planks for heavy bridge.

The desirability of having one type of decking only has finally led to the introduction of the 3-in. plank for all three types of

bridge; this plank is 9-in. wide and 11-ft. long, giving a roadway in the clear of 9-ft. 6-in.

The original ribands were 5-in. x 3-in. x 20-ft. 6-in. Oregon pine, reversible, provided with 1¼-in. buttons on one side for use with single chessing in light bridge, and 2½-in. on the other for use with double chessing in lorry bridge. On the adoption of the 9-in. x 3-in. deal as decking for all types of bridge, the riband requires the 2½-in. buttons on one side only.

The design of the outside shore baulks, to enable the chesses (single, double and 3-in.) to be easily placed and secured, and at the same time to avoid loose parts, was not in the first instance met satisfactorily.

The present design has only one bolt, a fixed wing nut and a fixed (but pivoting) riband. It appears to meet the present situation (*i.e.*, light and lorry bridge) admirably.

The trials in lorry bridge of the equipment which has now been described, completed the first stage in the production of the new pontoon equipment.

The trials, to which this equipment was subjected, included, amongst others, the passage of a loaded 3-ton lorry 15,000 times over the bridge.

It now became necessary to consider the design of substructure for use in heavy bridge. (See Plate II.)

In heavy bridge, the piers consist of twin-coupled pontoons, *i.e.*, four pontoons in all. It became necessary, therefore, to design the short joists which would rest on the saddles of the coupled pontoons, and which would carry centrally the saddle for the long (roadway) joists.

Owing to the up and down motion of the piers under load, it was obvious that the short joists could not be directly below the long joists, otherwise they would foul.

It was decided, therefore, to try a compound joist made up of two lengths of 6-in. x 3-in. M.S. Another advantage of the compound joist was stability, which is not obtained with a single joist.

In order to retain the saddle, which takes the long (roadway) joists in a central position, angles were fixed to the compound joists. These compound joists are used also in the trestle tower.

It was now possible to form heavy bridge, for which 11 joists per bay are required. The decking used was 3-in. planks with the button riband as finally approved. Under load the compound joists were found quite satisfactory. (See Plate II.)

Experiments on dry land have shown that a tank, when changing direction, has a tendency to produce side wobble in the long joists.

It was decided, therefore, to carry out tests with stiffeners.

The first idea was a diagonal stiffener of 3-in x 3-in. girder section, but this was not found satisfactory, owing to the long length of joist at each end unaffected by the diagonal.

Two stiffeners were then tried at right angles to the joists and spaced 7-ft. apart. Tests on dry land and in bridge proved that these stiffeners stopped all side wobble and also any tendency of the joists to overturn.

The stiffeners are fixed to the underside of the joists by fixed claws which grip the one flange of each of the 11 joists and by sliding claws which slide over the other flange; these sliding claws are then screwed up tight so that they do not move.

The whole operation of putting in a stiffener can be carried out by four men in $3\frac{1}{2}$ minutes. Two stiffeners will be used in each bay of heavy bridge, and one stiffener in each bay of lorry bridge. (See Plate II.)

The pier of four pontoons (coupled and twinned) as used in the heavy bridge was not found sufficiently rigid; similarly a cut raft in lorry or heavy bridge requires bracing.

Trials have shown that two diagonal ties with tensioners are required in the pier for heavy bridge and for all rafts; in addition, pontoons must be lashed to one another bow to bow and stern to stern. (See Plate II.)

Only one length of diagonal tie will be issued, which will be sufficiently long for use under all circumstances; the adjustment to approximate length will be made by means of a bulldog clip.

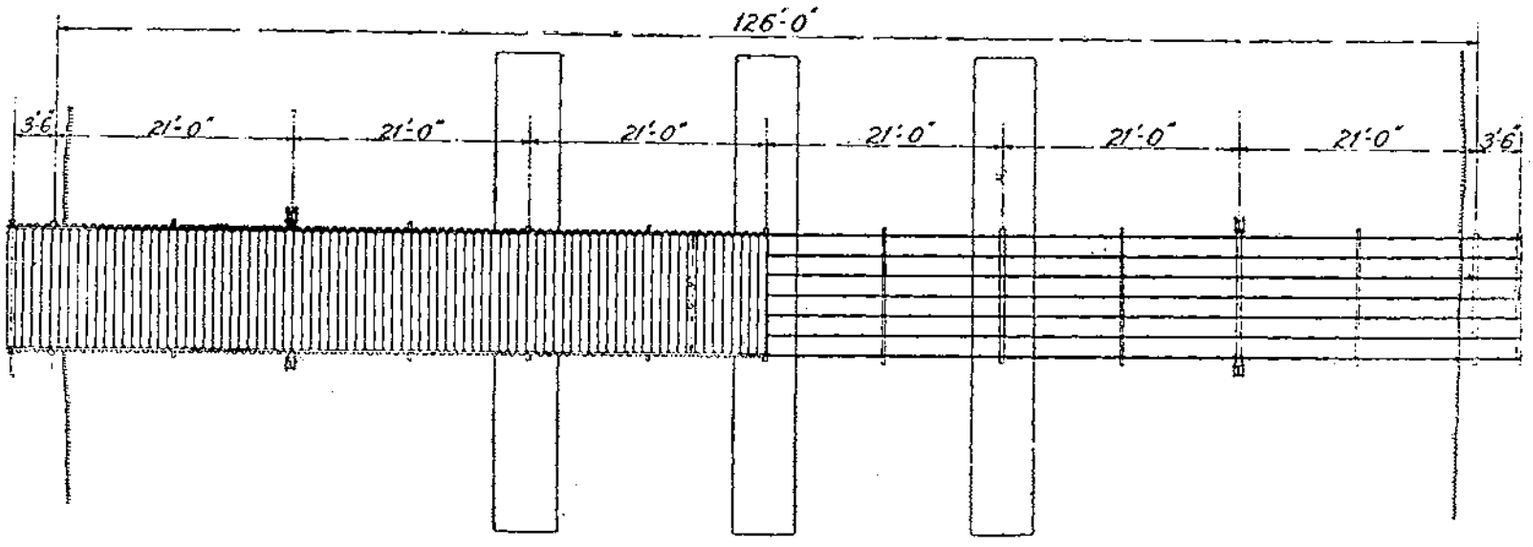
In connection with rafts, further experiments have been carried out of forming cut.

The original experiments envisaged the use of derricks on a raft for raising the roadway of adjacent spans, but it was soon recognised that the raft would be very unwieldy in a swift current, and the idea was abandoned. It was decided then that forming cut must be made by means of rafts, which must be as small and as handy as possible. Rafts are, therefore, practically touching one another with a cut bay approximately 12-ft. long between rafts.

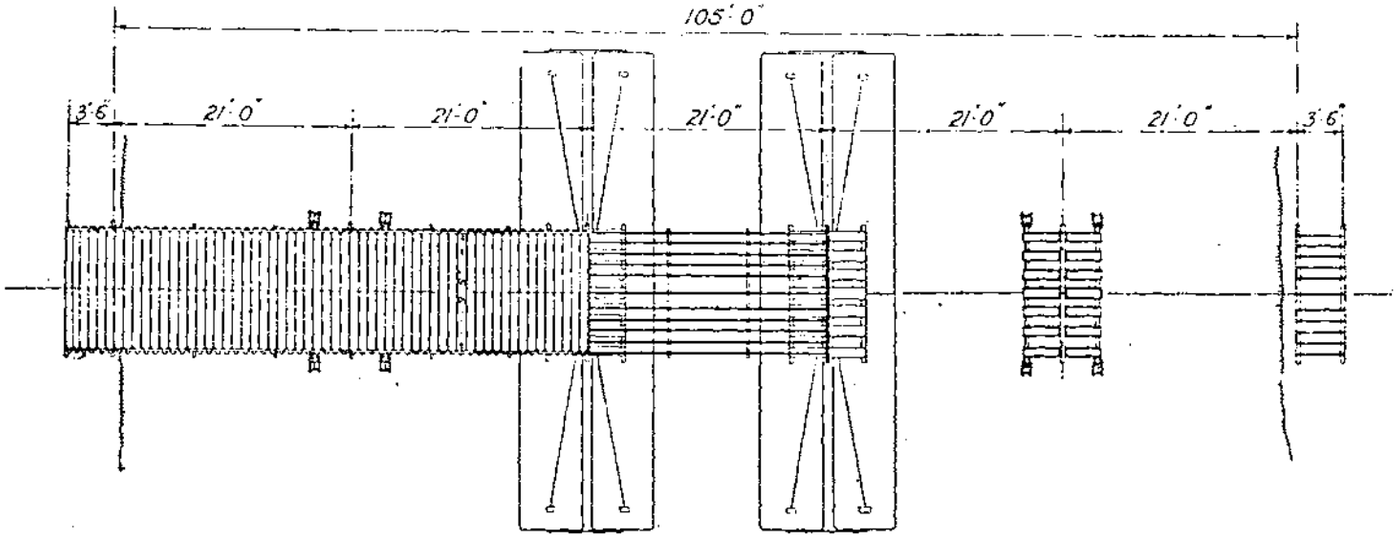
The cut bay consists of the same number of roadbearers as the remainder of the bridge, with the same type of roadway and ribands, etc. Cut can be made in $3\frac{1}{2}$ minutes. (See Plate II.)

In order to carry the new pontoon, which is 3-in. wider than the existing pattern, the pontoon wagon will require alteration; or alternatively a new trailer must be designed.

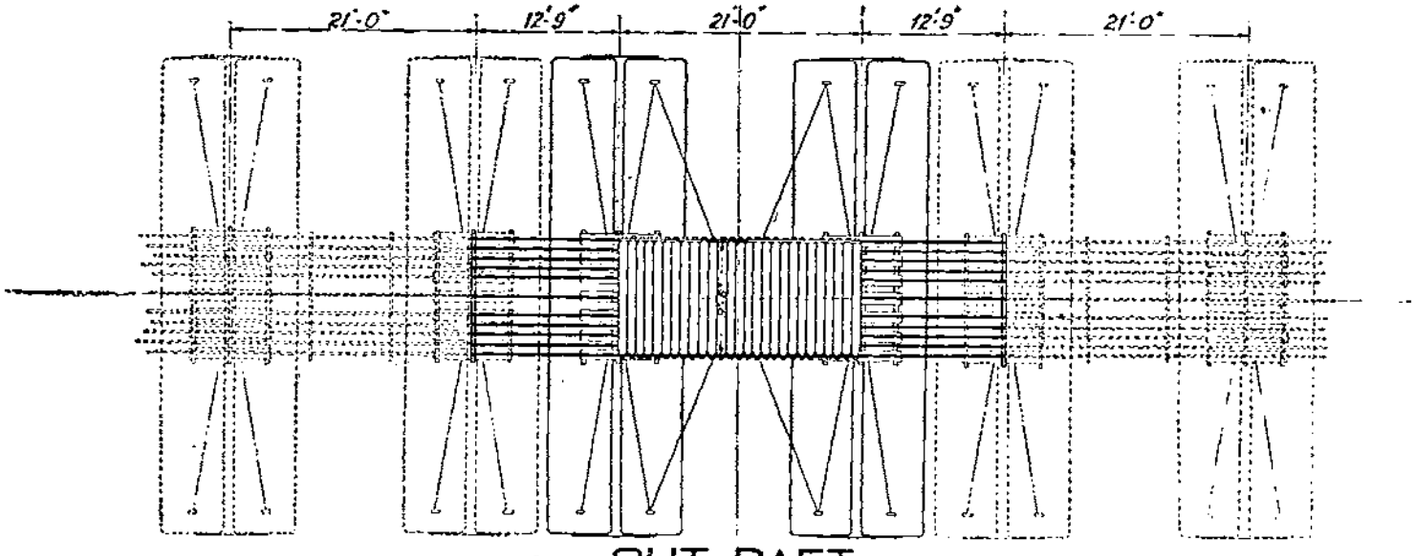
The above completes the history of the development of the new pontoon equipment.



MEDIUM BRIDGE



HEAVY BRIDGE



CUT RAFT

It must be realised that the design of the components of this equipment grew up upon the following suppositions :—

(*a*) That the allotment of bridging equipment was to be approximately on the pre-war basis, *i.e.*, a certain definite allocation of transport to each division for floating bridge equipment.

(*b*) That with this transport the division should be in a position to provide the greatest possible length of bridge of the most useful nature.

(*c*) That the floating bridge, especially the light bridge, should be capable of construction in the minimum of time.

Various alternative proposals as to the relative quantity of boats, trestles, and superstructure that could be carried were considered, but since the bridging organisation has been changed these need not be referred to here.

The above equipment may not prove by any means the most suitable under all conditions, and investigations have been begun in the direction of a far more substantial type of floating bridge equipment.

CORRIGENDUM.

With reference to the last paragraph on page 303 of the *R.E. Journal* for June, 1925, the statement therein that consuta wood is unsuitable for seaplane construction is not correct. Consuta wood is used in the construction of seaplane hulls and floats.

WATER SUPPLY FROM BORED WELLS.

By BREVET-MAJOR A. C. FINNIMORE, M.C., R.E.

SECTION I.—SUBTERRANEAN WATER SUPPLIES.

1. *Introduction.*

The art of well boring includes :—

(*a*) The selection of suitable sites for wells.

(*b*) The prediction of the depths at which water will be found and the quantity and quality of the supply that will be tapped.

(*c*) Estimation of the time that will be required, and of the degree of difficulty that may be encountered in the course of the operation.

(*d*) The selection of suitable plant and tools for the particular work in hand.

(*e*) The collection of the necessary plant, stores and personnel at the site, and arrangements for supervision, maintenance and repairs of the plant, and for the health and discipline of the crew.

(*d*) The performance of the work as arranged, and the surmounting of any unforeseen difficulties which may arise during the progress of the work.

It is intended in this article to outline the methods by means of which a Royal Engineer officer, who is not usually a specialist in the subject, may arrive at sufficiently accurate conclusions in selecting the site and method of boring for water, and some illustrations will be given of the difficulties which may be met during the practical execution of a scheme. Without the aid of a professional water diviner, a very fair estimate of the subterranean water supplies of a locality may be made by studying the physical geography of the neighbourhood.

2. *The Effect of Rainfall.*—It must be borne in mind that the water supplies of a country are dependent upon its rainfall, except for a small amount derived from heavy dews.

The total amount of precipitated moisture may be accounted for in three ways.

Heavy rains generally produce more water than can soak into the ground, and such precipitation results chiefly in the swelling of streams and rivers.

Light brief showers and dews do little more than moisten the surface of the ground, and most of the moisture so precipitated is either re-evaporated, or consumed by the vegetation.

It is chiefly *gentle protracted rainfall* which soaks steadily into the ground, and fills the subterranean reservoirs. Water so soaking into the ground will continue to descend until it reaches soil which is already saturated, or until it comes to an impermeable layer, such as clay or rock. Few strata are absolutely impenetrable, and the depth of saturated soil above such a comparatively impermeable stratum will depend upon the relative rates of water supply from the surface, and of leakage, which may be downward or lateral.

3. *Underground Water Storage.*—If in any permeable layer the lower portion is saturated, and water is being added at one place, while in another leakage is occurring, then the saturation level will naturally be higher near the spot where the water is entering, and lower near the place at which the water is leaving the stratum. Between these spots the saturation line will fall gradually. This *hydraulic gradient* depends upon the rate of flow, and upon the resistance to flow offered by the material of the stratum.

A fault may sometimes cause a water-bearing stratum to be blocked, or more often a concave curvature of the strata may form a basin, and in either case a reservoir is produced, which will fill with water to some fairly definite level.

The tilting of the strata, and subsequent erosion of the surface, may expose a portion of a permeable layer at a relatively high altitude. A block at a considerable distance may then cause the whole stratum to become saturated, and the lower portions may form a subterranean store of water at great pressure, from which artesian supplies may be obtained at places where the ground surface is considerably below the level of the highest saturated portion of the stratum, which may be many miles away.

4. *The Saturation Level.*—Except for the small amount of water re-evaporated from the surface, the ultimate destination of all water which falls upon the land is the sea; for any rise in the saturated level will cause an increase of flow towards lower regions.

Much water may find its way down in rivers; but, nevertheless, if the rainfall of any country exceed the rate of re-evaporation, water will also flow underground towards the sea.

Unless the conformation of the strata is such as to lead the whole flow in some other direction, it may be assumed that in any country whose rainfall is considerable the saturation plane will never be lower than sea level, and that, in consequence, water will always be struck in a well sunk down to that depth.

Moreover, since the direction of flow must be towards the ocean, shallow pits, sunk within a few yards of the sea, will often fill up to sea level or a little above, not with salt water, but with fresh water that has been percolating seawards in the ground.

Wells sunk further inland will generally fill to a higher level, due to the existence of the hydraulic gradient.

Thus water may be found at a considerable height above sea level, even where there are no impermeable layers to hold it up, but only the resistance to flow offered by relatively permeable or merely fissured strata. It should be realised that some strata such as sand or gravel may be truly permeable; while others, such as chalk, which are not really permeable in themselves, may nevertheless contain a considerable quantity of water, and may provide a copious flow, not in the pores of the material, but in crevices and fissures, which abound in chalk formations.

SECTION II.—WELLS.

1. *Surface Wells.*—Wells sunk only a little below the saturation line, though they may provide an ample supply of water, are neither reliable in quantity or quality. In dry weather they may fail, and normally a large amount of water contaminated by sewage may enter them before it has been effectively filtered.

Such wells are generally dug and lined with brickwork steyning. If the steyning is well built and properly capped to keep out the drainage water at the surface, they may be comparatively safe, but only if they are of considerable depth.

2. *Deep Wells.*—Wells sunk beyond the first impermeable stratum into the water-bearing strata below are in every way preferable to shallow wells. The stores of water are less affected by dry seasons, and the purity is generally assured, provided the steyning is well sealed into the impermeable layer through which it passes.

Such wells, if dug and lined with brickwork, are expensive and slow to produce, but have the advantage that large pumping machinery can be installed.

3. *Chalk Wells.*—In chalk and limestone districts, although the general rule regarding saturation line and hydraulic gradient still applies in principle, the problem of finding adequate supplies of water is complicated by the fact that the substance is only slightly porous, except for fissures, which provide passages through which the water can flow. If a well is dug down to the saturation line, water may appear, but will only enter very slowly unless one of the larger fissures is met. In that case also the delivery will be limited to the quantity of water carried away by that particular fissure.

To increase the quantity of water obtainable, it is necessary to drive out galleries below the saturation line, so as to intersect other fissures. The water obtained is generally bacteriologically pure, but is nearly always very hard. To obtain soft water, it is necessary to drive down right through the chalk and the clay that normally

lies under it, into the permeable layers below, which are generally sandy, carefully sealing out the chalk water.

For ordinary water supply purposes, it is usual to mix the chalk water with a proportion of the artesian, or sub-artesian, water from below, sufficient to render the hardness less objectionable.

4. *Boreholes.*—A much less expensive method of tapping the supplies of water at low levels is to bore a hole of only a few inches diameter, by one of several methods of drilling. The work can be done expeditiously, and supplies sufficient for many purposes can be obtained from a small borehole.

Where the water is truly artesian, that is, when the subterranean pressure is sufficient to drive the water out of the top of the hole, the method is simple and as near ideal as can be found.

It is seldom that truly artesian supplies are found, but frequently the pressure is sufficient to drive the water fairly near to the surface. Boreholes suffer from the disadvantage that only small-bore pumps can be used ; and since the weight of the rods of a deepwell pump absolutely prohibits anything approaching high speed working, the delivery of water is small.

In consequence it is normal to sink the well down to some fifty feet below the hydraulic level, of a diameter sufficient to accommodate a suitably large pump, and thence to continue down to the water-bearing strata at a reduced diameter.

For the supply of towns requiring millions of gallons per diem, it is usual to sink a dug well to accommodate the pumps. The borehole to obtain the sub-artesian water may then be driven from the bottom of this well ; or it may be driven alongside, if preferred, and the water carried into the pump-well through an adit, placed well below the hydraulic level of the water. The latter method is preferable, since the borehole can then be deepened or cleared out without dismantling the pumps, and conversely the pumps can be isolated entirely from the borehole by a valve in the adit, and the pump-well emptied, if the pumps should require inspection or repair. This method also provides for mixing different waters.

5. *Air-lift Pumping.*—For military purposes, which often necessitate quick installation, the mechanical efficiency being unimportant, the air-lift method of raising water is very suitable. The borehole need then be only of sufficient size to accommodate a rising main which will carry up the required quantity of water, since no pump is required in the well. A compressor at the surface is made to drive compressed air down a small pipe carried well below the surface of the water. The air is liberated in small bubbles into the water, whose specific gravity is thereby greatly decreased. A subterranean pressure, which can only force pure water about half way up the tube, will force the aerated and lightened water right up to the surface and deliver it in large quantity into a tank.

SECTION III.—METHODS OF BORING.

1. *The Norton Tube Well.*—A method of reaching water supplies that are at a slight depth only, and to attain which it is not necessary to traverse any hard strata, is provided by the Norton Tube Well. This consists of a stout pipe in sections, the lowest of which has a conical point, and is pierced with many small holes through which water is expected to enter. It is driven as a pile to the required depth.

Such wells have in any case a small delivery, they cannot be driven to any great depth, and cannot pierce any strata much harder than loams, sands and clays. The grid is easily blocked, and although it can generally be cleared by forcing water down through the tube, the inconvenience is considerable.

2. *The Earth Augur.*—A method available for sinking an open ended pipe in soft ground is that of removing the soil at the bottom of the pipe by means of an augur in the form of a shell, containing screw blades, and then driving down the pipe into the hole, which is necessarily of less diameter than the pipe.

The method is expeditious for shallow borings, but becomes very slow and tedious at greater depths. It cannot be applied to hard strata, such as chalk or rock of any description.

The augur is fixed to the end of a line of screwed rods, all of which must be drawn up every time the augur is filled. Progress becomes slower and the labour heavier as the depth increases, and with it the number of rods to be fixed and subsequently withdrawn at each filling. The method is chiefly used in clay soils in which there are no stones to prevent the use of the somewhat blunt and fragile augur.

3. *Rotary Drills.*—The rotary or trepanning drill is a development of the augur.

Within a tube lining, which can be sunk at first by means of an augur until the first hard strata are encountered, a separate boring tube is placed, fitted with means for revolving it, preferably by power such as a steam engine.

The lower end of the tube carries a trepanning tool, consisting of a special section of tube carrying a number of cutting teeth. As the trepanning tube revolves, the teeth cut an annular groove, leaving a solid core which enters the tube. At suitable intervals the tool is drawn up and the core removed.

In comparatively soft rocks hardened steel teeth are capable of cutting satisfactorily, and by substituting, for the steel teeth, diamonds set in suitable sockets, the hardest rocks can be cut; but progress is necessarily slow. Conversely, when boring in clay, the teeth are not necessary, and a plain pipe will descend if rotated with sufficient weight upon it, or even if dropped repeatedly upon

the bottom. Rotary drills present the peculiarity, most valuable from a geological point of view, that the core is removed undisturbed, with all the strata clearly defined and capable of accurate measurement, examination and analysis.

Whereas in soft ground the tool can be followed by a lining tube of slightly larger dimensions, which can be driven down around it, when hard strata are being penetrated, the tool can only cut a hole of its own diameter. If further soft strata requiring lining are found below, it is necessary to continue with a smaller lining and tool to correspond.

4. *Percussion Drilling.*—A rapid method of sinking an open ended tube consists merely of pulverising the ground immediately beyond the foot of the tube by repeated blows from a chisel, which may be handled by means of a rigid line of screwed rods or pipes, or merely by means of a rope.

The normal method of removing the soil is to churn it up with a quantity of water, which may have to be introduced for the purpose, and then bale out the resulting gruel with a tubular bailer or bucket, the bottom of which is generally fitted with a valve to facilitate the entry of the semi-liquid contents of the hole.

The form of chisel used depends largely upon the nature of the strata to be pierced, and also to some extent upon the method of working. The main requirements are, firstly a transverse edge that will break up the material directly opposed to the tool, and secondly a circular edge, which need not be continuous, to form the hole, leaving it round and clear.

In application, the chisel must be rotated slightly between successive blows, so that the edges may meet fresh material at every blow.

The angles of the cutting edges must be suited to the strata. In very hard material an obtuse edge is required for strength, since an acute edge would quickly break up, and correct hardening and tempering are of great importance.

In soft strata the angle and temper of the edge are of less importance, but here the quicker penetration of an acute edge is valuable, and such an edge is not so likely to break up.

The method of drilling with rigid rods is slow, and very laborious at great depths; since every length of rod must be unscrewed in turn, as the tool is raised after a period of drilling, before the bailer can be used, and they must again be screwed together, as the tool is lowered again. The method is preferred by many to the rope system, on account of the greater freedom from accident due to breakage. The speed of progress can be increased while traversing soft strata, by substituting a shell tool, consisting of a length of tube with a cutting edge and an internal throat near the foot, which collects the spoil inside it, and brings it up as a core when raised. Shells are particularly effective in strata consisting largely of clay.

5. *Rope Drilling.*—A very ancient method of sinking tube wells, which has been much used in the oil-fields of America, consists of suspending a heavy "string" of tools to the end of a rope, which is normally passed over a sheave at the head of a derrick, and brought down to a winch, which is generally power driven. This principle is often applied when rigid rods are used in the well, the rope being fastened to an eye on the uppermost section of the rod, which is always above ground level. In the American system a short metal rod is used, of a length only sufficient to guide the tool straight; the rope is taken down the well, and may be several hundred feet long, or even thousands. The elasticity of the long rope is considerable; and advantage is taken of this elasticity to economise in power, by storing energy in the tool, on the principle of resonance. Some device is provided for plucking, or shortening up the rope by two or three feet, and then releasing it. This "spudding" device should be tuned approximately to the natural frequency of the vibrations of the tool with the length of rope in use; then the vibrations will increase until the stroke of the tool may be twelve or fifteen feet.

The length of rope should be adjusted by means of the winch, so that the tool may strike the bottom vigorously, but not as a dead blow. The blow should be sharp and elastic, with the rope tense at the time, so that there may be no dwell at the bottom. Thus there is less tendency for the tool to stick, and a saving is made in power expended in retracting it, the heavy pull often needed in soft ground being supplied by the tension in the rope.

This method of drilling is very rapid, since the frequency of the blows is high; and after drilling for a suitable period, when the accumulation of debris makes it necessary to clear the hole, the tool can be very quickly hoisted by the power winch, so that the bailer can be used. There is an element of risk in the uncertainty of the life of the rope; and the breakage of a rope may lead to the loss of a string of tools in the well, which may have to be abandoned and a fresh bore started.

Apparatus is now available for fishing for a dropped tool, which if skilfully and energetically applied at once, before the tool can be buried by the debris washed up by inflowing water or falling from the sides of an incompletely lined hole, will generally recover the tool without much delay.

During the 1914-1919 war, boreholes of 200 to 400 ft. depth were normally drilled by this means in one week of continuous work night and day, two crews working in reliefs of twelve hours each, and the strata to be penetrated being generally chalk or clay, very easy strata. At least a month must be allowed for such a bore, made in normal circumstances, working eight hours a day. Naturally, the existence of hard strata greatly increases the time required;

for whereas a day of twenty-four hours' work may produce an advance of one hundred feet in chalk or clay, only three feet of a hard rock may be pierced during the ensuing day. Therefore, estimates of time required depend upon geological information.

Section IV. Plant for Percussion Drilling (Rope System).

Illustrated in *Military Engineering*, Vol. VI. Water Supply.

1. *The Boring Bit or Chisel.*—The bit is normally a fluted shaft of mild steel about four feet long, to the foot of which is welded a short piece of tool steel of a moderately high carbon content, sufficient to take a good degree of hardening without being too difficult to work.

This hard point requires to be so forged as to comply with the essentials outlined in Section III, paragraph 4. The angle of the actual chisel edge will depend upon the hardness or softness of the strata to be pierced. An included angle of 45° may be satisfactory in clay containing no large stones, while chalk, especially if it contains much flint, requires a stronger edge, such as 90°. In rock, the included angle may be from 120° to 150°, according to the hardness of the strata.

The circular edge, which shapes the hole, is not carried right round the circumference; but is normally limited to two portions of about one sixth of the circumference at opposite points. The remainder of the circumference is forged down to continue the flutes in the shaft, which permit the debris or drillings to escape away from the point. This forming edge is generally forged to a right angle. It should be a true edge or "arrise," and its bite is very important; for a blunt forming edge will allow the hole to become tapered and jam the drill; while a good sharp edge here will cause the chisel to cut large, and so keep itself free in the hole.

2. *Forging and Tempering Bits.*—The bit should be frequently re-forged. It will not remain sharp long in soft ground; and when drilling through rock or flinty chalk, it should not be used for more than a very few feet of descent without re-forging.

It must be brought accurately to size by setting up the point. A gauge of precisely the diameter of the tube lining should be used. Since the bit is gauged while hot, it will run easily in the tube when cold, for it will shrink considerably.

The point should be heated cherry red, and slaked out in brine, using a shallow-tub, in the bottom of which a piece of iron or steel plate has been laid to protect the wood. The temper should then be allowed to run down till the whole of the forming edge has just turned blue, and then finally quenched out.

3. *Taper Threads.*—The screwed connection between the "Bit" and the "Stem," the main shaft of the string of tools which supplies

the weight and direction, is normally of a steep taper. Thus the root of the "Pin," or male screwed portion, is strong. Similarly the "Box," or female portion, can be relatively thin at the exterior edge, while the walls are strong at the base.

The steep taper is a convenience in handling the string of tools when assembling or taking apart; since only a few turns are necessary, an important matter, for every part weighs several hundredweight. On the other hand, any slackness in tapered threads will lead to the string coming adrift while drilling. It is, therefore, essential that the threads shall be carefully protected from burring, by keeping them protected at all times by caps and plugs when not assembled in the string. They must be preserved from rust by ample coatings of grease; and before assembling them they must be absolutely clean and bright, since the slightest trace of grit will prevent them from screwing home properly. The direct thrust of the blow is not taken by the threads, but by accurately machined faces on the external portion of pin and box. These faces must be similarly protected and cleaned.

4. *The Boring Rig.*—The essentials of a boring rig are:—

(*a*) A derrick high enough to suspend the string of tools completely clear of the borehole, allowing for some projection of the tube lining, and strong enough to carry not merely the deadweight of the tools, but their live weight when working, and also the very heavy pull needed to dislodge them if they should stick. One large sheave is required for the drilling rope, and a smaller one for the "sand-line," a light wire rope used for handling the bailer and other light articles.

(*b*) Drums or winches to hold the drilling rope and sand-line respectively.

(*c*) A prime mover, generally a steam boiler and engine, capable of being put in gear with either winch separately.

(*d*) At least one means of working the tool by short pulls on the rope, and preferably two devices. One, for working on the portion of rope descending from the derrick head to the drum for starting the borehole, is known generally as the "spudding gear," and generally operates by plucking the rope by sudden movements of a jockey pulley. The other, for working on the rope close to the well head when the tools are below ground, is generally known as a "walking beam," and its object is to simplify the action and save the wear on the rope that occurs when working over the derrick sheave.

For convenience, either rope drum and either drilling gear should be capable of being put in gear with the engine, separately or in conjunction as desired, by means of separate controls. The main rope drum should have two separate brakes, and the sand-line one.

Friction drive is usual for both drums, except in heavy oil rigs for depths exceeding 1000 feet. It has the advantage that the engine

can be kept running all the time, and the drive is taken up without shock. All this gear, including the prime mover, is normally mounted on the same chassis, in the portable form that is most suitable for service purposes. It is also a great convenience if the engine can also be put in gear with the road-wheels, for shifting the plant over the hole and away as desired. The machine should not be expected to travel long distances under its own power, but should be carried by rail as near as possible to its work, or towed by traction engine if no rail is available.

The normal type of construction for chassis and derrick is the composite, struts and beams being of timber, and ties of steel rod. This is an advantage in isolated situations, since all repairs can be carried out by a wheelwright, or by a carpenter and a blacksmith. A small forge and anvil are normally provided with the rig, and a steam operated blower, for the main purpose of reforging blunted tools.

A self-propelling plant requires a platform, carrying a small coal box and water tank, and steering gear. For convenience in transport the derrick, chimney, and travelling platform should be capable of being removed with ease, and it is important that the overall dimensions shall be within the loading gauge of the railways to be used in getting to the site when such removable parts are taken on. A low truck is in any case necessary; and this entails some delay in arranging a move unless ample warning is given to the railway operating authorities.

5. *The String of Tools.*—For convenience in handling and working, the various portions of the string of tools are all screwed together with taper screws, and easily detachable. The bit screws into the foot of a stem, usually about 18 feet long. The stem screws into the rope socket, into which the rope is passed, and generally held in place by splicing back the rope into a cone shaped head to fit a corresponding conical hole in the socket.

When once the tools begin to disappear into the borehole, it becomes necessary to provide some means of delivering an upward blow to dislodge them if they should stick. For this purpose a pair of jars is placed between the stem and the rope socket. The jars consist merely of two links of chain, enabling an upward blow to be given by slacking off the rope until the links open, and then using the socket and upper link as a hammer by pulling up the rope.

At any time the string of tools can be unscrewed at any joint for some other tool to be substituted. For instance, a hook, screwed to fit into the rope socket, can be used for lifting tubes or any other weight by means of the derrick and winding drum; or a shell may be substituted for the chisel below the stem.

6. *The Temper Screw.*—After the borehole has been driven to a depth of one to two hundred feet, it is better to use the walking

beam instead of the spudding gear and derrick, although it is still possible to spud down to about four hundred feet. Spudding is the quicker method, but causes more wear. The temper screw is coupled to the yoke of the walking beam, and clamped to the rope at its lower end. While working, the screw is revolved a little between each stroke, and so the tool is kept rotating to make it cut freely, and simultaneously lowered as required as the hole deepens.

7. *The Floorjack and Spanner.*—The pressure exerted upon the chisel by the inertia of the other tools above it when it strikes rock, is enormous. This pressure is taken by the faces surrounding the screwed portions of the joint. If these faces can be forced closer together, the threads are thereby loosened, and may come unscrewed, particularly if the tools are spinning when the chisel strikes.

The only way to prevent this possibility is to cause a greater initial stress on the faces than the blow will cause. Then the opposing pressure of the threads will never be quite removed. Very powerful spanners are therefore provided, and a "floor-jack" with which a pressure of some twenty tons can be applied at the end of the spanners. The tools should be screwed up until two men swinging on a 6ft. handspike can drive the jack no further. The threads must be loosened when required similarly by the use of the jack. On no account should any attempt be made to loosen them by using a hammer in any way, since the jar may cause the threads to seize. If seizure occurs, the threads will be destroyed completely. The old-fashioned method of heating threads to loosen them may also be fatal in this case, since the pressure is great enough to cause welding at a comparatively low temperature.

8. *Tubes for Lining Boreholes.*—Three types of tube are used for lining bored wells, the choice between them depending mainly upon the strata pierced and the depth of well. In firm strata, in which the tool cuts a fair hole only a little larger than itself, or for comparatively shallow wells where little force will be needed in any case for driving, it is usual to line with Flush Jointed Casing tube. This is a weak lining, since the thickness is reduced by the screw threading to about one third at the joint. It generally sinks without any driving and is easy to withdraw.

In softer strata which are liable to collapse against the pipe, and make driving necessary, it is necessary to use something stronger, and for this the Swelled Casing may be suitable. It is fairly strong, but requires considerable driving, and is heavy to withdraw, on account of the friction of the joints in those strata which press on the casing.

In strata which bring heavy pressure upon the pipe, and therefore necessitate heavy driving to force the casing down, Butt Jointed Drive pipe may be necessary. This is very strong, and will stand much heavier driving than swelled pipe, but offers more resistance

both while it is being driven and if it should be desired to withdraw it. The bottom of the casing or pipe should be protected by a driving shoe of tempered steel, larger than the casing, or larger than the couplings if drive pipe is to follow it. This shoe should have a strong cutting edge of an angle of about 80°, and must be very well jointed to the pipe.

The pipe may be driven by means of driving clamps which, when bolted together on a squared portion of the string of tools, constitute the latter into a pile—driving monkey of great driving power. The head of the pipe requires a protecting cap or driving head. This should fit inside an externally threaded pipe, or outside an internally threaded socket; so that the threads may not be damaged. Pipe lifting clamps are generally made to lock round the pipe by means of a drop line, and have strong lifting ears or links. A socket or coupling should be screwed on above the clamps or they may slip. In conjunction with these clamps a pipe lifting hook may be used in the rope socket. A more powerful lift is obtainable by hooking in a large snatch-block to the lifting clamps, passing the rope from the derrick through the block and up again to an eye placed fairly low down on the derrick, thus giving a double purchase.

9. *Fishing Tools.*—Well boring is fairly simple straightforward work, provided sufficient care is exercised that nothing goes amiss. Accidents may occur, or errors may be made by the operators, producing any one, or any combination of the following stoppages.

(*a*) The tools stick, and cannot be withdrawn by the winch.
(*b*) The rope breaks in the well.
(*c*) The pipe caves in or breaks.
(*d*) The tools come unscrewed in the well.

When any one of these accidents occurs, and the tools are down the well, it is imperative to act at once with energy, since the chances of raising them again are in inverse proportion to the length of time they are down; and all the time dirt is settling down alongside and over them, or being washed up from below, jamming them worse, and finally burying them.

Fishing tools include a spudder for clearing the hole round lost tools, rope spears for catching hold of a broken rope, knife and chopper for cutting away the rope if a spear cannot get a good enough hold, and various sockets and latches for getting a grip of the lost tools when the rope is cleared out of the way. There are also swages for re-forming collapsed casing, internal pipe cutters, and a bumper for driving down a string of tools that may have stuck while hoisting them, owing to either casing bulging in or to a stone lodging alongside the tools.

A set of fishing tools should be strung together without delay, consisting of rope socket, sinker or short stem about 12 feet long, a pair of long stroke or fishing jars, and the suitable tool.

Unscrewed tools may be recovered by dropping one of the various sockets available over them.

Stuck tools may sometimes be freed by jarring upwards, but the fishing jars on the rope may break.

The rope spear will generally take hold of a broken rope, but will only tear out if the tools are badly stuck. In this case the rope must be completely chopped up and fished out, leaving the hole clear for the use of a string of fishing tools upon the lost set.

If the jars break, the appearance of the portion left on the rope socket will indicate the shape of the portion left below, and a suitable latch or socket must be put on to the fishing string.

If a good hold is obtained, and the only result is another broken rope or jars, it is unlikely that the tools will ever be recovered, and further attempts will probably be a mere waste of time and expense.

For military purposes when time is of more importance than anything else, it is essential that several spare sets of drilling tools should be available, so that if one is lost, a fresh borehole can be started at once. The heavy expense of maintaining any unit on active service, and the importance of employing all non-divisional troops on directly useful work only, will necessitate abandoning lost tools unless they can be very easily recovered, at any rate temporarily. In a slack period it may be possible and profitable to return and continue fishing operations, but only if the boring section would otherwise be idle.

SECTION V.—PRACTICAL DIFFICULTIES.

1. *Introduction.*—In the practical work of a well-boring section, locomotion is at present one of the greatest difficulties. Lack of correct geological information is another; and insufficiency or unsuitability of the tools provided may be equally disastrous.

A brief account of the problems encountered during the past year by the two crews based on Chatham may be of interest in showing the type of difficulty that may be met.

2. *Borehole at Digby, Lincolnshire.*—On the first of May, 1924, a Keystone Drilling Rig of the type described in *M.M.E.*, Vol. VI, was sent from Chatham by road to Digby, in Lincolnshire, towed by a traction engine, with a crew of one sergeant and three sappers.

The journey was disastrous, since the Keystone machine could not stand the strain of travelling on a hard road at traction—engine speed.

On the 3rd May, after travelling 62 miles, a casting, which held the back axle, broke in two. The next day was spent mainly in wedging up the back axle with hardwood blocks, after which 7 miles were covered. It was observed that several stays holding the boiler to the chassis had broken, that many bolts were missing, and the machine was suffering generally from the effects of jolting.

The remaining 78 miles were covered in the next two days, but

the machine was almost in pieces. The repairs necessary before it could be used occupied ten days, and on May 17th work was commenced. By the end of the 20th, two feet of Pinnet gravel and 6 feet of Hard Silicious sandstone had been pierced, when a valve rod on the engine broke, probably in consequence of the road journey. The repair occupied two days, during which the opportunity was taken to rig up a blacksmith's hearth for dressing tools, and to dig some drainage pits.

On the 23rd two feet of progress was made in the sandstone, but the 24th was spent in dressing up the now badly worn bit. By the 31st the depth of the hole was 47 feet, the last 2 ft. 6 in. being in hard blue stone, very difficult to drill.

On the 2nd of June, the 10 inch bit came unscrewed, and was fished out, no progress being made.

On the 12th of June, at a depth of 80 feet, water was rising in the bore. Much trouble had been caused by pieces of the hard stone dropping alongside the tools and jamming them.

Progress was now very slow, during one day no measurable progress was made, and by the 1st July the depth of the bore had only reached 105 feet. Some trouble had been caused by defects in the boiler injector and feed pump, and one day had been spent in recovering the bailer which had stuck.

On July 2nd, sand seemed to be rising in the borehole, and further progress was thought to be impossible without lining the hole with tube, so as to guide the tools through the sandbed which had apparently been reached. Tubing had been ordered before the crew started, but owing to various troubles, suitable tubes did not reach the site till September 14th. A temporary piece of pipe about 12 feet long had been used to hold up the surface soil, and when the proper lining arrived it was found that this short length of pipe could not be withdrawn. By September 22nd it had been removed, using hydraulic jacks and specially made clamps ; but now the new tubes would not go down the hole, since they were slightly oversize. The 10 inch bit was set up to a larger diameter, and by September 30th it was ready for work again, as shown in Fig. 1.

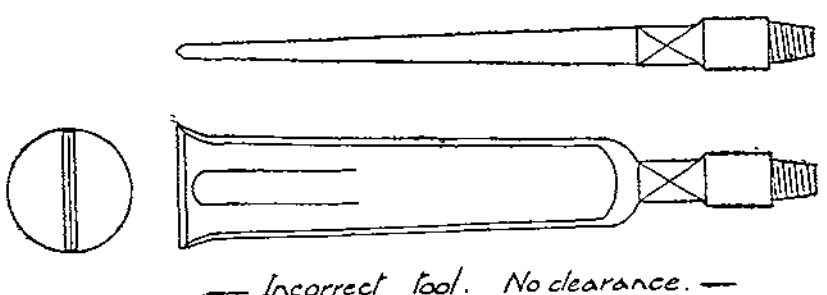


FIG. 1.

The reboring was completed on October 20th. It was found very difficult to keep the hole to gauge, and when the tubes were put down, they refused to descend further than 21 feet. It was now evident that the tool used had been too narrow, and had not sufficient circular cutting edge to make a round hole. It had not been turning, and had merely cut some featherways, as illustrated in fig. 2.

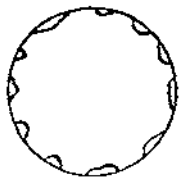


FIG. 2.

This featherway cutting is always likely to occur when re-boring unless a tool with very wide circular cutting edges is used, such as that shown in Fig. 3. By 29th October such a tool had been ob-

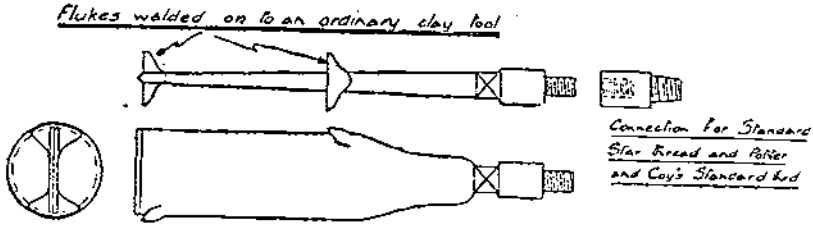


FIG. 3.

tained, and on November 22nd the hole had been properly rebored to 78ft. 6 in. This tool had stuck frequently, and the cable had broken several times. The welds between the ring and the tool had also opened out considerably. Now the tool stuck badly, and in trying to dislodge it the derrick of the rig was broken. Fortunately no one was hurt, but the derrick required to be completely rebuilt, and was only ready again on December 10th.

By January 6th, 1925, the hole had been drilled to 120 feet, the full depth intended.

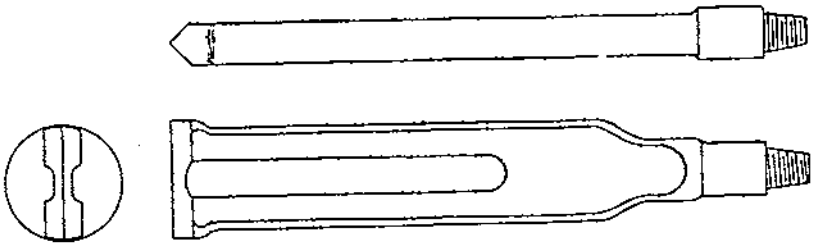
The suspected bed of sand did not exist. The section of the well is shown in Fig. 6.

At 115 feet, subartesian water was struck, and the level rose in the bore to within 27 feet of the surface. On January 8th tubes were put down to 29 feet, where they stuck. They were withdrawn and $\frac{1}{8}$ inch diameter skimmed off the cutting shoe. They then descended to 36 feet only. Finally they were driven to 54 feet, and grouted in with cement.

The job was finished on January 28th after 8 months' work, much too long, but the work had been done three times over, and much time had been spent in effecting repairs or waiting for stores. The actual days spent in boring were not excessive, and everyone had

gained experience in working under different circumstances and in totally different strata to the chalk and clay at Chatham.

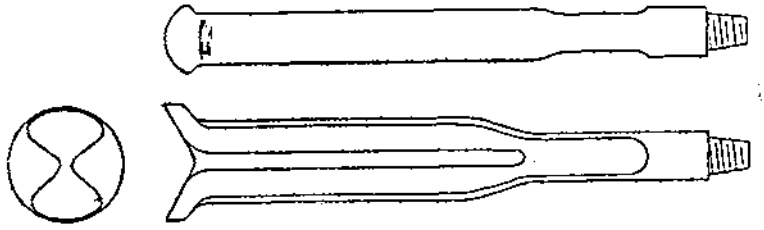
The difficulties in boring were mainly due to using unsuitable tools. Fig. 4 is a proper rock bit, but the tool used first was as Fig. 1.



— Correct Rock Drill —

FIG. 4.

The improvised reamer shewn in Fig. 3 was weak; and it was only when one as in Fig. 5 was obtained that progress was satisfactory in the re-boring operations.



— Fluted tool. Used for enlarging Borehole by Reboring. —

FIG. 5.

3. *Boreholes near Puddletown, Dorset.*

The Star Drill left Chatham on May 20th for Puddletown, near Dorchester, with a crew of one acting lance-corporal (trained in well boring) and three sappers under instruction.

In spite of orders that the speed was never to exceed 4 miles per hour, a front wheel came off the drill the first day, and the road was completely blocked for an hour.

The second day, going from Westerham to Dorking, 7 spokes broke in one hind wheel and one in the other, while the front wheels frequently overheated and required removing for lubrication.

On the third day, four miles from Aldershot, one hind wheel collapsed, and the Star drill was abandoned. Next day it was got clear of the road, and the back axle was taken off to be taken to Aldershot. By the 28th two traction engine wheels had been fitted and the journey was resumed. Now the machine had no brakes. On the 31st May the drill and crew arrived at Puddletown, but the

repairs necessitated by the jolting on the road occupied fifteen days. Various palm stays in the boiler had worked their rivets loose, and formed oval holes in the boiler shell. The steam pipe was broken, and a derrick stay had pulled out from the boiler. Apart from this, the damage done to the roads had upset the equilibrium of many ratepayers.

The boring of the first well was an easy proposition, since the chalk strata were familiar to the crew. The well was down 220 feet in eight days, and water stood at 49 feet from the surface. The machine was then moved half a mile to Waterston, and the second well commenced. Here the circumstances were very different. The bore was sited in the broad bed of a meandering chalk stream, only a hundred yards or so from the river itself. Any engineer conversant with well boring could have predicted trouble, but there was none on the spot. The difficulty in such a position lies in the fact that there is usually a heavy underground flow below the visible stream in chalk; and in consequence the bed is principally formed by subsidence, the chalk being thereby disintegrated for some distance below the surface. In two days twenty-four feet had been drilled, and then for nine days no progress was made. The bailer would not reach the bottom of the hole. The tools were working in a wet mass of sediment and broken flints, and brought up the tube with them at every up stroke. Quantities of stuff baled out were replaced continually in the hole by subsidence in the surrounding ground, and a cavern had formed round the tube as represented in Fig. 7. To save the drilling machine from being engulfed it was shifted away and a new hole started in slightly firmer ground on July 11th. By the 16th it was 50 feet deep, and the water stood at 6 feet below the surface.

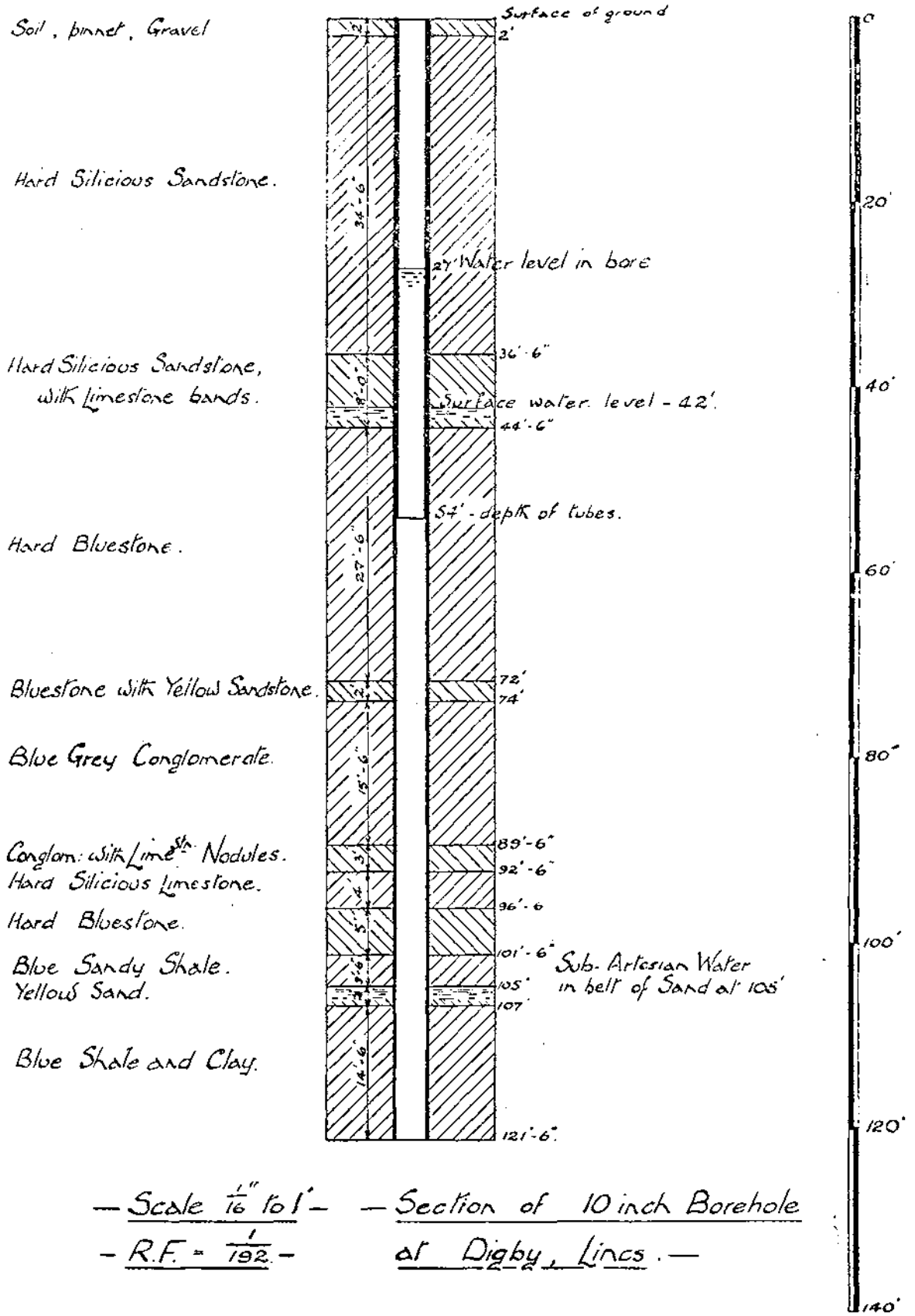
SECTION VI.—CONCLUSIONS.

1. *The Machine.*—It will be seen that when time is an important factor the transfer of the plant to the site is as important a consideration as the operation of boring. In one case a journey of 6 days caused damage which required 9 days to repair. In the other 12 days were occupied in covering 160 miles, and 15 days were then wasted in repairing the plant.

The American machines now used are quite unfit to travel long distances; a much better type of chassis should be provided, with tyres that can be trusted to cause the minimum of damage to the roads. Giant pneumatic tyres, with a well sprung chassis, would probably eliminate all this trouble.

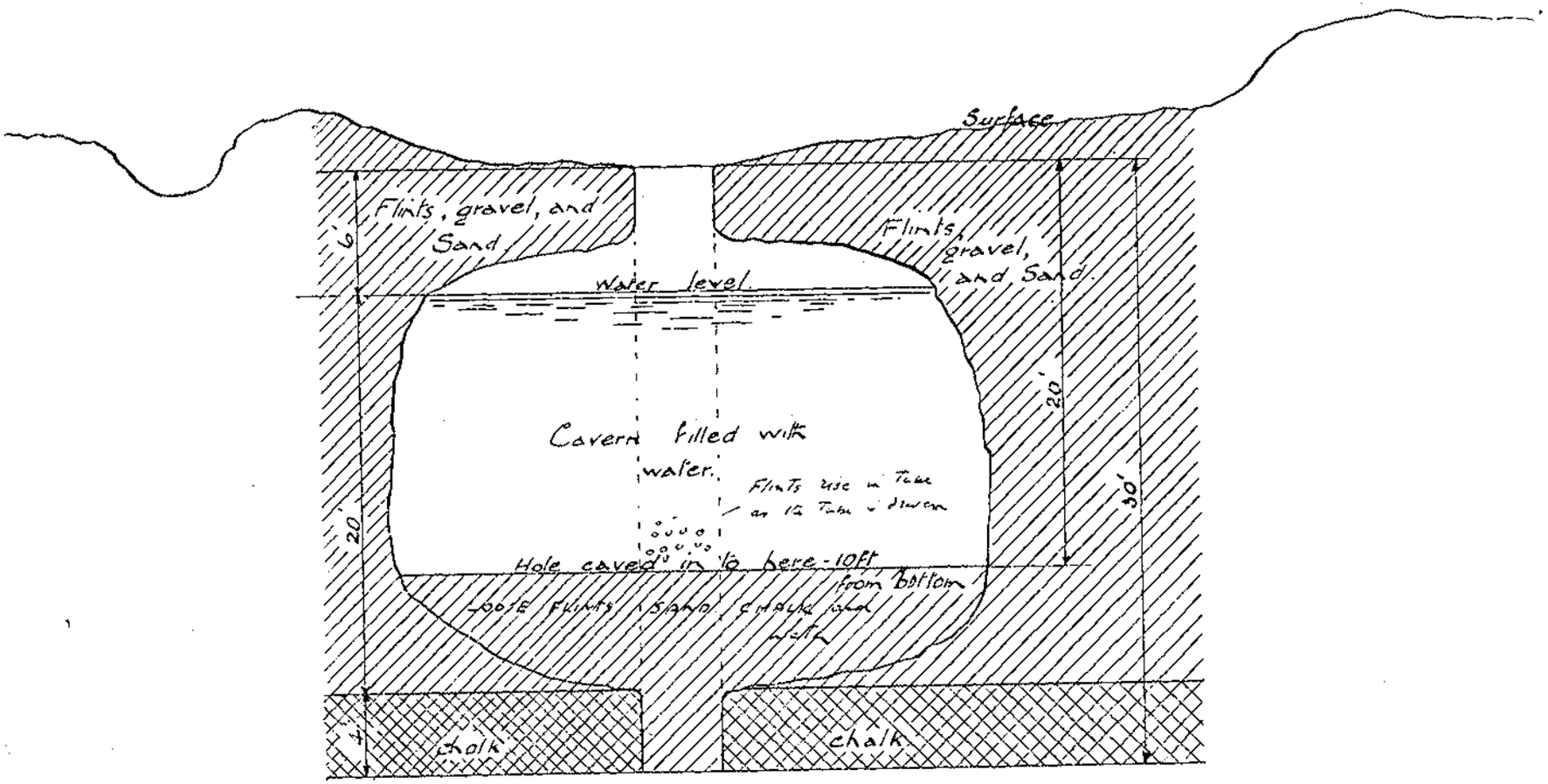
2. *The Crew.*—During the war of 1914-18, two machines were used at one bore, each machine by its own crew, working in reliefs. Every crew consisted of a foreman, well borers, smiths, fitters, engine driver, cook, etc. When a crew turned in after working a relief, the

WATER SUPPLY FROM BORED WELLS.



— Scale $\frac{1}{16}$" to 1' — — Section of 10 inch Borehole
— R.F. = $\frac{1}{192}$ — at Digby, Lincs. —

FIG. 6.



— Section of hole at Waterston. —

FIG. 7.

machine was run back away from the hole, the fitters went over the machine and effected any repairs needed, the smiths dressed the chisels, and the cook fed the crew. In consequence no time was lost, and no one was kept waiting. It is very poor economy to work with an insufficient crew. for in that case any repair to the machine, the dressing of a bit, or a trip to a neighbouring town for supplies or stores, will mean a day lost, because the well-borers must do these odd jobs.

3. *Supervision.*—It was very obvious in the cases quoted that the crews suffered from being "nobody's children." Difficulties arose over billeting, rationing and discipline. Important stores were delayed. Information was often lacking as to progress or difficulties encountered; and much time was lost from a lack of co-ordination. The inference seems to be that one officer should give his whole time to the supervision on one boring operation. He should be not merely trained in the operation, but also well provided with geological information.

He should be given ample warning of all schemes, so that he may have time to visit the site, decide on his plan of action, and demand the necessary stores in time to ensure their arrival before they are required. He should also have a reasonably free hand as regards the operation itself, and freedom to act on his own initiative. in case of any breakdown, for a delay may be more expensive than a repair of the largest order.

4. *Stores.*—Many delays may occur through difficulty in obtaining stores, such as tubing, tools, rope, etc. The standardisation, stocking, and turn over of such stores at some central spot would save these delays in most cases.

BATTLE HONOURS OF ROYAL ENGINEER UNITS.

(Continued).

Since the publication of the first lists of Battle Honours in the last *Royal Engineers Journal*, I have received the following letter which I have been asked to publish in full in substitution of the *Notice* which appeared on page 237 of that *Journal*. Arrangements have now been made for the lists to be completed, but Col. Pridham's lists dealing with the Gallipoli Campaign will not be published until all the lists referring to the Campaign in France have been completed.

Ed. *R.E. Journal*.

The War Office, 27, Pilgrim Street, Ludgate Hill, London, E.C.4.
(Medal Branch, A. G. 10.) 8th July, 1925.

To the *Secretary, Institution of Royal Engineers.*

DEAR SIR,—You will have noticed that from time to time notifications of the award of Battle Honours to Regiments of Cavalry and Infantry have been appearing in Army Orders and in the Press.

This work is now completed after a great deal of research, and Regiments have been awarded Battle Honours in strict accordance with the terms laid down by a "Battles Nomenclature Committee" appointed in August, 1919. This Committee tabulated Theatres of War and Actions with a definite system of nomenclature denoting their relative importance, and defined the geographical and chronological limits of each Action. The Battles Nomenclature Committee's report is an official publication and can be obtained through any newsagent for two shillings.

From the tabulated Theatres of War and Actions a list of those for which Battle Honours might be awarded to Infantry and Cavalry was drawn up by a special Battle Honours Committee and accepted by the Army Council. This list is enclosed for your information.

Although the grant of individual Battle Honours is not applicable to Royal Engineer units, since the motto "Ubique" covers every theatre of operations, it could not fail to be of very great interest to the Corps if complete lists were compiled to show what Battle Honours would have been gained by the several units which participated.

At first Colonel G. R. Pridham, D.S.O., O.B.E., and afterwards Lieutenant Colonel J. D. Monro, O.B.E., have devoted their entire time for some months in collecting information for the War Office as to the eligibility of Engineer units for Battle Honours, on the same lines as laid down and approved by the Army Council for Infantry and Cavalry, and I am authorised to enclose a copy of this work so far as it is completed, and to state that though their task has been extremely difficult, the movement of every unit has been carefully tabulated.

I am to ask if the Committee would be agreeable to publish a copy of this explanatory letter in *The Royal Engineers Journal* with the lists of units, which would have been awarded Battle Honours, as an appendix in small type.

We invite publication now as criticism would assist in the elimination of any small errors, and the movements of each unit should be of general interest. The lists will in any case form a backbone for further regimental history.

Yours faithfully,

G. T. BRIERLEY,

Colonel.

The Secretary,
Institution of Royal Engineers,
Chatham.

THEATRE OF WAR HONOURS.

France and Flanders.
Italy.
Macedonia
Gallipoli.
Egypt.
Palestine.
Mesopotamia.
Persia.
N.W. Frontier India.
Baluchistan.
Murman.
Archangel.
Siberia.
E. Africa.
S.W. Africa.
Cameroons.

BATTLE HONOURS.

Mons.
Le Cateau.
Retreat from Mons.
Marne 1914.
Aisne 1914.
Antwerp
La Bassée 1914.
Messines 1914.
Armentières 1914.
Ypres 1914.
Langemarck 1914.
Gheluvelt.
Nonne Bosschen.
Festubert 1914.
Givenchy 1914.
Neuve Chapelle.
Hill 60.
Ypres 1915.
Gravenstafel.
St. Julien.
Frezenberg.
Bellewaarde.
Aubers.
Festubert 1915.
Hooge 1915.
Loos.
Mount Sorrel.
Somme 1916.
Albert 1916.
Bazentin.
Delville Wood.
Pozières.
Guillemont.
Ginchy.
Flers-Courcelette.
Morval
Thiepval.
Le Transloy.
Ancre Heights.
Ancre 1916

Bapaume 1917.
Arras 1917.
Vimy 1917.
Scarpe 1917.
Arleux.
Oppy.
Bullecourt.
Hill 70.
Messines 1917.
Ypres 1917.
Pilckem.
Langemarck 1917.
Menin Road.
Polygon Wood.
Broodseinde.
Poelcappelle.
Passchendaele.
Cambrai 1917.
Somme 1918.
St. Quentin.
Bapaume 1918.
Rosières.
Arras 1918.
Avre.
Ancre 1918.
Villers Bretonneux.
Lys.
Estaires.
Messines 1918.
Hazebrouck.
Bailleul.
Kemmel.
Béthune.
Scherpenberg.
Aisne 1918.
Marne 1918.
Soissonnais-Ourcq.
Tardenois.
Amiens.
Somme 1918.
Albert 1918.
Bapaume 1918.
Arras 1918.
Scarpe 1918.
Drocourt-Quéant.
Hindenburg Line.
Havrincourt.
Epéhy.
Canal du Nord.
St. Quentin Canal.
Beaurevoir.
Cambrai 1918.
Ypres 1918.
Courtrai.
Selle.
Valenciennes.
Sambre.
Pursuit to Mons.

Isonzo.
Piave.
Vittorio Veneto.

Kosturino.
Struma.

Doiran 1917.
Doiran 1918.

Helles.
Landing at Helles.
Krithia.
Anzac.
Landing at Anzac.
Defence of Anzac.
Suvla.
Sari Bair.
Landing at Suvla.
Scimitar Hill.

Agagiya.
Suez Canal.
Rumani.
Rafah.

Gaza.
El Mughar.
Nebi Samwil.
Jerusalem.
Jaffa.
Jericho.
Jordan.
Tell 'Asur.
Megiddo.
Sharon.
Nablus.
Damascus.

Aden.

Basra.
Shaiba.
Kut al Amara 1915.
Ctesiphon.
Defence of Kut al Amara.
Tigris 1916.
Kut al Amara 1917.
Baghdad.
Khan Baghdadi.
Sharqat.

Merv.
Baku.

Troitsa
Dukhovskaya.

Tsingtao.
Herbertshöhe.

Kilimanjaro.
Behobeho.
Narungombe.
Nyangao.

Gibeon.

Kamina.

Duala.
Garua.
Banyo.

NEUVE CHAPELLE. 10TH—13TH MARCH, 1915.

Unit.	Formation.	E.	Remarks.
54th Fld. Co.	7th Div.	E.	
55th „ „	„ „	„	
2nd Highland Fld. Co.	„ „	„	
7th Sig. Co	„ „	„	War Diary missing. Presumptive evidence.
2nd Fld. Co.	8th. „	„	
15th „ „	„ „	„	With 23rd Inf. Bde.
1st Home Counties Fld. Co.	„ „	„	
8th Sig. Co.	„ „	„	
20th Co. 3rd S. & M.	Lahore Div.	„	
21st „ „ „	„	„	
Lahore Divl. Sig. Co.	„	„	Lines to Brigades within area.
3rd Co. 1st S. & M.	Meerut Div.	„	
4th „ „ „	„	„	
Meerut Divl. Sig. Co.	„	„	Lines to Brigades within area.
1st Siege Co. R. Anglesey R.E.	IVth Corps.	„	

Verifications.
IVth Corps. and Indian Corps Signals.
1st Army Signals not present.

HILL 60. 17th—22nd APRIL, 1915.

Unit.	Formation.	E.	Remarks.
59th Fld. Co.	5th Div.	E.	
1/2nd Home Counties Fld. Co.	„	„	
5th Div. Sig. Co.	„	„	Communications maintained to Hill 60 during battle.
171st Tunnelling Co.	Army Troops	„	

YPRES 1915. 22nd APRIL—25th MAY.

Unit.	Formation.	E.	Remarks.
171st Tunnelling Co.	2nd Army	E.	
2nd Bridging Train	„	„	
2nd Siege Co. R. Anglesey R.E.	Vth Corps.	„	
4th Siege Co. R. Monmouth R.E.	„	„	
Vth Corps Signals	„	„	
IInd Corps Signals	2nd Corps	D.	
1st Fld. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	„	„	Communications to Brigades.
2nd Fld. Sqdn.	2nd Cav. Div.	„	
2nd Sig. Sqdn.	„	„	No diary. Presumptive evidence.
3rd Fld. Sqdn.	3rd Cav. Div.	„	
3rd Sig. Sqdn.	„	„	
9th Fld. Co.	4th Div.	„	
1/1st West Lancs. Fld. Co.	„	„	
4th Sig. Co.	„	„	Communications to Brigades.
59th Fld. Co.	5th Div.	„	
1/2nd Home Counties Fld. Co.	„	„	
2/1st N. Midland Fld. Co.	„	„	
5th Sig. Co.	„	„	Communication to Brigades.
17th Fld. Co.	27th Div.	„	

YPRES 1915. 22nd APRIL—25th MAY.

Unit.	Formation.	E.	Remarks.
1/1st Wessex Fld Co.	27th Div.	E.	
1/2nd Wessex Fld. Co.	,,	,,	
27th Sig. Co.	,,		No diary. Presumptive Evidence.
38th Fld. Co.	28th Div.	,,	
28th Sig. Co.	,,	,,	Communications to Brigades.
1/1st Northumbrian Fld. Co.	50th Div.	,,	
1/2nd Northumbrian Fld. Co.	,,	,,	
50th Sig. Co. (Northumbrian)	,,	,,	Brigades of the Div. in the area.
20th Co. 3rd S. & M.	Lahore Div.	,,	
21st Co. 3rd S. & M.	,,	,,	
Lahore Div. Sig. Co.	,,	,,	
1st Canadian Fld. Co.	1st Can. Div.	,,	
2nd ,, ,,	,,	,,	
3rd ,, ,,	,,	,,	
1st Can. Sig. Co.	,,	,,	
54th Fld. Co.	7th Div.	,,	
55th Fld. Co.	,,	,,	
2nd (Works) Cornwall Fortress Co.	G.H.Q.	,,	
1/1st Wilts. Fortress Co.	IInd Corps	D.	Diary missing.

Verifications.

172nd Tunnelling Co.	Not present.	31st Fortress Co.	Not present.
173rd ,, ,,	,, ,,	42nd Co.	,, ,,
174th ,, ,,	,, ,,	1st Monmouth Siege Co.	,, ,,
175th ,, ,,	,, ,,	7th Field Co.	,, ,,
176th ,, ,,	,, ,,	1st S. Midland Fld. Co.	,, ,,
177th ,, ,,	,, ,,	3rd London Fld. Co.	,, ,,
25th Fortress Co.	,, ,,		

GRAVENSTAFEL. 22nd—23rd APRIL, 1915.

Unit.	Formation	E.	Remarks.
171st Tunnelling Co.	2nd Army	E.	
2nd Siege Co. R. Anglesey R.E.	Vth Corps	D.	No diary.
4th Siege Co. R. Monmouth R E.	,,	E.	
Vth Corps Signals	,,	,,	
IInd Corps Signals	IInd Corps	D.	
1st Fld. Sqdn.	1st Cav. Div.	E.	
59th Fld. Co.	5th Div.	,,	
1/2nd Home Counties Fld. Co.	,,	,,	
17th Fld. Co.	27th Div.	,,	
1/1st Wessex Fld Co.	,,	,,	
1/2nd Wessex Fld Co.	,,	,,	
38th Fld. Co.	28th Div.	,,	
28th Sig. Co.	,,	,,	
1/1st Northumbrian Fld. Co.	50th Div.	,,	
1st Canadian Fld. Co.	Can. Div.	,,	
2nd ,, ,,	,,	,,	
3rd ,, ,,	,,	,,	
Canadian Sig. Co.	,,	,,	
No. 2 (Works) Cornwall Fortress Co.	G.H.Q.	,,	
1/1st Wilts. Fortress Co.	2nd Corps	D.	Unit Diary missing.
27th Div. Sig. Co.	27th Div.	E.	No diary. Presumptive evidence.

ST. JULIEN. 24th April—4th May, 1915.

Unit.	Formation.	E.	Remarks.
171st Tunnelling Co.	2nd Army	E.	
2nd Siege Co. R. Anglesey R.E.	Vth Corps	,,	
4th Siege Co. R. Monmouth R.E.	,,	,,	
Vth Corps Signals	,,	,,	
IInd Corps Signals	IInd Corps	D.	
1st Fld. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	,,	D.	
2nd Fld. Sqdn.	2nd Cav. Div.	E.	
2nd Sig. Sqdn.	,,	,,	
3rd Fld. Sqdn.	3rd Cav. Div.	,,	
9th Fld. Co.	4th Div.	,,	
1/1st West Lancs. Fld. Co.	,,	,,	
4th Sig. Co.	,,	,,	
59th Fld. Co.	5th Div.	,,	
1/2nd Home Counties Fld. Co.	,,	,,	
2/1st N. Midland Fld. Co.	,,	,,	
17th Fld. Co.	27th Div.	,,	
1/1st Wessex Fld. Co.	,,	,,	
1/2nd Wessex Fld. Co.	,,	,,	
27th Div. Sig. Co.	,,	,,	No diary. Presumptive evidence.
38th Fld Co.	28th Div.	,,	
28th Sig. Co.	,,	,,	
1/1st Northumbrian Fld Co.	50th Div.	,,	
1/2nd Northumbrian Fld. Co.	,,	,,	
50th Northumbrian Fld. Co.	,,	,,	
20th Co. 3rd S. & M.	Lahore Div.	,,	
21st Co. ,,	,,	,,	
Lahore Div. Sig. Coy.	,,	,,	
1st Canadian Fld. Co.	Canadian Div.	,,	
2nd ,, ,,	,,	,,	
3rd ,, ,,	,,	,,	
Canadian Sig. Co.	,,	,,	
54th Fld. Co.	7th Div.	,,	
55th Fld.	,,	,,	
2nd (Works) Cornwall Fortress Co.	G.H.Q.	,,	
1/1st Wilts. Fortress Co.	IInd Corps	D.	Diary missing.

FREZENBERG. 8th—13th May, 1915.

Unit.	Formation.	E.	Remarks.
171st Tunnelling Co.	2nd Army	E.	
2nd Bridging Train	,,	,,	
2nd Siege Co. R. Anglesey R.E.	Vth Corps	,,	
4th Siege Co. R. Monmouth R.E.	,,	,,	
Vth Corps Signals	,,	D.	
IInd Corps Signals	IInd Corps	,,	
1st Fld. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	,,	,,	
3rd Fld. Sqdn.	3rd Cav. Div.	,,	
3rd Sig. Sqdn.	,,	,,	

FREZENBERG: 8th—13th MAY, 1915.

Unit.	Formation.	E.	Remarks.
9th Fld. Co.	4th Div.	E.	
1/1st West Lancs. Fld. Co.	,,	,,	
4th Sig. Co.	,,	,,	
59th Fld. Co.	5th Div.	,,	
1/2nd Home Counties Fld. Co.	,,	,,	
2/1st N. Midland Fld. Co.	,,	,,	
17th Fld Co.	27th Div.	,,	
1/1st Wessex Fld. Co.	,,	,,	
1/2nd Wessex Fld. Co.	,,	,,	
27th Div. Sig. Co.	,,	,,	No diary. Presumptive evidence.
38th Fld. Co.	28th Div.	,,	
28th Sig. Co.	,,	,,	
1/1st Northumbrian Fld. Co.	50th Div.	,,	
1/2nd Northumbrian Fld. Co.	,,	,,	
50th (Northumbrian) Fld. Co.	,,	,,	
1/1st Wilts. Fortress Co.	IInd Corps	D.	No diary.

BELLEWAARDE. 24th—25th MAY, 1915.

Unit.	Formation	E.	Remarks.
171st Tunnelling Co.	2nd Army	E.	
2nd Siege Co. R. Anglesey R.E.	Vth Corps	,,	
4th Siege Co. R. Monmouth R.E.	,,	,,	
Vth Corps Signals	,,	D.	
IInd Corps Signals	IInd Corps	D.	
1st Fld. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	,,	,,	
2nd Fld. Sqdn.	2nd Cav. Div.	,,	
2nd Sig. Sqdn.	,,	,,	No diary. Presumptive evidence.
3rd Fld. Sqdn.	3rd Cav. Div.	,,	
9th Fld. Co.	4th Div.	,,	
1/1st West Lancs. Fld. Co.	,,	,,	
4th Sig. Co.	,,	,,	
59th Fld. Co.	5th Div.	,,	
1/2nd Home Counties Fld. Co.	,,	,,	
2/1st N. Midland Fld. Co.	,,	,,	
17th Fld. Co.	27th Div.	,,	
1/1st Wessex Fld. Co.	,,	,,	
1/2nd Wessex Fld. Co.	,,	,,	
27th Div. Sig. Co.	,,	,,	No diary. Presumptive evidence.
38th Fld. Co.	28th Div.	,,	
28th Sig. Co.	,,	,,	
1/1st Northumbrian Fld. Co.	50th Div.	,,	
1/2nd Northumbrian Fld. Co.	,,	,,	
50th Sig. Co. (Northumbrian)	,,	D.	Diary missing.
1/1st Wilts. Fortress Co.	IInd Corps	,,	No diary.

AUBERS. 9th MAY, 1915

Unit.	Formation.	E.	Remarks.
173rd Tunnelling Co.	1st Army	E.	
25th Fortress Co.	IVth Corps	,,	
23rd Fld. Co.	1st Div.	,,	
26th Fld Co.	,,	,,	
1/1st Lowland Fld. Co.	,,	,,	
1st Div. Sig. Co.	,,	,,	
1/3rd London Fld. Co.	47th Div.	,,	
1/4th London Fld. Co.	,,	,,	
47th Sig. Co.	,,	,,	
54th Fld. Co.	7th Div.	,,	
55th Fld Co.	,,	,,	
1/2nd Highland Fld. Co.	,,	,,	
7th Sig. Co.	,,	,,	No Diary. Presumptive evidence.
2nd Fld. Co.	8th Div.	,,	
15th Fld. Co.	,,	,,	
1/1st Home Counties Fld. Co.	,,	,,	
8th Div. Sig. Co.	,,	,,	
20th Fld. Co. 3rd S. & M.	Lahore Div.	D.	
21st. Fld. Co. 3rd S. & M.	,,	E.	
Lahore Div. Sig. Co.	,,	,,	
3rd Co. 1st S. & M.	Meerut Div.	,,	
4th ,, ,,	,,	,,	
Meerut Sig. Co.	,,	,,	
5th Fld. Co.	2nd Div.	,,	
11th Fld. Co.	,,	,,	
2nd Div. Sig. Co.	,,	,,	
1st Siege Co. R. Anglesey R.E.	IVth Corps		
2/1st West Riding Fld. Co.	49th Div.		
1st Corps Signals	1st Corps	D.	
IVth Corps Signals	IVth Corps	E.	
Indian Corps Signals	Indian	D.	

Verifications.

Not present.

170 Tunnelling Co.
176 ,, ,,
31st Fortress Co.
1/1st E. Anglian Fld. Co.
1/1st Highland Fld. Co.
2/2nd ,, ,,
51st Sig. Co.
1st, 2nd & 3rd Canadian Fld. Co.
Canadian Sig. Co.
1st & 2nd Bridging Trains
29th Co.
2nd Cornwall Siege Co.
1st R. Monmouth Siege Co.
1/1st S. Midland Fld. Co.
171 and 175-174-172 Tunnelling Cos.
4th Co. R. Monmouth R.E.
2nd Siege Co. R. Anglesey R.E.
42nd Co.

FESTUBERT. 15th—25th MAY, 1915.

Unit.	Formation.	E.	Remarks.
170th Tunnelling Co.	1st Army	E.	
173rd Tunnelling Co.	,,	D.	Cannot verify from diary.
1/3rd London Fld. Co.	47th Div.	E.	
1/4th ,, ,,	,,	,,	
47th Sig. Co.	,,	,,	
54th Fld. Co.	7th Div.	,,	
55th Fld. Co.	,,	,,	
1/2nd Highland Fld. Co.	,,	,,	

FESTUBERT. 15th—25th MAY, 1915.

Unit.	Formation.	E.	Remarks.
7th Sig. Co.	7th Div.	E.	No diary. Presumptive evidence.
21st Co. 3rd S. & M.	Lahore Div.	D.	
Lahore Div. Sig. Co.	,,	,,	
3rd Co. 1st S. & M.	Meerut Div.	E.	
5th Fld. Co.	2nd Div.	,,	
11th Fld. Co.	,,	,,	
1/1st E. Anglian Fld. Co.	,,	,,	
2nd Div. Sig. Co.	,,	,,	
1/1st Highland Fld. Co.	51st Div.	,,	
2/2nd Highland Fld. Co.	,,	,,	
51st Sig. Co.	,,	,,	
1st Canadian Fld. Co.	Can. Div.	,,	
2nd ,, ,,	,,	,,	
3rd ,, ,,	,,	,,	
Canadian Sig. Co.	,,	,,	Diary incomplete. Presumptive evidence.
4th Co. 1st S. & M.	Meerut Div.	,,	
Meerut Div. Sig. Co.	,,	,,	
174th Tunnelling Co.	2nd Army	D.	
1/1st Hants. Fortress Co.	1st Corps	,,	No diary.
Signals 1st Corps.	,,	,,	
IVth Corps Signals	IVth Corps	E.	
Indian Corps Signals	Indian Corps	D.	

Verifications.

Not present.

176th Tunnelling Co.
31st Fortress Co.
25th ,, ,,
23rd Fld. Co.
26th ,,
1/1st Lowland Fld. Co.
1st Sig. Co.
2nd Fld. Co.
15th Fld. Co.
1st Home Counties Fld. Co.
8th Sig. Co.
20th Co. 3rd S. & M.
1st & 2nd Bridging Trains
29th Co.
2nd Cornwall Siege Co.
1st Co. R. Monmouth R.E.
1/1st S. Midland Fld. Co.
171-175-172 Tunnelling Cos.
4th Co. R. Monmouth R.E.
2nd Siege Co. R. Anglesey R.E.
42nd Co.

HOOGE, 1915. 19th, 30th JULY and 9th AUGUST.

Unit.	Formation.	E.	Remarks.
56th Fld. Co.	3rd Div.	E.	
1/1st Cheshire Fld. Co.	,,	,,	
3rd Signal Co.	,,	D.	One brigade certainly engaged.
12th Fld. Co.	6th Div.	E.	
1/1st London Fld. Co.	,,	,,	
6th Sig. Co.	,,	,,	
61st Fld. Co.	14th Div.	,,	
62nd Fld Co.	,,	,,	
89th Fld. Co.	,,	,,	
14th Sig. Co.	,,	,,	
171st Tunnelling Co.	2nd Army	N.E.	
172nd ,,	,,	,,	
174th ,,	,,	,,	
177th ,,	,,	E.	
2nd Bridging Train	,,	N.E.	
2nd Siege Co. R. Anglesey R.E.	Vth Corps.	,,	

HOOGE, 1915. 19th, 30th JULY and 9th AUGUST.

Unit.	Formation.	E.	Remarks.
Vth Corps Signals	Vth Corps.	N.E.	
175th Tunnelling Co.	2nd Army	E.	Mines fired on 19.7.15.
1st Cornwall A.T.Co.	,,	D.	No diary.
4th Siege Co. R. Monmouth R.E.	Vth Corps.	N.E.	

LOOS. 25th SEPTEMBER—5th OCTOBER, 1915.

Unit.	Formation	E.	Remarks.
1st Bridging Train	G.H.Q.	E.	
Special Brigade, R.E.	,,	,,	No diaries kept by Companies. 187 and 189 Cos. are mentioned in other diaries and are E. 186 and 188 Cos. were attached to Corps in the area and are probably E.
170th Tunnelling Co.	1st Army.	E.	
173rd ,,	,,	,,	
176th ,,	,,	,,	
180th ,,	,,	,,	
181st ,,	,,	N.E.	
145th A. T. Co.	,,	,,	
31st A.T.Co.	Ist Corps.	E.	
1/1st Hants. A.T. Co.	,,	D.	No diary for the unit. C.R.E. 7th Div. mentions 1/2nd Hants. Fortress Co. which did not exist and probably means 1/1st Hants. If so the unit is E.
Corps Signals	Ist Corps	E.	
25th A.T. Co.	IVth Corps.	,,	
138th A.T. Co.	,,	,,	
Corps Signals	,,	,,	
Corps Signals	XIth Corps	,,	
139th A.T. Co.	Indian Corps	N.E.	
1st Siege Co. R. Anglesey R.E.	,,	,,	
Corps Signals	,,	,,	
5th Fld. Co.	2nd Div.	E.	
11th Fld. Co.	,,	,,	
1/1st East Anglian Fld. Co.	,,	,,	
2nd Div. Sig. Co.	,,	,,	
54th Fld. Co.	7th Div.	,,	
95th Fld. Co.	,,	,,	
1/2nd Highland Fld. Co.	,,	,,	
7th Div. Sig. Co.	,,	,,	No diary. Presumptive evidence.
63rd Fld. Co.	9th Div.	,,	
64th Fld. Co.	,,	,,	
90th Fld. Co.	,,	,,	
9th Div. Sig. Co.	,,	,,	
38th Fld. Co.	28th Div.	,,	
2/1st Northumbrian Fld. Co.	,,	,,	
101st Fld. Co.	,,	,,	
28th Div. Sig. Co.	,,	,,	
3rd Fld. Sqdn.	3rd Cav. Div.	,,	
3rd Sig. Sqdn.	,,	,,	
23rd Fld. Co.	1st Div.	,,	
26th Fld. Co.	,,	,,	

LOOS. 25th SEPTEMBER—5th OCTOBER, 1915.

Unit.	Formation.	E.	Remarks.
1/1st Lowland Fld. Co.	1st Div.	E	
1st Div. Sig. Co.	,,	,,	
73rd Fld. Co.	15th Div.	,,	
74th Fld. Co.	,,	,,	
91st Fld. Co.	,,	,,	
15th Div. Sig. Co.	,,	,,	
1/3rd London Fld. Co.	47th Div.	,,	
1/4th London Fld. Co.	,,	,,	
2/3rd London Fld. Co.	,,	,,	
47th Div. Sig. Co.	,,	,,	
55th Fld. Co.	Guards Div.	,,	
75th Fld. Co.	,,	,,	
76th Fld. Co.	,,	,,	
Guards Div. Sig. Co.	,,	,,	
69th Fld. Co.	12th Div.	,,	
70th Fld. Co.	,,	,,	
87th Fld. Co.	,,	,,	
12th Div. Sig. Co.	,,	,,	No diary. Presumptive evidence.
97th Fld. Co.	21st Div.	,,	
98th Fld. Co.	,,	,,	
126th Fld. Co.	,,	,,	
21st Div. Sig. Co.	,,	,,	
103rd Fld. Co.	24th Div.	,,	
104th Fld. Co.	,,	,,	
129th Fld. Co.	,,	,,	
24th Div. Sig. Co.	,,	,,	
3rd Co. 1st S. & M.	Meerut Div.	N.E.	
4th Co. 1st S. & M.	,,	E.	
Meerut Div. Sig. Co.	,,	,,	
81st Fld. Co.	19th Div.	,,	
82nd Fld. Co.	,,	N.E.	
94th Fld. Co.	,,	E.	
19th Div. Sig. Co.	,,	,,	

PROFESSIONAL NOTES.

THE VICTAULIC PATENT PIPE JOINT.

Communicated by the R.E. Board.

The Victaulic pipe joint was described briefly in the *R.E. Journal* in 1921 (Vol. XXXIV, No. 5, p. 230); since that time the construction of the joint has been slightly modified, and it is now accepted throughout the tube trade.

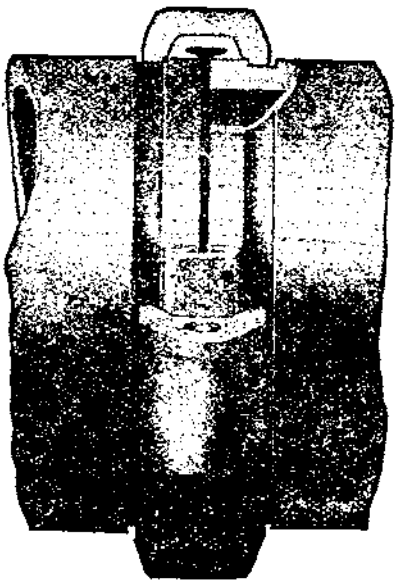


Fig. I. (a).
The Victaulic joint in part section; showing tubes with grooved ends.

The halves of the housing are now bolted together (before they were tapered on the outer diameter and retained by a keep-ring with a taper bore), but the essential "leak-proof" ring remains.

This ring, shown in Fig. I (*a*) and (*b*), has flexible inturned lips which are stretched on to the pipes and sealed by the internal fluid pressure; a supplementary grip is also exerted by the tightening of the housing.

Tubes for use with the joint have expanded or grooved ends, as shown in the sections Fig. I (*a*) and (*b*); they are supplied by the leading tube makers. Thin gauge tubing, in sizes up to 3", can be expanded by hand—without pre-heating—with a portable tool supplied by the Victaulic Company. This is useful for making up lengths *in situ*.

Thick tubing may be grooved. The groove is shallow and about the same depth as an ordinary screw-thread; there are portable tools for this operation, and sizes up to 12" bore can be grooved by hand, each tool generally having a range of about 2". For any particular size

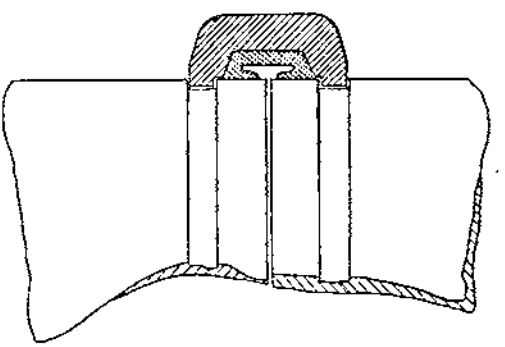


Fig. I. (b).

of piping the housing differs slightly for expanded or grooved ends, on account of the variation in the diameters of the seating for the housing.

The shoulders of the tube, clearly shown in Fig. I (*a*) and (*b*), are loosely engaged by the housing. Clearance is provided radially and longitudinally so that, whilst still coupled positively together and with the flexible leak-proof ring sealing the joint, the pipe-ends can move longitudinally or make an angle, one with another.

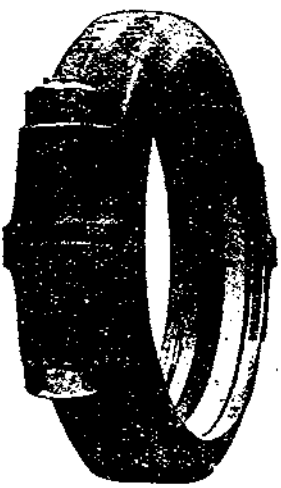


Fig. II.
A typical Victaulic Joint

The joint needs no skilful fitting or adjustment. The seal does not depend upon tightness, as the joint is self-sealing; the degree of tightness is, therefore, independent of the skill of the fitter.

This simplicity of fitting saves a great deal of time when laying pipe-lines. In an emergency 400 yards of $2\frac{1}{2}$" tubing have been laid at night by the light of oil lamps, the line being laid *and in use* in less than an hour. Further, the men who volunteered for the work are understood to have never seen a Victaulic joint before. The illustration (Fig. V), shows the flexibility of the line, to which is due, of course, a great deal of the saving in time, owing to there being no need for accurate alignment of the tubes. The flexibility is more clearly seen in Fig. VI, which shows a cast-iron main laid in a trench, and in Fig. IV, where the pipe-lines, laid in oil-fields, have been laid under conditions analagous to emergency service in the field.

A length of damaged pipe is very easily replaced, the time required being very much less than for screwed pipes; hence, on active

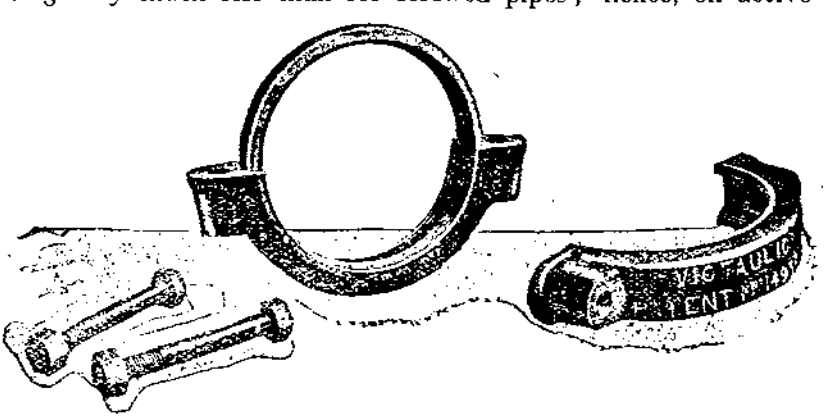


Fig. III.
Showing the parts of the joint.

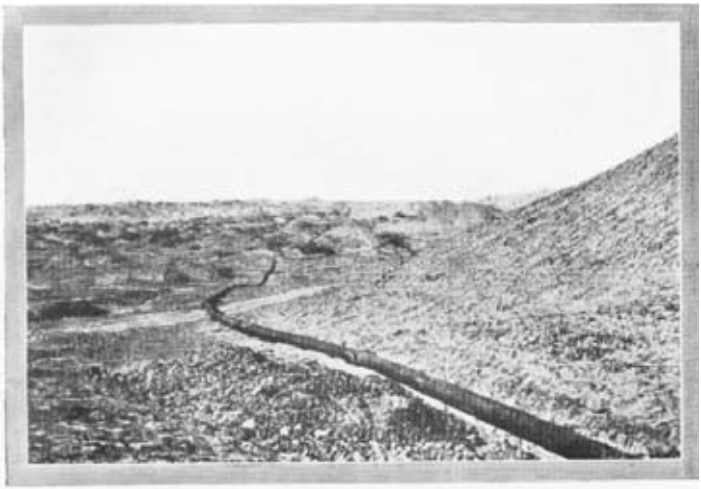


Fig. IV.

6" line carrying natural gas at pressures up to 250lbs. per square inch on the Peru oil-field of the London & Pacific Petroleum Co. (Standard Oil Co. of New Jersey). Other lines carry oil and salt water.

Fig. V.

At this colliery, 400 yards of 21" were laid in less than an hour—by men who had never seen a Victaulic joint before. The occasion was an emergency, and the men were working in the dark.

Fig 1V & V

Fig. VI.

This photograph shows Victualic joints fitted on a 5in. cast iron main at the Harton Coal Company's Whitburn Colliery. It illustrates how the joints permit the pipes to be laid without any special alignment.

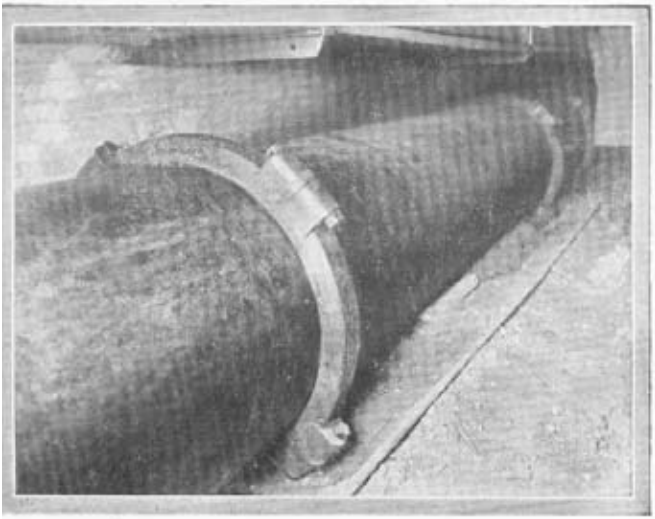


Fig. VII.

A 30in. main laid in a tunnel by the Metropolitan Water Board. Pressure 90 rounds; test pressure 170 pounds. In this case the housing is made in four parts to facilitate manufacture and fitting.

V1 & V11

service where damage to water-supply systems is sometimes very considerable, Victaulic joints would be very advantageous.

The flexibility of the Victaulic joint is not only of assistance when laying the pipe-line, but also preserves it against damage by the effects of subsidence and vibration; the joint is, in fact, used in some 350 collieries in this country, because of being proof against movement of the ground.

Fittings for use with the joint have the same typical "ends" as the tubes and pipes, and the system is rapidly and easily built into complete systems of any desired degree of complexity, owing to the simple interchangeability of the parts.

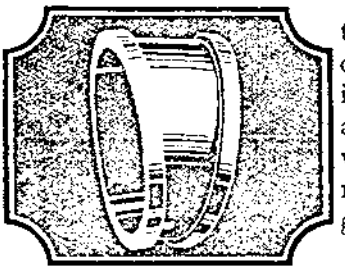


Fig. VIII.
The setting piece

The setting piece (Fig. VIII) enables the direction of a pipe-line to be changed to a slight extent. It is used, in particular, for avoiding obstructions and for laying a line on uneven ground without robbing the joints of that reserve of flexibility which is their safeguard against subsidence.

Victaulic hose-couplings are also supplied; the principle is identical with the Victaulic pipe-joint, and an instantaneous and leak-tight coupling is made between lengths of hose, machines or mains.

The adaptability of the Victaulic joint, with its appropriate fittings, is shown by its recommendation by Messrs. Armstrong-Whitworth—who hold the Marine rights—for such intricate and close-built pipe-systems as those on board-ship.

The address of the Victaulic Company, Ltd., is King's Buildings, Dean Stanley Street, Millbank, S.W.1.

RAPID HARDENING PORTLAND CEMENT.

A recent development in structural work on which the engineer should keep his eye is the production of a rapid hardening Portland cement (not to be confused, of course, with "quick setting" cements). As soon as *Ciment Fondu*, the new aluminous cement, appeared on the scene from France, and had proved its immense superiority in the direction of rapid hardening over any Portland cement that was then available, it was at once clear to everyone that, in spite of its price, it was bound to sweep the board whenever time was the essence of the contract. It is obvious that in concrete work the upper parts of high buildings cannot be poured until the concrete below has set, pile driving cannot begin until the piles are mature, repairs to roads are a formidable affair if weeks have to elapse before traffic can run

over the new surface, and if, by any chance, we should see another war of position the sooner a concrete dug-out hardens sufficiently to stand shell fire the better—there is no need to labour the point.

It is, therefore, a matter of interest to note the advent of a new cement called "Ferrocrete" (Rapid Hardening) Portland Cement, which claims to have the same strength at two days that ordinary Portland cement is generally assumed in calculations to have at 28 days.

In Table I below are given comparative results of the ordinary laboratory tests on mortar briquettes and concrete cubes made with both Ferrocrete and ordinary Portland cement.

TABLE I.—LABORATORY TESTS.

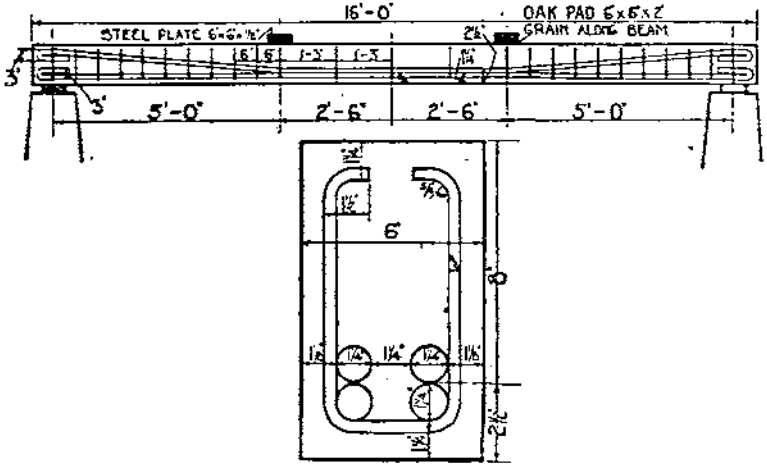
	Fineness Residue on sieve of 32400 meshes per sq. inch.	Setting Time. Initial. hr. mins.	Setting Time. Final. hrs. mins.	Soundness. Le Chatelier Test. 24 hrs.	Tensile Tests in lbs. per sq. inch. 3 parts Sand, 1 part Cement. 1 day.	2 days.	3 days.	5 days.	7 days
"Ferrocrete" (Rapid-Hardening) Portland Cement	0.3%	1 10	2 20	1 mm.	312	516	583	611	688
Ordinary Cement ..	6.05%	1 50	3 30	1 mm.	117	218	354	405	432

COMPRESSION TESTS IN LBS. PER SQUARE INCH—6-IN. CUBES.

4 parts Ham River Ballast, 2 parts Ham River Sand, 1 part cement.

	1 day.	2 days.	3 days.	5 days.	7 days.	28 days.
"Ferrocrete" (Rapid Hardening) Portland Cement ..	1,750	2,910	3,853	4,840	5,360	6,810
Ordinary Cement	—	—	—	—	2,860	4,140

While laboratory tests on small specimens are of undoubted value, they are not always entirely convincing to practical engineers; and the firm producing Ferrocrete cement has, therefore, had a number of full size reinforced concrete beams constructed and tested by an independent authority. The design of these beams is shown in the drawing given below.



DESIGN OF TEST BEAM.

The test load was brought to bear at two points, each one-third of the way along the beam, i.e., one half of the total load at each point.

The extremely high proportion of steel should be noted. This is, of course, for the purpose of ensuring that the concrete shall fail under test before the steel has reached the elastic limit.

The result of tests to destruction on these beams is given in Table II below.

TABLE 2.—TESTS OF REINFORCED CONCRETE BEAMS.

Cement.	Approx. Age of Beam.	Breaking Load in lbs.	Approx. Max. stress in concrete calculated from usual formulae. Lbs. per sq. in.
	hrs.		
"Ferrocrete"	52	13,970	3950
Ditto	53	14,990	4250
Ordinary	54	3,700	1250
Ditto	54	4,130	1350
	days.		
"Ferrocrete"	4	10,680	5500
Ditto	4	13,600	5200
Ordinary	4	6,350	1950
Ditto	4	6,860	2100
"Ferrocrete"	7	20,900	5800
Ditto	7	22,545	6250
Ordinary	7	9,260	2700
Ditto	7	7,475	2250
"Ferrocrete"	14	24,500	6750
Ditto	14	24,240	6700
Ordinary	14	12,140	3500
Ditto	14	12,710	3650

The last column is not given on the authority of the people who made the test, but has been calculated by the writer by means of the ordinary formulae. How far these hold good with such a high steel ratio in a test to destruction is problematical. Taking them at their face value, however, they appear to show that the laboratory tests on small specimens are a very reliable guide. In any case, the rapidity of hardening of the new cement as compared with cements in general use, which is the main point at issue, is clearly proved. Ferrocrete cement is stated not to differ in chemical composition from ordinary cement; but to be a true Portland Cement, and to owe its special qualities to refinements in the process of manufacture. It stands, therefore, in much the same relation to the new aluminous cement, that an officer of proved worth, whose value has recently been greatly enhanced by a special process, such as at the Staff College, does to a Young Officer of exceptional promise who still has to endure the test of time.

Further details regarding the tests are obtainable from the January issue of *Concrete and Constructional Engineering*.

W. A. FITZG. K.

MEMOIRS.

COLONEL HENRY VERO BIGGS, D.S.O.

Henry Vero Biggs, the fourth son of Colonel T. Biggs, R.A., of Wrington, Somerset, was born at Belgaum, India, in 1860. When he was five years old his mother died of cholera and he also nearly succumbed to it. Twenty years later he had another attack of the same disease in Baluchistan. Returning to England from Belgaum in 1865, he was educated at a private school, and in 1877 he passed 5th into the R.M.A., and thence into the Royal Engineers.

During his two years at the S.M.E. he made friends by whose intercourse his faith in God was strengthened. He then purposed with God's assistance that his work in the army should be done as a duty to God first, and then to his country. From that purpose he never swerved.

After a year on the Thames and Medway Defences he was posted to the Bombay Sappers and Miners in 1883. He served with them on the North West Frontier in Baluchistan for 2½ years. His company was first employed on road construction in the Bolan Pass, but in 1884, when the Russian advance north of Herat was beginning to seriously threaten the frontier of Afghanistan, it was decided to build a permanent broad gauge railway to Quetta by the Hurnai Pass. Major General Sir James Browne (R.E.) was put in charge of the work, with Lieut. G. K. (afterwards Major General Sir George) Scott-Moncrieff as his personal assistant. Seven companies of Sappers and Miners, including Biggs' company, were sent to help in the work at one of its most difficult points in the Chappar Rift, where the railway passed by a series of tunnels and a lofty bridge through a precipitous gorge.

The railway was rapidly completed in the face of tremendous difficulties of transport, climate and disease, and through formidable engineering obstacles. In a wild scene of desolation named The Mud Gorge the shale soil was so hard that it had to be blasted, yet it literally melted when exposed to rain, and the whole railway slid down the side of the valley. In this work Biggs took his full share, in spite of a slight attack of cholera.

He also took part as a Field Engineer in the Zhob Valley Expedition, in which there was considerable hardship, though no fighting. On the outbreak of war with Burma in the autumn of 1885, Biggs joined the Expeditionary Force, and took part in much of the fighting before and after the capture of Mandalay.

Colonel Henry Vero Biggs, D.S.O.

Colonel Henry Vero Biggs DSO

In February 1887, he was invalided from fever and sciatica brought on by bivouacking in the jungle in heavy rain. He had then been four years continuously under canvas or in bivouac, except for short periods of leave.

On returning to India he decided to revert to garrison duty with the Military Works Department, in view of his impending marriage to the daughter of Colonel C. H. Ewart, B.S.C.; but it was not without many regrets that he left his rough, campaigning life, for " the call of the wild " was always strong on him, and a search for big game, the more strenuous the better, was his ideal of a holiday.

He made a special study of the science of ballistics, as applied to sporting rifles. At that time a .577 express was considered the smallest rifle which could be safely used with tiger. Biggs was convinced from calculations that an equally deadly weapon could be made with a smaller bore, using a higher velocity, and he got an express rifle made to his specification. His ideas have been embodied in modern rifles.

For the next ten years he was employed in the Military Works in various large cantonments. Whatever his work was he did with his might what his hand found to do. " His reports and plans were marvels of completeness." Nor were his interests confined to his own branch of the service. In spite of the very heavy work involved in the execution of extensive building and engineering works, he found time to keep himself abreast of all military questions.

Major General S. H. Sheppard writes of him: " I always looked on him as one of the straightest and most loyal men I have ever met, and there was no man I would sooner have had with me in a tight place whether in war or in the face of a charging tiger. He was a Spartan in many ways ; and, in the days when I knew him in India, as hard as nails ; and the keenest *shikari* I have ever known, especially after big game. No trouble was too great and no day was too long, if he was after a " warrantable beast." With all, he was singularly human, and a great lover of nature, and I could not have wished for a more delightful companion on the many walks aud small expeditions with gun and rod, that I so often had with him."

When the Frontier troubles broke out in 1897 he joined the Khyber Column from leave, but was recalled ; but shortly afterwards he was appointed Adjutant with the Tirah Expeditionary Force.

He was present at Dargai, where after other attacks had failed, the Gordon Highlanders stormed the position in old fashioned style, to the tune of the bagpipes.

The enemy never " faced the music," again, but our columns were persistently and heavily sniped by men who were past-masters in scouting and shooting. It was not until our troops learned to play the enemy's game that we really got on terms with them. For

his services in this campaign Biggs was mentioned in dispatches, and received the D.S.O.

His C.R.E., Colonel Thurburn, writes: "I looked upon him as one of the best officers I ever served with. In the intimate relations which existed between us during the campaign I never once knew him put out at any of the many difficulties we had to encounter, but he was always ready with some idea for overcoming them. His energy was enormous, and no amount of physical exercise seemed to tire him."

After a year at Chatham, he was given charge as C.R.E. of many important works at Rawal Pindi and on the Frontier. In 1906 he officiated as A.A.G. R.E. at Army Head Quarters, Simla, for 7 months, with a view to permanent appointment; but he then, at his own request, was transferred to the 5th (Mhow) Division as C.R.E.

After 1½ years' furlough and sick leave in 1908-9, he returned to Rawalpindi as C.R.E., whence he made two shooting trips into Kashmir. He was promoted substantive Colonel in 1910. In 1912 on taking furlough, he was informed that if he returned to India he would be offered an important military command, but he decided for family reasons to retire. In 1914, on the outbreak of war, he immediately offered his services, and was posted as C.R.E. Exeter. His district covered five counties, in every part of which there were urgent and extensive works to carry out. The stress of the work was very great, but it was all done quickly and well, for he knew how to trust the subordinates who served him well, and was always loyal to them. He therefore got the best out of them. Perhaps this was also his one weak point, for occasionally, it may be, he trusted a subordinate too much. Being always actuated by the highest sense of duty himself, he found it impossible to believe that any who had served him well might not always be influenced by the same motives.

In spite of a temporary breakdown through overwork, he served in this arduous appointment throughout the war.

The rest may be told in a delightful description of him by Major-General Sir Francis Bond.

"In the passing of Henry Vero Biggs, I like many others, have said good-bye on earth to a true and valued friend. It is 32 years now since we first met in Secunderabad, whither he had come to take over from me the office of Executive Engineer of the Military Works. From the first I was impressed with the modest, quiet, steadfastness of his purposeful character. The 32 years since have confirmed and increased the respect I then conceived for him and his work, and have given me an unvarying friendship which he never allowed to flag or diminish.

"In later years, when we had grown old in the service, it was my

good fortune to be put over him in an appointment, to which my previous record would hardly have entitled me; but the receipt of a most charming letter of welcome from my old friend, with others of a like nature from brother officers, gave me a happiness, which only those who have felt the true friendship of our Corps can rightly value. I had then many opportunities of seeing his work again, and of sharing in the quiet happiness of his home, when staying with or near him. His work was always of the highest order and of most extraordinary thoroughness in every detail, evincing the method and care he bestowed on his every pursuit.

"Biggs, as a soldier, should have gone to a far higher place, but he never pushed his claims, nor attempted to obtain promotion or credit for the work he did. As a sportsman he was *facile princeps* of all whom I have ever met. A great student of ballistics, as his published papers show, he arrived in India with theories of his own, which he was eager to prove. At Mount Abu, soon after his arrival, he wanted above all things to decide whether he was right in believing that to stop a charging tiger with a hollow bullet, it was necessary to let him come within 6 yards from the muzzle of his rifle. His theories made people regard him as almost a dangerous lunatic, but they soon changed their minds.

"Going out alone with a *shikari* to a place where a tiger was located, he arranged to have the animal beaten out to him, while he placed himself standing on foot under a single palm tree in the open. The tiger came out and was passing by, but catching sight of the sportsman as he looked round, he charged. I have seen the skull and skin of the great tiger, with the bullet straight between the eyes. The *shikari* said that as the tiger fell head over heels at his feet the *sahib* took a measuring tape from his pocket and quietly measured the distance, saying "Yes, 6 yards."

"How on another occasion he crawled into thick scrub after a wounded leopard and finished him in the same way, is only one of many stories told of him. Out of one rocky hill alone near Secunderabad he got five leopards, which he pursued on foot. Many tigers fell to his unerring aim. He was a man of extraordinary courage, self reliance and rare purpose, with behind it all a strong faith that served him to the end, in the last days of his painful illness.

"For some time our friendship has been renewed, when we were both on the shelf; and looking back over the long range of years, I see always the picture of a true, loyal and steadfast man, unswerving in his purpose of seeing the right, and of doing it without thought of self.

"Biggs was a whole hearted Sapper of whom the Corps may well be proud."

J. A. GIBBON.

COLONEL BERTRAM HOPKINSON, C.M.G.

M.A. (Cantab.), B.Sc. (London), F.R.S. Cambridge University Officers' Training Corps att. Royal Air Force.

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Bertram Hopkinson was the eldest son of John Hopkinson, D.Sc., F.R.S., Major, Royal Engineers (Volrs.), President of The Institution of Electrical Engineers in 1890 and 1898, the eminent electrical engineer, and of Evelyn, his wife, of "Ellerslie," Adams Road, Cambridge (b. at Woodlea, Birmingham, January 11, 1878).

He was educated at St. Paul's School, London (1886-1891) where he had a brilliant career; he was elected a Foundation Scholar in September, 1886, and gained several class prizes during the years 1886 to 1891, and also the Smee Prize in 1888. He took a First Class in the Matriculation Examination of the London University in January, 1890, and, at the age of sixteen and a half years, won a Major Scholarship at Trinity College, Cambridge, but did not enter the University at once. He also gained a leaving Campden Exhibition in 1891.

On leaving school, he spent a year under his father at the Engineering Laboratory at King's College, Strand, London, and then proceeded to Trinity College (1892-1896). Whilst at Cambridge he won the Perry Exhibition in 1892; he also passed the Intermediate Examination for the Degree of Bachelor of Science of the University of London in 1893, gaining 1st class honours in Mathematics and Physics; he won a London University Exhibition and graduated a Bachelor of Science in that University in 1894, gaining 1st class honours and the University Scholarship in Mathematics. He graduated as a Bachelor of Arts of the University of Cambridge in 1895, and, on the termination of his course there, obtained a First Class, First Division, in Part II of the Mathematical Tripos, and was honourably mentioned for the Smith's Prize. He was admitted to the Degree of Master of Arts in 1903.

He joined the Inner Temple as a student in the Trinity Term of 1895, and having passed the Bar Final Examination, was called to the Bar by the Benchers of his Inn in the Easter term of 1898, when he at once began to practise as a Barrister-at-Law in London. In the summer of the year last mentioned he was on his way to Australia to obtain evidence on commission, when the tragic death of his father, his brother and two sisters whilst mountaineering in Switzerland, changed the whole course of his life. He returned immediately to this country, abandoned his career at the Bar, and joined in partnership with Mr. Charles Hopkinson, his uncle, and Mr. E. T.

Talbot, his father's valued assistant, and began to practise as a Consulting Engineer; he was responsible with these two gentlemen for the design of the tramways in Liverpool, Newcastle-on-Tyne and Leeds, for the electric lighting scheme at St. Helens, and for the electric supply schemes at Crewe, Ealing, Faversham and Sale.

The adoption of the course which he pursued required high courage and rare adaptability, both these qualities he possessed in abundance. The step he took was possible perhaps only by reason of the fact that he had absorbed a good deal of engineering during his intercourse with his father, with whom he had been a close companion. He not only succeeded in the practical aspect of his new profession but soon found in it material for scientific research. The three partners read a Paper in 1902 before the Institution of Civil Engineers on "Electric Tramways," in which, *inter alia*, particulars of his experiments in electrolysis were given; for his contribution to this Paper he was awarded the Watt Gold Medal by the Council of the Institution of Civil Engineers.

He was appointed to the Chair of Mechanism and Applied Mechanics in the University of Cambridge in 1903, and took up his duties in the Michaelmas Term of that year. The appointment involved his assuming the charge of the Cambridge Electrical School, which had under his brother-in-law, Professor Alfred Ewing, F.R.S. (afterwards Sir Alfred Ewing, K.C.B.), by that time become an exceedingly important section of the University. He now found a wider scope than had been open to him previously, for research work, and at once entered upon a period of remarkable productivity. The development of the gas-engine and other internal-combustion engines appealed strongly to him, he invented an optical indicator which proved itself to be a most effective instrument for revealing what happens in the cylinder of such engines. He investigated problems of heat, flow and temperature distribution; he also gave much time to the study of gaseous explosions, the devices used in this research were of great ingenuity, and the experiments were prosecuted with conspicuous thoroughness. He also invented a new type of torsion meter for the measurement of horse-power, which was widely used with great success. He contributed many valuable papers to the Royal Society, The Institution of Civil Engineers, The Iron and Steel Institute and the British Association; for a paper on "Heat-flow and temperature-distribution in the gas-engine," read before The Institution of Civil Engineers in 1908, the Council of that Institution awarded him the Telford Gold Medal. His published works included a memoir of his father, written as a preface to the reprint of John Hopkinson's Collected Papers, as well as many accounts of his own researches.

He took a leading part in the work of several Research Committees; *inter alia*, he served jointly with Mr. Dugald Clerk, D.Sc., F.R.S.

(afterwards Sir Dugald Clerk, K.B.E.), as Secretary of the British Association Committee on Gaseous Explosions; he was an original member of the Advisory Committee set up in connection with the establishment of the Department of Scientific and Industrial Research; he acted as Secretary to the Committee of Engineering Experts appointed by the Royal Society to advise on problems of the Great War; he served on the panel of Lord Fisher's Board of Invention and Research.

He took a keen interest in the Volunteer movement, and early in his career joined the Volunteer Force. He was given a Commission in the Royal Engineers (Volunteers) in March, 1896, and posted to the Submarine Miners (The Tyne Division); he was promoted Captain in August, 1897, and transferred to the branch of the Corps known at the time as "The Electrical Engineers," a unit of the Royal Engineers (Volunteers), which was raised by his father, who was its first commanding officer. He received promotion to the rank of Major in the branch last mentioned in September, 1903. On the re-organization of the Electrical Engineers in June, 1907, on a divisional basis, he was posted to the London Division. On the creation of the Territorial Force under Lord Haldane's Re-organisation Scheme in April, 1908, he was transferred to the Unattached List of this Force, and, in January, 1909, was posted to the Cambridge University Officers' Training Corps. He did much to promote the interest of the Corps, and, on his initiative, the Military Authorities formed No. 1 Fortress Company of the Engineer branch of the University Corps, a unit of which he became the first Commanding Officer.

On the declaration of war in August, 1914, he was mobilised and relinquished his ordinary activities; he was appointed Instructor in Field Fortification at the School of Military Engineering, Chatham, on October 11, and held this appointment until the spring of 1915, when he went to the Admiralty to undertake important work on wireless telegraphy. Whilst employed at Whitehall, he became a member of the various technical committees as they were formed by the Board of Admiralty and during the period of his service under the Board, devised a means of protecting ships against torpedo attack.

In November, 1915, he received an appointment as Staff Captain in the Aircraft Equipment Directorate of the War Office, being employed under the Director-General of Military Aeronautics, and thus was established his first official connection with the Royal Flying Corps. He became responsible for both the design and supply of bombs, bomb-gear, guns and ammunition. A great part of the experimental work for the Flying Corps was at the time being carried out both at the manufacturers' works as well as at the central Flying School, Upavon (Wilts.). The combination of experimental and

training work at one station had many drawbacks; he therefore urged the formation of a separate station for the experimental work. His recommendations having been accepted, an armament experimental station was brought into existence at Orfordness, Suffolk, in the spring of 1916, and, in the March of the same year, he was promoted to the appointment of a Deputy Assistant Director in the Aircraft Equipment Directorate, the work at the new station being placed entirely under his control. He was now released from responsibility for the Supply Section at Headquarters, and, in consequence was able to devote himself to purely experimental work. This work was very varied in character, and the data thus obtained had a marked influence on the development of the armament of the Royal Flying Corps, and its successor the Royal Air Force. Towards the end of 1916, the testing of aeroplanes, which had hitherto been carried out at Upavon, was placed under his immediate direction and removed to Martlesham Heath, Suffolk.

The Air Board was reconstituted in January, 1917, and, in the November following, he was transferred to this Board in the position held by him at the War Office (Deputy Assistant Director). The re-organization introduced by Lord Rothermere at Headquarters at the end of 1917 still further increased his responsibilities, owing to the work at the Aircraft Experimental Stations in the Isle of Grain being transferred to his control. The fusion of the naval and military Air Services, which resulted in the creation of the Royal Air Force, took place in April, 1918; in the June following, he was appointed Deputy Controller of the Technical Department (Aircraft Production) at the Headquarters of the Air Ministry, and was at the same time given the rank of Lieutenant-Colonel. He was transferred to the Ministry of Munitions in May, 1918; he retained control of the work upon which he was engaged (Aircraft Production) and was given the temporary rank of Colonel, whilst so employed.

He considered it his duty to learn to fly, although he was over 40 years of age; he was soon at home on many types of machines. The fact that he had acquired the skill to fly undoubtedly increased his influence, especially over the officers at the Experimental Stations, and, at the same time, added to his judgment. He took an intense pleasure in flying, and, as far as possible when paying official visits to the stations under his control, travelled to them by air. On the morning of August 26, 1918, he started in a Bristol Fighter from Martlesham Heath for London. The weather was threatening and the clouds were low at the time; as he approached London the conditions were most unfavourable and the sky became completely covered with low lying clouds. It is presumed that, in descending through these clouds, he must have lost control over his machine, and probably had not sufficient height in which to recover. His

machine "crashed" near Hainault Farm, Paston, Essex, and in the fall he was killed, probably instantaneously.

For his distinguished services in the War, he was created a Companion of the Order of Saint Michael and Saint George (*London Gazette*, January 24, 1917), and his name was brought to the notice of the Secretary of State for War (*London Gazette*, January 25, 1917). Age 44 years 7 months.

* * * * * * *

He possessed an obviously forceful personality, yet a notable characteristic was his unruffled kindliness and serenity in the most trying circumstances. He was at all times a cheerful comrade, and quickly won the liking, confidence and respect of all with whom he came into contact.

In his memory and that of his brother Cecil, who died of wounds received in Flanders towards the end of 1915, there has been founded by members of the family and friends, at Cambridge University, 'The Hopkinson Lectureship in Thermo-Dynamics," a Lectureship which will, no doubt, be eventually converted into a Professorship.

He married, at St. Mary Abbots Church, Kensington, on December 31st, 1903, Mariana Dulce, the eldest daughter of Alexander Siemens of Campden Hill Court, Kensington; he is survived by his widow and a family of seven daughters.

He was elected a Fellow of the Royal Society in 1910, and was serving on its Council, to which he was elected in November, 1917, at the date of his death. He was elected a Member of the Institution of Civil Engineers in December 1904, and a Member of The Institution of Mechanical Engineers in the same year. He had become an Associate Member of the Institution of Electrical Engineers in 1897, a Member in 1903, and was a Member of its Council 1914-16.

Colonel Bertram Hopkinson CMG

BOOKS.

WAZIRISTAN 1919-20.

By H. DE WATTEVILLE, B.A. OXON., *p.s.c.*, late Lt.-Col. R.A. and General Staff. (Constable and Co., Ltd. Price 10/6.)

In his acknowledgment the author confesses to never having served on the North West Frontier of India. In spite of this handicap, he has succeeded in drawing a very accurate picture of the country in that part of the world and of the fighting that took place in it.

Not the least interesting part of the book is contained in the first four chapters which describe the country, its people and its history since the first Waziristan campaign in 1860, as well as the events leading up to the inception of the 1919 campaign. These chapters deserve close study by all who are interested in the politics of the North West Frontier of India; in them are described, clearly and fearlessly, the factors which have made for trouble in the past, some of which have still to be counted with, such as the miserable economic conditions at home which drive the Mahsud to raiding as a livelihood, the activities of the Soviet government in Afghanistan and the persistent intrigues against British interests in Waziristan by the Afghans. The obvious lesson, which is the keystone of the present policy of the Government of India, is admirably stated on page 10 in the words "the enforcement of more peaceful modes of life in Waziristan had long shown itself to be essential if India was to be considered secure against Afghan machinations among these wild people." Chapter III contains a summary of the various military operations carried out in Waziristan from 1860 up to the close of the Great War, and it closes with a reasoned appreciation which clearly shows the futility of attempting to achieve permanent results by means of what is colloquially termed the "burn and scuttle" frontier expedition. Control of the country from within its borders was an obvious, if costly, solution of the problem, and the late Lord Curzon's policy of garrisoning places like Wana and the upper Tochi Valley with tribal militias showed the first beginnings of giving such a policy a trial. That this policy broke down in 1919 at the time of the 3rd Afghan War, was not due to its inherent weakness, but to the methods adopted of putting it into practice. The tribal militias were located in the right places, but the proximity of reinforcements of regular troops was and is a *sine qua non*, if these irregular troops are expected to remain loyal in time of trouble. Chapter IV describes clearly how and why these tribal militias failed, and the state of lawlessness that ensued all along the Bannu and Derajat border. Between the outbreak of the Afghan War in May, 1919, and the beginning of November of that year, nearly 200 raids had been carried out by the Wazirs and Mahsuds into British India; these had resulted in nearly 300 military and over 600 civilian casualties, not to mention the looting of large quantities of cattle, stores and money. The chapter ends with the significant words that "The time had now come for recourse to drastic measures for terminating this unending catalogue of violence and depredation."

The action which the Government of India decided to take is outlined in Chapter V, and it is interesting to note that in the first instance there was no declared intention of permanent occupation being the ultimate objective of the Expedition. The exaction of reparations, and the construction of roads within the "protected area" were amongst the more important terms that were placed before the tribes concerned, and it was estimated that the enforcement of these terms would involve three separate military operations, viz., against the Tochi Wazirs, the Mahsuds and the Wana Wazirs, which were to be undertaken in the order named. For this purpose the Waziristan Force (which had been in existence for some months) was raised by the middle of November, 1919, to a strength of nearly 30,000 combatants and 35,000 non-combatants. These figures were subsequently increased to 41,800 and 37,900 respectively, but it is interesting to note that the "striking force," i.e., that portion available for action at the head of the L. of C., barely amounted to 8,500 combatants and 6,500 non-combatants, so great were the demands for L. of C. protection and supply. The remainder of this chapter gives interesting details on the subject of L. of C. organization and transport which constitute the main administrative problem of a frontier expedition.

The submission, without fighting, of the Tochi Wazirs simplified matters by enabling earlier action to be taken against the Mahsuds, and this submission of the Wazirs has an important bearing on their friendly attitude during the Razmak operations of 1922-23.

Chapter VII deals with the projected campaign against the Mahsuds and contains interesting discussions on the alternative lines of advance, the plans of operations and the policy to be adopted towards the Mahsuds. In this the author deals very clearly with the ultimate objective "which would satisfy the purposes of the Expedition," and logically arrives at the conclusion that nothing short of some form of permanent occupation of the country will achieve lasting results. This is the conclusion to which, after considerable vacillation, the Government of India eventually brought itself round. This Chapter is worthy of close study by those who are likely in the future to be confronted by similar problems.

Chapters VIII to XII deal with the actual operations in the Takki Zam (or as the author calls it, the Tank Zam) and the advance to Makin and Kaniguram. The fighting is well described and no attempt is made to minimise the defects from which the Indian Army was suffering at the time. The successes of the Mahsuds in the opening stages of the campaign in December, 1919, are described and the reasons of the failure of the Indian troops (for there were no British infantry present) are analysed. The reasons for these failures are not far to seek, being almost entirely due to lack of training. It must be remembered, in all fairness to the Indian Army, that since the Armistice it had, in a very large measure, carried on the policing of the Empire. The disbandment of the British Army had begun soon after the Armistice, and the re-constitution and training of its regular units had not, by the end of 1919, gone very far forward. The old and new units of the Indian Army were therefore carrying on, all over the world, work which, in part at any rate, should have fallen to the share of their British comrades. The increase in numbers of the Indian Army during the war, coupled with the loss of

practically all their original captains and subalterns, had left units in a low state of efficiency; many of the officers who had joined the Indian Army during the war were unable to speak the language of their men, and in consequence could not train them properly. The continual demand for more units meant insufficient individual training for the recruit, who, on joining his unit, often hardly knew how to load his rifle, still less how to fire it. It is not surprising then that some units, especially those drawn from the less warlike races of India, failed, and failed badly, when faced by the Mahsud, who combines great personal bravery with astonishing skill as a skirmisher. It is to the lasting credit of the Commander of the Derajat Column and of the British officers and Indian troops under him, that, starting with such a handicap,they succeeded in the end at defeating the Mahsud at his own game.

The most interesting features in the fighting in the Tank Zam were the co-operation of aeroplanes, the institution of permanent piquets for guarding the L. of C. and the employment of night advances to secure difficult ground—these are worthy of the close attention of students of frontier fighting. Chapter XIII deals with the operations against the Wana Wazirs in the Autumn of 1920; and Chapter XIV deals with the Razmak operations of 1922-23. The chief interest in the latter Chapter lies in the obvious improvement which had taken place in the fighting spirit and efficiency of the Indian Army since the beginning of the 1919 campaign; the author, however, fails to bring out the fact that the friendliness of the Wazirs materially assisted the British forces during these operations. The advance from the Tochi into the Khaisora Valley and thence on to the Razmak plateau took place through Wazir territory. Not only was there no fighting until Mahsud territory was reached, but the Wazirs actually assisted the regular troops in piqueting the route, and in finding escorts for the R.E. officers who preceded the column when engaged in reconnoitring the alignment of the motor road, the construction of which was one of the main objects of the Razmak Expedition.

The book concludes with chapters on "Modern artillery and military armament in frontier warfare," on "Aircraft in frontier warfare," and on the "General lessons of the Campaign of 1919-20." All three are well worthy of study, and the pith of the last chapter is contained in the following sentence, the truth of which is perhaps not as fully realised as it should be:—

"So it comes about that in operations of this nature the bludgeon methods applicable to mass fighting must yield to the finer art of individual combat. But even a high pitch of training adequate for warfare on the plain is hardly sufficient for this class of fighting. The soldier required for frontier warfare must be trained for the end in view."

The author has a pleasant style which makes his story easy to read; his criticisms are made in a very fair spirit, and he deduces sound lessons. The book is illustrated with air photographs, the oblique ones of which give an excellent idea of the type of country in which the fighting took place. There are one or two mistakes in proper names in the text:—for instance, on page 47 "General Matheson" should read "General Malleson." On page 36, the objective of the 1917 operations is stated to have been the Khaisora Valley; this should be spelt Khaisara, which is the name

of the stream in Southern Waziristan which eventually drains into the Shahur Tangi. The Khaisora is situated in Northern Waziristan and constitutes one of the main drainage systems immediately south of the Tochi River. These names are confusing in their similarity and the mistake is perhaps not unnatural.

The book forms a valuable addition to our none too large stock of literature on frontier warfare, and is one which all soldiers should study.

J.R.E.C.

PARIS, OR THE FUTURE OF WAR.

By CAPT. B. H. LIDDELL HART. (Kegan Paul.) 2/6.

WHEN a member of a profession writes on a professional subject for general consumption, his public, if themselves not well informed, are inclined to take all the statements and arguments as to a certain extent inspired. There rests on the author therefore a grave responsibility, and he should be careful that his statements are accurate and fair, and his conclusions sober and just. Captain Liddell Hart in his position as journalist apparently has forgotten the responsibility resting on him when he retains the military title of Captain. It is a pity that he allows his journalistic hyperbole to spoil a case with much of which every thinking soldier is in agreement. In enthusiasm over his subject the author loses perspective, and makes statements which will hardly bear cold investigation.

The attack is opened by a diatribe against the principles of war as the author imagines them accepted by the "military pundits" of the day. His references give an inaccurate impression of phrases of the regulations, which he entirely divorces from the context, and from the spirit exhibited on every page of the manuals of various military powers. For example, we are told that in the words of *Field Service Regulations*, the accepted military objective in war is the enemy's main forces on the battlefield. The author is endeavouring to show the blindness of the soldier to the moral objective, forgetting, or possibly not having read, the neighbouring paragraph which describes the first duty of the general staff as being "to appreciate the course of action which . . . . . will most rapidly influence the enemy people in the required direction. This demands . . . . . a careful study of the psychology of the enemy people, of their national characteristics, resources, and means of existence." Such a travesty of facts will be patent to the military student, but is mischievous in the hands of a less informed public.

To gain some idea of the author's ideal military brain it is amusing to note his attacks on the "military pundits" from "the Corsican vampire who drained the blood of Europe a century back," through Clausewitz "whose house was built on sand," to Marshal Foch who, among certain better qualities, displays "the recurring delusion of the military mind that the opposition to the Napoleonic theory must necessarily be dictated by mere sentimentalism." On the other hand he appears to laud the dictum of Marshal de Saxe, "I am not in favour of giving battle . . . . . I am even convinced that a clever general can wage war his whole life without being compelled to do so"!

Having stressed the importance of the moral objective supported by the untenable hypothesis that the influenza epidemic of 1918, which he forgets struck America as seriously as any other nation, was due to years of strain and want, he passes on to the means by which the objective may be obtained. Though his criticicisms are mostly directed against military authorities, the means suggested are chiefly in the hands of the statesman rather than the soldier.

The author proceeds to examine the various arms, and the section referring to the future of air power is one of the best and most convincing in the book. He considers that sea and land weapons will only remain effective till the air weapon reaches maturity. In the meantime discussing naval and military power, he draws attention to the serious menace which the submarine fleet of France, coupled with an unfriendly Ireland, might prove.

With regard to the Army the author adds little to the views expressed by military leaders and writers of all countries as to the future of cross country movement. The importance of rapidity, and freedom of movement, of armoured vehicles is almost axiomatic. After discussing the economic aspect of war in the earlier pages of the book, and stating in the epilogue that " future wars will be waged by weapons which are the products of peace time industry," it is somewhat difficult to see how the huge amount of cross country transport necessary is to be provided, till the track vehicle is on demand in civil life.

The book which, as has been shewn, needs not the skill of a Paris to discern its vulnerable points, may be read with amusement and a certain amount of interest by the informed mind. In the hands of a less informed public it may achieve its presumable object of producing a terror of war in the future, but may also it is feared produce an impression that the ideas of military leaders are in a state of complete stagnation, which is altogether unjustified.

R.P.P.-W.

LA GRANDE GUERRE SUR LE FRONT OCCIDENTAL. VOL. XI. Bataille de la Somme (1 Juillet, 1916—1 Janvier, 1917) par le Général PALAT. (Paris: Berger Levrault.) 20*fr.*

THIS volume is not up to the standard of the preceding ones. The narrative is somewhat slight and the more difficult to follow as only one general small scale map for the Somme is provided; it includes the latter part of the operations at Verdun—very properly, as they are dependent on what happened at the Somme. There is little information from German sources except extracts from the *communiqués* of the time. The account of the British operations is derived mostly from Sir D. Haig's despatches. Time after time the author emphasises the perfect accord between General Joffre and the British Commander-in-Chief and their respective staffs; and he makes the point that there was unity of command without having to resort to a written protocol, which the politicians introduced in 1918 in the hope of persuading the public that they had a share in winning the war.

The chapter dealing with the continued efforts of the parliamentarians—eventually successful—to oust Generals Joffre and Foch from their posts,

and substitute for them generals more subservient to parliamentary control, is particularly interesting and full.

General Palat, relying on German information, states that the British bombardment at the opening of the operations had very little effect, and speaks of the battle as an "apprenticeship for the unexperienced British troops." Engineers are not mentioned from first to last; there is one short paragraph on preparations, in which he refers to the improvement and making of roads, and to water difficulties. "The British alone installed more than a hundred pumps and more than 120 miles of water-pipes." There is mention of mud and in one place of duck boards. But there is no hint that the operations were most seriously affected by lack of roads, road material, and consequently of ammunition, or limited by rail transport and water supply.

On the first employment of tanks General Palat comments, "it would have been wiser to defer it until there were more of them." He draws attention to the fact that the Germans made every effort to conceal their losses at the Somme and Verdun, and on the 7th December, 1916, suppressed the official list of casualties which gave the regiment and arm of the killed. The Kaiser's peace proposals at the end of 1918 are described as a mere trap.

The author states, quoting from the report of the Secret Committee, that even in November 1916, the French had only 5,121 heavy guns, of which 4,314 were old pattern.

J.E.E.

LAS FORTALEZAS, ANTES EN Y DESPUÉS DE LA GRAN GUERRA.

Por ALEXIS V. DE SCHWARZ, Teniente general del ejército imperial Ruso. (L. Bernard, Buenos Aires.)

IN this volume on fortresses, in the Spanish language, by an ex-Russian general with a German name, who was the defender of Ivangorod and is now Professor at the Argentine Staff College, there is a mass of information about French, Belgian and Russian fortresses, some already available, some new. It appears to be authoritative; for besides the collaboration of Russian officers who took part in the defence of Novo-georgievsk, Kovno and Grodno, the author has had the assistance of General Hellot, Inspector General of Engineers of the French Armies, and General de Grandprey, Inspector of Engineers of the French Third Army, during the war.

General de Schwarz's main point is that there were no up-to-date fortifications in 1914 except on the German side, and in most cases, therefore, the artillery had the better of the fortresses; but even the slight improvements made with ferro-concrete to the forts of Verdun enabled them to resist the German super-heavy guns.

He considers that the original deductions drawn from the fall of Liége, Namur and Maubeuge were entirely erroneous, and that by a proper dispersion of the guns and defences, provision of mined shelters and the use of camouflage, fortresses should play just as important a rôle in the future as in the past. There are descriptions with ground plans of the

Verdun forts, and an account of the damage done to them, which it is believed are not available in any other book, and reproductions of a number of photographs.

The following is the account of Fort Douaumont—a pentagonal "detached fort"—omitting the portions about the armament :—

> "This fort was begun in 1885; its works were constructed of stone and mortar with 2.5 metres of earth over. In 1887 the living casemates, gorge-casemates and the artillery shelters were reinforced by a course of concrete laid on a course of sand 1 metre thick. The concrete was 1.5m. thick in the eastern part of the works and 2.5m. in the western part; over this there was 1 to 4 metres of earth. . . . . In the period 1901-1903 some new work of ferro-concrete and special concrete was added. (There would therefore appear to be a layer of this, a layer of common concrete, a layer of sand, and then a masonry arch.). . . . . Under the living casemates (shown in the plan as a single range) was another tier with water cisterns, supply stores and magazines. At the gorge there was a stone escarp, but a slope on the counter-scarp side with a railing; in the other ditches this arrangement was reversed. Wire about 30 metres wide, on iron posts, surrounded the fort on all sides. The living casemates had a capacity of 600 men lying down and 200 sitting, besides a bakery with two ovens. . . . . One 75 mm. gun turret and its observation post were protected by concrete before the war, but the gun cupolas were not so treated. . . . . On the 14th December, 1916, there were only five uninhabitable casemates in the fort: No. 33, hit on the 23rd October by a 16-inch shell; No. 34 and 35; No. 36 (under which the German bomb store had exploded) traversed by a 16-inch shell on the 14th December, and the bakery casemate hit by a 16-inch on 16th February, 1916. The other 15 casemates of the tier were in good condition and perfectly habitable, and the lower tier had no damage, except cistern 19, the arch of which had been destroyed by the explosion of the German bomb store on the 25th May. Thus, after a two-years' bombardment with heavy guns, the casemates of Douaumont had suffered insignificant damage."

In Fort Vaux, all the works covered by a layer of concrete were in very good condition, except the left corner of the rear passage of the living casemates, apparently destroyed by the Germans. Even the caponiers and counter-scarp galleries were in a good state.

J. E. E.

DER PIONIER.

BEARBEITET und ZUSAMMENGESTELLT VON KLINGBEIL, Major and Kommandeur des 4 (Preuss) Pionier Bataillons. 1925. (Charlottenburg, "Offene Worte," 4*s.* 6*d.*).

THIS handbook (of 1190 pages) for the self-instruction and training of the young sapper,* compiled by the commander of an engineer battalion,

* The German engineer field troops are called "Pioniere." To translate this by "Pioneers" would be misleading, as the ranks are recruited from men of suitable trades, and the officers are trained like our own R.E.

belongs to a series prepared for the different arms and for the various "other ranks" in those arms.† Each book—an aide-memoire for the lower ranks—contains all that a private, gunner, sapper, corporal or sergeant should know of his duties and work. It is a series which we, with our Territorial Force, and evil habit of improvizing armies, might well copy; such books would without doubt have saved thousands of lives and months of war in 1914-18; for, as an Australian said, our *F.S.R.* and training manuals were as much use to a beginner as "cuneiform inscriptions on a Babylonian brick." The compilation of such books was suggested in 1910, but turned down by a high authority, who was in a position to do so, and distinguished himself in the war by holding the record, it is believed, for the number of appointments from which he was *dégommé*. The reason he gave was that the British Army possessed no one who could prepare such a compendium.

The German handbook is profusely illustrated, not only by reproductions from the training manuals, but by photographs and explanatory diagrams. It is divided into two parts, "General military and infantry duties" and "Engineer duties."

Under the first there is a summary of the history of Germany, the German Army and the Engineers in particular. The present state of the German army, method of recruiting, promotion, pay, rations, clothing, leave, military law and method of military correspondence are next explained. This is followed by chapters on the proper behaviour of a soldier, saluting, warnings against spies and communism; duties in barracks, care and use of kit and equipment; physical training; infantry drill; weapons; musketry; minor tactics; billets and bivouacs; map reading and sketching; signals; duties in aid of civil power; transport by rail and motor; army and engineer songs.

The second part, "Engineer Duties," contains chapters on pontoon and temporary bridges; field fortification, including camouflage; demolitions; camps, including water supply; roads; electric-light projectors and mining.

As regards field fortification, pits for single men and groups are illustrated, with shallow communication trenches, for men crawling from one pit to another. The wire favoured is the single fence with apron. A tank obstacle is given, formed of rails dug in at an angle and connected by cross ties. The other types of field fortification, dug-outs, etc., are those that were used in the war.

The "pionier" in marching order now wears laced boots and putties, instead of the Blücher boots with the trousers tucked in of the 1914 period.

J. E. E.

† Those for the infantry private and infantry N.C.O., artillery recruit and artillery N.C.O., and cavalryman are already on the market.

LA GUERRE D'ESPAGNE.

Tome II. Par COMMANDANT A. GRASSET. (Berger-Levrault). 20 fr.

THIS important history of the Peninsular War, published under the direction of the Historical Section of the French General Staff, was commenced some twenty years ago, and the first volume, which described

Junot's conquest of Portugal, Murat's arrival in Madrid and the revolution which placed the crown of Spain on the head of Ferdinand VII, was published in 1914. The author now explains that post-war conditions have necessitated economies and certain curtailment, but nevertheless the present volume, which opens with Murat's suppression of the rising in Madrid on the 2nd May, 1808, in no case carries the narrative beyond the end of June. We have the exile of the royal family to Bayonne, the rising of the Spanish people in almost every village in the country—engineered by the priests at the bidding of Rome, in retaliation for Napoleon's ill-treatment of the Pope—the isolation of Dupont in Andalusia, the surrender of Admiral Rosily's fleet at Cadiz (so shortly to be followed by two more surrenders, Baylen and Cintra), Moncey's march to Valencia, outbreaks in the north and west, and finally Lefebre Desnoëttes' failure to capture Saragossa by assault. We hear little of British influence in the revolt, beyond the fact that the various *juntas* undoubtedly counted upon British support. The name of Commandant Grasset as author is sufficient guarantee that the story is well told, and we look with keen interest to its further development.

F.E.G.S.

STRATÉGIE DES TRANSPORTS ET DES RAVITAILLEMENTS.

Par le Général RAGUENEAU. (Berger Levrault). *6fr.*

THIS book by the Military Chief of the French Railways during the war is a reprint of three articles which appeared in the *Revue Militaire Française* last year.

The greater portion of the book is devoted to an outline of the part played by the railways in France and to thoughts on the use of railways in a future war.

Both the French and the German concentrations were allowed to take place quite unmolested, but it is impossible to conceive of this happening again. If some lines are blocked, even temporarily, it seems essential that some should be left spare in the original programme to prevent the time-table getting hopelessly deranged.

Even before the concentration was completed railways were being used to shift formations from one point of the line to another. It is obvious that lack of depth in the original dispositions makes this manœuvre all the harder.

After the invader has advanced a certain distance, the defender, provided he has destroyed the railways in his retreat, manœuvres at a great advantage, as was shown at the Marne.

When the fronts had stabilised, both sides set to work to improve railway facilities. The great need felt by French and Germans alike was for more transverse lines behind their fronts.

Great emphasis is laid on the necessity for depth in communications. Failure to maintain this necessary depth and flexibility was one of the main causes of the German breakdown in Nov., 1918. Through over-confidence they had sited their Supply Depots too far forward.

Another point of interest and cause of failure was the presence in the

centre of the German line of the Ardennes, a large area with poor railway communications.

Some lessons appear to be—

(1) Railways have strict limitations, but when these have been allowed for they afford a very accurate method of moving troops;

(2) Railway authorities must be in close and continual touch with the General Staff and must always be looking ahead;

(3) In the national mobilisation of man power, consideration must be given to the needs of the railways if this powerful weapon is to be used to its full extent.

Road transport, light railways and transportation by sea and air are also touched on.

The function of M.T. and light railways must always be to supplement and not to replace railways. With regard to M.T., the author considers that vehicles should be equally capable of carrying personnel or materiel, and that reserve groups of M.T. should be centralised under G.H.Q.

Transportation in war demands the most careful study. "The first principle of war organisation is mobility," *F.S.R.* 1 2 (2). In a future war the influence on strategy of communications will be as great even as that of armaments.

E. H. CLARKE, Major R.E.

LES DOCTRINES DANS LA PREPARATION DE LA GRANDE GUERRE.

By General ARTHUR BOUCHER. (Berger Levrault.) 8 *fr.*

THE object of General Boucher's book is to show that the principles of war have not changed since the earliest days of Military History, and that the application of these principles in the French plan of campaign for the Great War might have obviated the disasters of 1914. Since the war a great deal of justifiable criticism has been levelled at the original plan and its execution, but the critics have generally ignored the reasons for the formation of this plan. General Boucher traces, in some detail, the development of both the German and French plans between 1870 and 1914, culminating on the French side in the famous "Plan XVII." This portion of the book will probably be of the greatest interest to the student on Military History, especially in showing the dangers of a particular school of thought in the General Staff becoming so predominant, that the higher commanders have to conform to its theories.

After the disasters of 1870, the experience of the war was put to such good use by the French military authorities that, by 1896, when the Franco-Russian alliance was made public, Schlieffen, the German Chief of Staff, admitted that France was impregnable on the common frontier. It was on this basis that the plan of violating Belgian neutrality and overwhelming the French left was evolved, first by Schlieffen and later by the younger Moltke. In the meantime, radical changes were taking place, both in the French plan of campaign and in the doctrines which were installed into the French army. The prime movers in these changes were General Bonnal and Colonel Grandmaison, and their theories are subjected by the author to an impartial and detailed criticism which is well worth studying.

General Bonnal, an instructor at the French War College, was responsible for the introduction of a fresh war plan based on the Napoleonic strategy of the "battalion square," which Bonnal considered the solution to all strategical problems. At the same time reserve formations were eliminated from the first line troops, on the theory that extra training was necessary till the soldier became a fighting machine. Thus the striking force at the outset of the war was reduced to a considerable inferiority as compared with the German first line army, in which reserve formations were actually employed. The disadvantages of Bonnal's plan are clearly set out; but the chief lesson to be drawn from this portion of the book is the danger of attempting to find a short cut to victory in the methods of a great commander, rather than in his general application of the principles of war.

Colonel Grandmaison, who was Chief of the Operations section of the General Staff, developed the theory of the offensive "à outrance" as being essential in all operations. The immediate reason for this doctrine was the necessity for raising the morale of the French Army, which had suffered greatly from political dissensions; but General Boucher shows quite clearly how this doctrine, combined with the teaching that artillery should only support an attack, without preparing for it, was one of the chief causes of the collapse of the French plan in 1914.

In the last part of the book, the assistance of one of the earliest leaders in history, Xenophon, is called in to criticise the French and German plans, and to give his solution of the French problem. This may seem rather far-fetched to a good many readers, but should not deter anyone from reading an excellent analysis of the French plan, which is made all the clearer by the chapters tracing its growth since 1870. At the same time it is made perfectly clear that the majority of the principles which governed the operations of the great commanders of antiquity were deliberately violated, and that the failure was mainly due to their violation. The author's criticisms are open to few objections, except perhaps where he suggests a concentrated offensive into Luxembourg, combined with a defensive on the rest of the front, as the correct action on the outbreak of war.

General Boucher's book can be thoroughly recommended, either as a bird's-eye view of the development of the French and German strategy at the outbreak of the Great War, or as a basis for the detailed study thereof.

H. A. J. P.

L'EFFONDREMENT DU PLAN ALLEMAND EN SEPTEMBRE, 1914.

General CAMON. (Berger Levrault. 8 *fr.*)

The three studies into which the book is divided are reprints of articles which from time to time appeared in the *Revue Militaire Française*. They are here collected to form a connected strategical study of the causes which led to the failure of the German plan of campaign in 1914.

In the first study the author discusses the plan of campaign and the history of its development; the second deals with the execution of the

plan and the causes of failure ; in the third General Camon asks whether the study of the Napoleonic campaigns is still of value, and proceeds to show how many successful strategical conceptions of the Great War followed closely the methods of Napoleon.

The " motif " recurring on almost every page is, that to follow strictly in the steps of the Great Master is the only sure road to success in war, and that adherence to the teachings of Clausewitz and the methods of Moltke was the primary cause of the failure of the German plan. The two systems, labelled " la manœuvre Napoléonienne " and " le schèma de Cannes " are shown constantly in conflict. The reiteration of the theme is somewhat disturbing to the reader and gives the impression that the author looks on the whole art of war as covered by one sealed pattern manœuvre. Briefly the two systems are—

(*a*) Manœuvre by one wing against the flank and rear of a demoralised enemy ;

(*b*) envelopment of both wings of the enemy forces leading to complete annihilation—conception of Cannae.

1ST STUDY—GENESIS OF THE GERMAN PLAN.—In this study General Camon traces the development of German strategic thought from Frederick II and Clausewitz to Moltke ; discusses the clash of opinion in Germany as to the merits of convergence on front and both flanks on the battlefield, as exemplified by Sadowa, the traditional Moltke manœuvre ; finally, describes the first and second plans of Schlieffen, discusses in detail the factors which led to his final plan of 1905, and ingeniously shows that by transposing appropriate names and numbers in Napoleon's proposals for the conduct of the campaign of 1806, written to his brother, the King of Holland, Schlieffen's plan is almost exactly similar in its main outlines.

Schlieffen's final plan allotted 37 Divisions and 5 Cavalry Divisions to the decisive wing, I, II and III Armies, leaving a weak force of 11 Divisions and 3 Cavalry Divisions in Alsace and Lorraine. He visualised the abandonment of much of this area, and the check of the French offensive on the fortified line Metz-Strasbourg. The French would then be so far compromised that any transfer of troops to the threatened left flank would be difficult. Molke, taking counsel of his fears, depletes the right wing by 11 Divisions to strengthen his VI and VII Armies and the force in East Prussia, and does not dismiss the possibility of an offensive by the left flank armies, a development which General Camon stigmatises as veering to the " conception of Cannae " and, therefore, in itself containing the germ of defeat.

2ND STUDY.—EXECUTION OF THE GERMAN PLAN.—General Camon now deals in detail with the operations culminating in the battle of the Marne and the German retreat to the Aisne. The action of the right wing armies is first discussed, familiar ground. He deduces eight reasons for the German failure on this wing, apportioning the responsibility to individuals in each case. They are—

(1) Moltke's initial error in strengthening the left wing at the expense of the right.

(2) Failure to envelop the Belgian Army on the Gette—Moltke, Bulow and Von Hausen.

(3) Failure to envelop the British and French V Army on the Sambre—the same three are to blame.

(4) Moltke's error in sending two Corps to East Prussia prematurely.

(5) Failure to envelop the British and French V Army on the Oise—Kluck, Bulow and Hausen.

(6) Moltke's Directive of September 4th.

(7) Kluck's withdrawal of the III and IX Corps from the front of the British and French V Army.

(8) Bulow's gratuitous detachment of one Division to Von Hausen.

Above all, General Camon blames Schlieffen, who, he says, prepared a perfectly correct Napoleonic manœuvre, and afterwards spent the remainder of his life advocating the "conception of Cannae," double envelopment, thus inculcating an incorrect strategic outlook in the German Higher Command and Staff.

The action of the left wing armies in Lorraine is then described, and provides a detailed and interesting study, well worth reading, in view of the somewhat hazy conception that exists as to the course of events on the right wing of the Allies. Prince Rupprecht, like most of the German Army Commanders, but little amenable to the orders of O.H.L., was more than once in conflict with Moltke as to the rôle of his armies and, whilst failing to prevent the French from detaching troops from the East to assist the left wing, his offensive operations precluded any reinforcement of the I and II Armies as originally visualised by Schlieffen.

3RD STUDY—THE VALUE OF STUDYING NAPOLEON'S CAMPAIGNS.—Napoleon's two systems of manœuvre are—

(*a*) manœuvre against the enemy's rear, of which General Camon says he has counted 27, including Lodi, Marengo, Ulm, Jena and Vilna;

(*b*) manœuvre against the hostile centre, as, for example, the opening phase of the Waterloo campaign.

During the Great War, General Camon considers that Ludendorff made use of the first system at Lodz, Bialystok and Vilna, in every case with important results. The second system is exemplified by the offensive of March 21st, 1918, and by the allied offensive against the Bulgarians in September, 1918.

Military history may, therefore, be studied from two points of view: first that of historical interest as a matter of patriotic education in which the study of detail is only limited by powers of memory; secondly, that of technical interest, in which tactical details are valueless, but the eternal principles of war may still be studied and applied to the handling of armies at the present day.

The book contains a number of very indifferent sketch maps.

R.L.B.

PRACTICAL ASTRONOMY.

By GEORGE L. HOSMER. (New York: John Wiley and Sons.) 13/6. pp. 270 + ix.

THIS is a handy and well-printed little book, which is intended, as the preface tells us, to serve the needs of civil engineering students, who are not likely to take up advanced astronomy. It deals chiefly with those observations which can be made with surveying instruments; the instruments in question being assumed to be the engineer's "transit," i.e., transit theodolite, and the sextant. The inclusion of the latter may, perhaps, be due to the fact that there is a chapter on nautical astronomy, in which a good account is given of the determination of position at sea by Sumner lines.

The author has adopted the laudable device of printing in small type all those paragraphs which are not essential for a first study of the subject. Paper and type are excellent.

Not much originality is to be expected, or desired, in an elementary text book. What is chiefly required is clearness of exposition, and this is to be found in the book under review. It is, generally speaking, up-to-date. Thus, the abolition of the difference between civil and astronomical time is noted; and a brief account is given of the determination of longitude by the receipt of wireless time signals. But this account is too sketchy to be of value to the explorer. The answer to this remark would, no doubt, be that the book was written with the engineer in mind and not the explorer. But from this point of view it is curious that some pages of small print should have been devoted to an account of the fixing of longitude by moon culminations, a method, which, as the author points out, is incapable of giving results of any accuracy. One would not, in fact, be surprised if the mean of a week's work at moon culminations were a mile in error.

An excellent feature is the relatively large space devoted to the determination of azimuth, with a view of emphasizing the importance to the engineer of using the meridian in his surveys; and another good feature is the discussion of the effect of errors, for instance in altitude, by differentiating the usual spherical formulæ.

C.F.C.

AERIAL SURVEYING BY RAPID METHODS.

By B. MELVILL JONES and Major J. C. GRIFFITHS. (Cambridge University Press, 1925.) Price 16/-.

HERE is a most welcome book. It can happen but seldom that so obvious a gap exists in the literature on any subject or that the peg, where it appears, should so exactly fit the hole. Surveying from air photographs is the joint labour of three craftsmen, the surveyor, the photographer, and the pilot. There is abundant literature under the first heading, enough, at the moment, under the second, and hitherto practically nothing under the third, and yet in the British Empire especially, we are most dependent upon the proper study of how navigation should be carried out for survey photography and upon a well reasoned diagnosis

of the errors which are due to its conditions and methods. In Europe generally the problem is of a different nature. Surveys extend practically everywhere and it is new maps at medium and not small scales which are wanted. The resection methods to which the authors allude, but do not describe, must then be the rule in old civilisations. But in the Empire at large the problem is still that of the first maps for development and administration. We want quarter inch or half inch maps, and to use the camera economically for such a purpose is the main preoccupation of the moment to the photo-surveyor.

Canada, it is true, has tackled and solved the problem in the flat water and forest regions of the north west, and has done so by the happiest co-operation of surveyor and airman, but it does not follow that her methods will be equally applicable elsewhere. The surveyors of the Empire must in fact, study their own individual conditions and suit method to country and to revenue.

Glib proposals and estimates omitting such insignificant factors as scale and type of country have been common and have hindered rather than helped. One does not map a continent or even a colony by any one method. The surveyor has as many tools in his bag as the golfer and, like the latter, will not use his brassie in a bunker, his iron for a long shot on the pretty or confine himself for good and all to a cleek. Air photo surveying can only be helped along by a reasoned statement of the pros and cons and by pointing out those matters for which it has special economic value. If this book had, then, contained little else but its introduction it would still have been worth while.

The authors, practical pilots both, and peculiarly suited by temperament and occupation to research, enjoyed special facilities for co-operation with the Air Ministry and set themselves to tackle the problem of how best to secure the photographs wanted for the mapping of new countries at small scales. Even since the date of their field work new equipment (sights, etc.) have appeared. But the value of their work is not thereby diminished. If Civil firms design special aircraft for the purpose there is much to think over in the chapter on Equipment and Detailed Procedure. The instruments used in the experiments and their performances are carefully described and above all a really practical routine in the air has been evolved. This or that pilot may no doubt have found, by experience, methods peculiarly suited to himself and differing from those here advocated, but if so, they have, so far, been inarticulate and not even the most skilled can fail to profit by a study of this book.

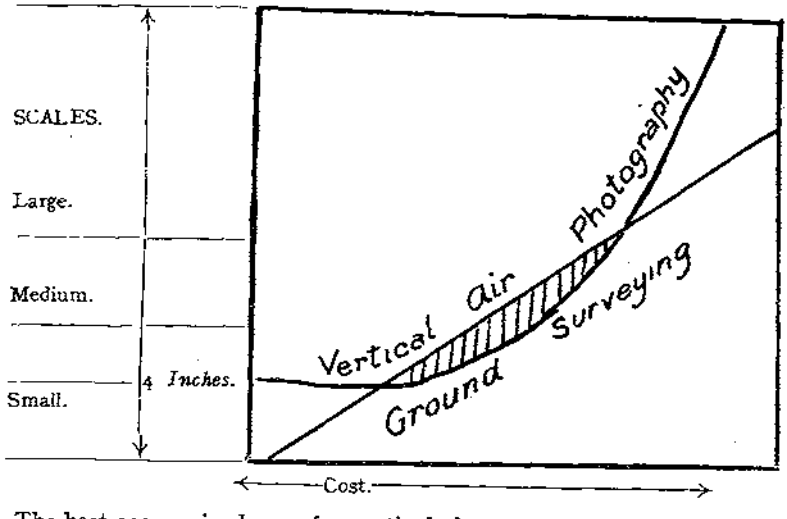
To the surveyor the most interesting chapter will be that on mapping by navigation and oblique photographs. Canada maps from obliques but in her case photographs are used singly and the perspective grid employed allows the draughtsman to copy the detail direct on to the map. Obviously this system postulates flat country. The authors on the other hand use each oblique photograph as evidence of angular measurement only. The interesting grid they describe is azimuthal in character and is designed to record horizontal and vertical angles. The plotting is done from pairs. Elsewhere in the book there is little or nothing on contouring except in very approximate fashion, and to the surveyor this is a most important omission. Contours, however, rough, are an indis-

pensable feature of maps which may be used for development. The first investigation of a railway project, for example, demands them.

We should have liked to have seen some mention of that co-operation between ground and air topography, which must sooner or later, obtain. In no very large area will air photography serve all purposes, and yet in all areas it would help. In the future one would like to see airmen attached to large surveys so that the really difficult places could be photographed and not the easy ones, and that quick transport and supply could serve the ground parties. Indeed, Canada has already found how invaluable reconnaissance from the air, and the transport of survey parties by the same means can be, especially during a naturally short field season.

Dominion and colonial surveyors will be interested in the question of costs. The authors quote no actual figures, but their conclusions, in terms of flying time, number of exposures, etc., will be valuable in framing estimates.

Naturally, confined as it is to small scale method, the book says little about the influence of scale on cost and little has appeared elsewhere in print. It is, however, an interesting point. The cost of ground surveying varies roughly in proportion to scale and not to area on paper, because the surveyor does not map the same amount of detail on a small as on a large scale, and visits fewer places. His expenses mount then more or less in a straight line if we show them on a graph. "Vertical" photography is, however, an area question and its expenses mount in a curve. Photography is not practicable at scales smaller than two inches to the mile, and a photograph may be enlarged to about double the scale for mapping. These facts mean that the relative expenses will mount, with increasing scale, something after the pattern of the figure, and that photography will be as cheap for a four inch map as for a half inch.



The best economic chance for vertical photography is bound, therefore, to lie somewhere in the medium scales however large or small the shaded area may be under any given circumstances.

The appendices to which mathematical discussion has been relegated, will not be understood by all, but are most valuable to the surveyor and are put as clearly as could possibly be done.

Professor Melvill Jones speaks eloquently of his colleague, who was so unfortunately killed. I knew him in France and subsequently at home and would like to add a tribute to the keenness, perception and character he brought to his work.

It must be delightful to an author to have the result of his labours printed at the Cambridge University Press. Printing, paper and illustration leave nothing to be desired.

To those who are peculiarly interested in these small scale air-photo surveys of new countries the following publications will be useful as amplifying, from a survey angle, the book under under review.

LEVÉS PHOTOTOPOGRAPHIQUES AU MAROC. Cahiers du Service Geographique l'Armee No. 38 Août, 1919.

REPORT ON CIVIL AVIATION, 1922, 1923, 1924. Department of National Defence, Ottawa, Canada.

GRAPHICAL PLOTTING FROM AIR PHOTOGRAPHS. Lt.-Colonel L. N. F. I. King, O.B.E., R.E., (now in Press) H.M. Stationery Office.

AERIAL SURVEY OF THE MISSISSIPPI DELTA. G. C. Mattison. Department of Commerce, U.S. Coast and Geogetic Survey. Washington Government Printing Office, 1924.

THE MILITARY ENGINEER XVI Nos. 88, 89 and 90. Washington Soc. of American Military Engineers, 1924.

TRAINING REGULATIONS, 190-27 War Department, Washington. Topography and Surveying "Aerial Photographic Mapping." Government Printing Office, Washington, D.C.

H.ST.J.L.W.

THE CONCRETE YEAR BOOK, 1925.

(Concrete Publications, Ltd.) 2/6 net.

THIS publication, first issued last year, is a cheap, sound and useful book. It is divided into 3 parts; a handbook, a directory of British Engineers, Contractors and Manufacturers dealing with the subject, and a catalogue or classified series of advertisements.

The second and third parts will be of value chiefly to engineers at home, but the first part has a more universal appeal, since it includes a fairly complete bibliography of concrete, classified under sub-heads, useful tables of materials, proportions, R.C. slabs, &c., and some hundred or so pages of the theory and practice of concrete.

Some of the chapters in last year's issue have been omitted and replaced by new matter. The name of Dr. Oscar Faber, cited on the title page as joint Editor, is evidence that the new matter is based on sound laboratory work, and it is satisfactory to find that practice is by no means overweighted with theory; but the omission of complete chapters from the previous edition seems to constitute a weakness. For instance in 1924 there was a chapter on "Concreting in Cold Weather," in 1925 the only reference in the index to this aspect of the subject is wrong. All theory of proportioning has been omitted this year for the same reason.

The index, which by the way is at the beginning, might be expanded with advantage and the subject matter of the first part would be simpler to refer to if arranged on a more logical plan. These minor weaknesses will no doubt be rectified in future editions.

The detail of tests is good and among the other subjects dealt with are floors, roads, tennis-courts, sewers and cottages.

A.M.

REINFORCED CONCRETE DESIGN.

VOLUME I, THEORY.

By OSCAR FABER, O.B.E., D.SC., M.INST.C.E., A.C.G.I., etc., and P. G. BOWIE, A.C.G.I., A.M.INST.C.E. Price 14/-.

VOLUME II, PRACTICE.

By OSCAR FABER. (Edwin Arnold and Co.) Price 18/-.

THESE two volumes are mainly devoted to the design of beams and columns of reinforced concrete, and the subject is very fully treated.

The mathematics involved are unavoidably ponderous from the very nature of the subject, but wherever possible they have been banished to appendices ; while in all cases a clearly understandable result is produced in the form of a simple table or graph, which can be easily handled by the practical engineer when he comes to design his structure. Plenty of numerical examples are given ; and the fact that the symbols used are nearly all identical with those to which one is accustomed saves a vast amount of mental effort.

BEAMS. Simple bending is first dealt with. The authors consider that the formulæ generally recommended for T beams and doubly reinforced rectangular beams are too complicated, and show how close approximations can be made by simpler methods.

Beams continuous over two or more spans are then considered in great detail. The various bending moments produced by different conditions of loading, such as all spans loaded, alternate spans loaded, etc., with uniform, central, two point, and triangular loads, are worked out for varying proportions of the weight of the external load to the weight of the structure itself, and shown graphically. Comparing these results with those obtained by the usual " ends fixed and half-fixed " approximations, it would appear that the latter is quite good enough for simple structures ; except that a small percentage of negative reinforcement over the centre portion of each span should be provided to allow for the possibility of very uneven loading.

In the above the stiffness of the supporting concrete columns is neglected. This assumption is on the safe side ; except at the ends of the beam when the outside columns are monolithic with it, and this case is separately treated.

A study of moments in beams, allowing for the stiffness of all supporting columns, is also given. As regards this latter the authors give it as their opinion that " only the most skilful and experienced engineers should consider this treatment—for all others it is too dangerous. Even for them t is too cumbersome for general use in practice, except in special cases."

COLUMNS. After reading what the author has to say on the subject one is forced to the conclusion that to design R.C. columns, monolithic with beams, for direct compression only, without calculating the moments induced in them by the beams, is definitely unsafe. Obviously this is especially the case when dealing with outside columns. This subject is fully gone into and a series of graphs is given by means of which the induced bending can be taken into account. This is perhaps the most important portion of the books.

STANDARD BEAMS AND COLUMNS. Everyone knows the benefits that have been derived from standardising steelwork sections, and the authors argue that standard sections are just as necessary in reinforced concrete work.

They give a certain number of examples with their properties worked out in full detail.

SHEAR AND ADHESION. The treatment of this subject is too compressed to be really satisfactory, though much valuable information is given. Bending combined with Direct Forces, Unequal Spans, Rolling Loads, Reservoirs, Retaining Walls, Materials, Specifications, Quantities, and Notes on Practical Applications. The Specialist Engineer and the Contractor. All contain plenty of useful information.

The two volumes are labelled respectively "Theory" and "Practice." It is a surprise, therefore, to find the last four chapters enumerated above in the "Theory" volume. As a matter of fact Volume II is in the main an extension of Volume I, written several years afterwards and amplifying the matter contained in the latter; and it would be an improvement if the two could be combined in one volume and the chapters rearranged.

The outstanding merit of the books, which contain a great deal of original work, is undoubtedly the way in which unwieldy masses of facts have been reduced to a form in which they can be readily handled. Mention must also be made of the fact that the books are written in a very clear style, and are enlivened at intervals by the authors frank statement of their opinions, of which the following may be cited as an example :—"The systematic calculation of bending moments in columns, which has so long been shirked at great risk, which was not generally realised, becomes so simple when the curves in Part II are combined with the use of standard sections that from henceforth a man will be more knave than fool who omits to design for them."

W. A. FITZG.K.

THE PRINCIPLES OF MACHINE DESIGN.

By ROBERT F. MCKAY. (London: Edward Arnold & Co., 1924.) Price 18/-

THE author has limited his treatment of the subject to the component parts and connections which are more or less common to all types of machinery—his aim being to develop the basic principles on which machine design rests.

Part of the function of this book is to indicate that kinematical and strength perfection in a machine is not all sufficient, but that cost may

often be cut down without sacrificing safety, by due attention to the considerations of manufacture and assembly—a point that does not appear to always be considered by designers of purely war machinery.

Various properties of different materials used in machine construction are enumerated, together with the usual tests applied to them. Following this are some useful remarks on the utility of mechanical tests from a designer's point of view, and tables shewing factors of safety recommended under different conditions.

Various methods of making permanent or temporary connections are classified and described. Two chapters are devoted to rivets, riveted joints and boiler work.

Structural work and ships riveting are separately considered. Many formulæ are given and examples worked out.

Bolts and bolt connections, locking devices, strength of bolts, etc., are fully described and illustrated.

The information given on pipes and pipe installations is useful from an R.E. point of view; practically every method of jointing pipes is illustrated, together with details of flexible couplings, sliding expansion joints, expansion bends, corrugated expansion pieces, pipe anchorages and supports, etc.

The design of joints for transmission of longitudinal motion shafts, shafting, keys, couplings, etc., are lucidly explained. The chapters on lubrication, bearings, etc., are not very lengthy, and yet are full of the right kind of information.

There are 82 tables in different parts of the volume, many of these give actual dimensions of various sizes of machine parts such as clutches, plummer blocks, etc., together with the conditions under which they should be used.

No tables of physical constants, or compilations of mathematical tables, etc., are included—the author taking the view that the text book and the pocket book have separate functions; the former indicating basic principles, and helping to show how the various empirical formulæ used by practical engineers are arrived at, rather than attempting, as in the latter, to give all the information required by a designer in the course of his duties.

G.C.G.

A HISTORY OF R.E. CRICKET, 1862-1924.

By Captain R. S. RAIT KERR, D.S.O., M.C., R.E. (Institution of Royal Engineers, Chatham.) Price 5/4 post free.

R.E's. past and present, and especially cricketers, will welcome "A History of R.E. Cricket" by Captain R. S. Rait Kerr, D.S.O., M.C.

The records of R.E. cricket, from 1862, are condensed into a small compass, and to these are added a brief but clear history of the club, a chapter on the cricket ground, memoirs of distinguished Corps cricketers, and other details. Those who take an interest and pride in the Corps

and have not the access to old papers and books are enabled to see the development of the game from its commencement as a Corps institution.

The book will bring back to the older generations many recollections of happy days connected with R.E. cricket, and to the younger generations it will show the high standard that was reached in the past, and be an incentive for them, not only to maintain R.E. cricket at the same high level, but to go one better and improve it.

Your reviewer remembers, when he was a Y.O. at the S.M.E., the encouragement that was given to Corps games by the Commandant, Sir T. L. Gallwey, and his Brigade Major, Major Marindin, was very helpful, and there is no doubt an officer good at games is good also at his work. I am sure R.E. Games owe a great deal to this help from their commandants.

Before the ground was enclosed every hit was run out, until many a real good bat has got himself out, by his wish to get a tenner or a figure approaching that, and utterly exhausted from his exertions, has fallen a victim directly afterwards. The distinguished Adjutant General to the forces in France in the last war was one who saved scores of runs by his energy, pace and throwing powers down the hill towards the New Brompton Road.

Some unselfish and important members of the team whose fame and names are omitted from the book are those who were told off to entertain our guests when more important members slipped off to bed. Many a good bat has shortened his cricket career the next morning from that last game of Hi-cock-a-lorum jig-jig-jig, and his entertainer who fell on top of him the last night fell metaphorically beside him next day. These omissions must be overlooked when we think of the care and pains taken in the collection of the mass of information in the book. All the essentials are there and it will give great pleasure to those who knew Renny, L. K. Scott, Jim Fellowes, Hedley and other giants to read again and again of what they did—and to those who only know them by reputation to read of what they did for Corps cricket. Your reviewer is sure that all R.E.'s will heartily thank Capt. Rait Kerr for "A History of R.E. Cricket," and we certainly owe him a debt of gratitude for what must have cost him many hours of hard work for the honour of Corps cricket. It is also satisfactory to know it was written by an R.E. cricketer who made his century against the Gunners.

C. WINGFIELD-STRATFORD.

AT THE CAPTAIN'S TABLE.

By C. W. DAVY (Simpkin, Marshall). Price 6/-.

MOST of us at one time or another have experienced the hospitality of the Captain's Table and have been grateful to it for relieving the monotony of a voyage. Like the real thing, in Colonel Davy's imaginary voyage the flow of a conversation contains both excellent fooling and serious discussion, while the voyage itself is not wanting in some exciting incidents. Altogether the book may be recommended as a suitable companion for some hours of idleness in the holiday season.

F.E.G.S.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

(*March*, 1925.)—*The Motorization of the Army.* By this expression General Camon means the replacement of the horse by the internal combustion engine, a process which he recognises as inevitable to meet modern war conditions. The vehicles required in the army are the lorry moving on wheels on roads, and the tractor capable of moving across country. Sufficient of the former are obtainable in the open market; the latter are not so common, and on these the writer concentrates, discussing the types now manufactured in France, their qualities and defects, and arriving at the conclusion that the Latil agricultural tractor could readily be adapted to military needs and save specialization and consequent high cost of production. (*To be continued.*)

Dogma or Opportunism. Capt. de Gaulle in this article utters a warning against the French predilection for absolute and concrete systems of warfare, deducing from history the manner in which this peculiarity has already led military opinion astray. The victories of Frederick II led French officers to believe that heavy fire was the secret of success; hence it was only necessary in every case to place in line the greatest possible number of rifles and guns. Fortunately the great military chiefs of the Revolution cut themselves adrift from dogma. Napoleon excelled in adapting his plans to existing circumstances, the condition of the enemy, the ground, distances, the personalities of his commanders, the state of his troops. From the date of his defeat in 1815 for forty years conditions in France were unfavourable to military progress. In 1855 and 1859 the Crimean and Italian wars were taken to prove the invincibility of infantry fire; immediately after this the issue of the *chassepot* and machine gun to the French troops appeared to confer on them a marked superiority of armament, so that in 1870 it was considered only necessary to hold a prepared position from which powerful long range fire could be developed. Deducing by degrees that the German victory in this war was partly due to French passivity, carried so far that they refrained from attacking even to take advantage of openings which German rashness had placed in their way, the new *Infantry Regulations* of 1875, and even those of 1896, advanced to the other extreme; it was only necessary to attack the enemy whenever and wherever he was met to ensure victory, a doctrine which still held good at the opening of the World War. Napoleon's careful study of the special circumstances obtaining as he undertook each campaign was forgotten; fire effect was a secondary consideration; it caused delay in getting to grips with the enemy, and field fortification was absolutely neglected. The grave objections to this doctrine which had been advanced by Col. Pétain and others were brushed on one side. Tactically the fallacy of the doctrine was proved during the frontier battles at the opening of the war, strategically in faults in the concentration, and neglect of the fortresses in the North of France. The victory of the Marne showed a return to saner principles, but the lesson was not finally assimilated until after the disastrous opening of the 1917 campaign,

and only applied consistently from the summer of that year. The "*Réglement sur la conduite des grandes unités*" is based on sound principles, and refrains even from suggesting any general rule of action, but theories and abstractions are again raising their heads, and require drastic pruning.

Concerning a German Opinion. Chapter II of the article by Col. Alléhaut and Major Goubernard, dealing with artillery matters. (A.) General von Taysen states that the French Army is well supplied with artillery, that heavy to light guns are in the proportion of 1 to 1.2, yet many are not satisfied, claiming a proportion of gunners to infantry of 1 to 1. This is true, but no one suggests that all these guns should be integral parts of the division; the latter would be overloaded in the ordinary way, but there are many occasions when the divisional artillery requires to be supplemented temporarily. The divisional artillery is now probably sufficient for open warfare, at any rate, when the infantry can advance after the initial engagement, but certainly a proportion of gunners to infantry of 1 to 1 could only be obtained at the expense of infantry, and would be a national danger. (B.) The General remarks adversely on the centralization of the artillery command in the army corps and division. With this criticism the writers are inclined to agree. No doubt the concentrated effect of massed artillery is decisive in the opening stages of a pitched battle, but later on it is the infantry who carry on the fight. They require support here, there and everywhere, and for this to be opportune and take the enemy by surprise, decentralization, at any rate for the time being, is essential. (C.) There is no subordination of the artillery to the infantry. This, again, the writers think a fair criticism; it raises a very thorny question, but is not quite so serious as the German contends. Out of the mass of artillery certain batteries are always told off for the direct support of the infantry, which the regulations say should act "either in accordance with the pre-arranged plan, or following the demands of the infantry which must be satisfied at every stage of the battle." But is this sufficient? Assuming that the infantry commander is lucky enough to get a message through to his supporting battery so far to the rear, will the battery commander infringe the orders of his time-table to satisfy a request of the infantry? The French regulations should make more definite the subordination of the supporting artillery to the infantry, and this point is argued at length. Even the accompanying artillery, when a suitable weapon shall have been invented, cannot afford all the benefit that can be obtained from the more powerful guns. These guns should be separated from the mass of the artillery to follow their infantry units more closely, so as to facilitate rapid communication with them. This arrangement need only be temporary; if the whole line is held up these guns would be recalled to the divisional mass to help to batter another opening into which the infantry can enter. (D.) Unreasonable demands from the infantry for a special artillery weapon. Certainly a demand is made for guns to accompany the infantry closely; the Germans have felt the same want and have adopted the heroic remedy of detaching field guns for the purpose. (*To be continued.*)

An Encounter Battle. Virton. Commandant Grasset's article is continued, and traces the action of the 8th Division up to 10 a.m., by

which time it was fully deployed. Accompanied by a sketch showing the general situation at 10 a.m. (*To be continued.*)

The Decline of the German Effectives in 1918. The continuation of Lt.-Col. Paquet's article, dealing with the German offensive on the Aisne (27th May) and showing that the density of their troops was considerably less than it had been in March. (*To be continued.*)

Powders and Explosives. By Squadron Commander Duchemin. By powders is meant explosives which are comparatively slow acting, and are used as propellants, such as the French *poudre B.*; by explosives those which are instantaneous in their action. A short description of the difficulties experienced in France at the outset of the War in meeting demands for explosives, and of the remedies applied, with remarks on various nitro-compounds and on the raw materials used in their manufacture. (*To be continued.*)

(*April*, 1925.)—*The Motorization of the Army.* The conclusion of the article by General Camon. His main idea is to encourage the use by agriculture and commerce in times of peace of such vehicles as might be readily adapted in time of war to warlike ends. Excepting certain special vehicles and such ordinary ones as may be required by the army in peace time for the covering troops and for training, all others will be obtained by requisition on the outbreak of war and will consist of agricultural tractors, and taxis, delivery vans and lorries. Of the last three the chassis only will be of use to carry guns, and for the guns special mountings will be required. A chapter is devoted to the supply of petrol and other fuels. The whole matter requires to be worked out in detail by the General Staff in consultation with the Ministers of Commerce and Agriculture.

The British Empire in 1924. By Commandant Texier. An analysis of the effect on the land, air, and sea forces of Great Britain of the advent to office in 1924 of a Labour Government. The writer has not, however, mentioned the fact that Labour, although in office, was not in power. This month the mother country only has been dealt with, the imperial policy of Labour is to follow. (*To be continued.*)

Concerning a German Opinion. Chapter III of the article by Col. Alléhaut and Commandant Goubernard dealing with cavalry and tanks. The former is dismissed with a few lines, the German General's remarks being in the main true. Tanks, *i.e.*, the French *Renault*, are discussed at great length. The General remarks that the French possess more tanks than any other nation, whereas his opinion, backed by that of many other Germans, is that in future wars tanks will prove to be of comparatively negligible value. He allows their stimulating effect on their own infantry, but states that therein lies a danger, for troops accustomed to them will hardly attack boldly without them. He quotes statements from the French press and books in support of this contention, and continues that, granted the development of anti-tank defence, the destruction of the tanks would have a moral effect opposite to that expected. The authors then summarize the defects charged against the *Renault* tank, and claim that these are to a great extent exaggerated. The article should be read in the original. (*To be continued.*)

An Encounter Battle.—Virton. Commandant Grasset continues his account of this battle from 10 a.m. to 12 noon, and a sketch is attached showing the general situation at the latter hour. During this period more troops on each side entered the battle, and the French Artillery was making its pressure felt. The German front line troops had halted and firmly entrenched themselves; the French had made little or no use of the spade and were eager to advance but checked by the Germans' superior artillery. (*To be continued.*)

Anti-Aircraft Fire and Defence. The continuation of Col. Pagézy's article. In Chapter III the writer summarizes the characteristics of A.A. guns, and the limitations of the existing models. Their moral effect on the enemy aircraft is very great; at the same time they are themselves very vulnerable, principally owing to the large numbers of trained men required to work them and all the observing and calculating machines involved; a single casualty in the detachment is difficult to replace. A section is devoted to what is named the "volume of action," *i.e.*, the height, range and horizontal angle within which the fire of a gun is effective; another to the mobility of different mountings, such as the *auto-canon*, the gun carried on a trailer, and platform models. Chapter IV is devoted to considerations governing dispositions for the defence of a forward area, including the protection of observation balloons. (*To be continued.*)

A German Controversy. By Commandant H. Martin. The *Reichsarchiv* recently published the first two volumes of "Der Weltkrieg 1914-1918." The authors not only record facts, but comment on them and give their opinions, localizing mistakes and fixing the responsibility for them. Some of their decisions have already aroused controversy, such as General Wetzell's article in *Wissen and Wehr* No. 1 of 1925, defending Moltke in part and Bülow entirely from the accusations of the *Reichsarchiv*.

Books and Reviews. La Bataille de Flandres. By Col. René Tournés and Capt. H. Berthemet (C. Lavanzelle et Cie.). Published under the direction of the Army General Staff. The great interest of this book is due to the fact that all the German 4th Army records of this battle from 9th to 30th April, 1918, were captured, and from them it has been possible to reconstruct events "in the atmosphere of the German High Command," and compare them with the measures being adopted by the French at the same hours and dates.

La Turquie, l'Allemagne et l'Europe depuis le traité de Berlin jusqu 'à la guerre mondiale. By Gen. M. Moukhtar Pasha (Berger-Levrault.) A half century of Turkish political history by a man who played a considerable part in the late Ottoman Empire. Minister of Marine in 1910, and commanding the Turkish 2nd Army in 1912, he was the defender of the Chatalja lines, and was Turkish Ambassador to Berlin during the World War. He clearly explains Turkey's decision to range herself on the side of the Central Powers against the Entente.

May, 1925.—French and German Fortifications. By R. Normand, Col. of Engineers. A short outline of the fortress systems on the French and German frontiers, sketching their history and the objects for which they were constructed and modified from time to time. Generally speaking in their first conception, those of the French were intended for defence

and to cover the mobilization of their armies, those of the Germans to facilitate invasion of the adjoining countries. Latterly criticism of the French purely defensive system invoked reconsideration of the scheme, but little was done, while the Germans, no doubt in preparation for an attack on France through Belgium, during the years immediately preceeding the late war, spent large sums on the fortresses facing France, openly adapting them for the defence of Alsace and Lorraine, and for limiting the possible avenues of approach thereto from France, in fact, adopting the system already developed on the French side. Defects in the German system are pointed out, and the article is accompanied by a sketch map—scale about 35 miles to the inch. (*To be continued.*)

Concerning a German Opinion. The continuation of the article by Col. Alléhaut and Major Goubernard, arguing that the tank is really an infantry weapon, and that the infantry would be serving their own best interests in protecting it and favouring its advances in every way they can. Protection of the tank by artillery, even by the guns detached from the divisional artillery for direct support of the infantry, is impossible in practice. In short, full protection for the tank against anti-tank weapons unexpectedly brought into action will only be attained when the infantry shall have their own accompanying guns, weapons not yet realized. Still, the *Renault* tank, if more is not demanded of it than it can conceivably perform, is not to be despised.

Chap. IV. *Aviation* is only treated briefly by Von Taysen. He exaggerates certain expressions in the French regulations and individual opinions expressed in magazine articles to bolster up his theory that, in this field as in all others, French military ideas tend to sacrifice moral to material superiority. In Chap. V.—*Infantry*—the authors first give a summary of Gen. von Taysen's arguments, and in Part II their own comments. Briefly, von Taysen accuses the French of having made a dogma of the necessity for fire superiority on the side of the attack, of subordinating their infantry to the material arms—artillery, tanks, aviation—of diminishing their infantry effectives for the benefit of the other arms, and of degrading them from the rank of principal arm. This dogma kills the spirit of the infantry. But even if the French regulations do insist upon the necessity for superiority of fire in the attack, it is a principle universally admitted; the Germans themselves go so far as to contemplate the temporary attachment of guns to companies, and of *minenwerfer* to sections and even to combat groups. As regards the rest of his points it is possible that French ideas are not entirely free from mistakes, and by meditating on them it should be possible to arrive at just conclusions. (*To be continued.*)

An Encounter Battle.—Virton. Commandant Grasset's article now follows from 10 a.m. to noon the fortunes of the 3rd Division of the 2nd Corps, which was on the left of the 8th Division, and afterwards reverts to events near Virton from noon to 18.00 hours. Early in the afternoon General Boëlle (4th Corps) decided to retire the 8th Division slightly and occupy a position south and south-west of Virton, which was fairly well organised by 15.00 hours. A map gives the positions of the troops at that hour. Endeavours were also made to open up communication

with the 7th Division on the right of the 8th, which was found to be heavily engaged near Ethe, and from which the first news only reached the Corps Commander about 12.30 hours. At 18.30 the battle died down for the day, and orders were issued as to the line to be held by the two divisions for resumption of the battle next day. (*To be continued.*)

The German Command and Tanks during the War. By Capt. Perré. After a brief sketch of the production and employment of tanks by France, England and Germany during the War, the writer investigates the reasons for the extraordinary inferiority in numbers and design of the German tanks. This he attributes to three causes: the initial delay in ordering them, the indecision of the high command as to their value, and the decrease of industrial efficiency in Germany; the second being the most important and reacting on the other two. The first would not have occurred if the command had insisted on having tanks, and had organised industry to that end; industrial weakness would have been less felt if manufacture had been seriously commenced at an earlier date. The German High Command failed by underestimating the physical value of tanks while to some extent appreciating their moral effect, which, however, it considered could be overcome by accustoming the infantry to their presence, and by destroying them by artillery fire. Its interpretation of the experiences of the Allies was entirely erroneous; a failure in the effect was attributed to inherent defects in the tank, success to a combination of circumstances favourable to them, such as fog, smoke screens, or the fatigue of the German troops.

Anti-Aircraft Fire and Defence. The conclusion of Col. Pagézy's article. Chap. V. considers the defence of the "*Arrière-front*" and of the interior of the country, the former of which may be attacked by day or night, the latter usually only by night. The scheme of defence must be based on three considerations, which are dealt with separately: (1) What it is practicable for the enemy's machines to attempt, (2) the apparatus available for active and passive defence, and (3) the employment of these. Chap. VI deals with the French methods of organisation and command.

Propellants and High Explosives. Commandant Duchemin's article is continued, dealing this month with the production of the commoner high explosives, melinite, tolite, cresylite, and describing the apparatus required, the sources of raw materials, and substitutes, such as ammonal, schneiderite and chlorates. A section is devoted to shell filling. (*To be continued.*)

Foreign Military News. A German Controversy. The *Militär Wochenblatt* for 15th March, 1925, publishes a protest by General Borries against General Wetzell's defence of von Bülow and Moltke (*see R.M.F.*, April, 1925). Short military histories are published of General Richard von Berendt (Artillery), of General Ritter von Möhl, and Lt.-General von Taysen (Infantry).

Books and Reviews.—Mobilization industrielle. By Col. Reboul (Berger-Levrault). A history of the industrial mobilization in France during the War, 1914-18.

A.R.R.

REVUE DU GÉNIE MILITAIRE.

(*April*, 1925.)—*Application of Graphs to Reinforced Concrete Calculations.* This article gives graphical representations of the formulæ employed in the calculations for reinforced concrete construction and shows how these graphs can be used to shorten the time spent in checking the details of a construction project. By the use of graphs the work is not only very rapid, but is extremely simple.

Collapsible Panels to ensure the Safety of Horses in Case of Fire. A description of a method for releasing horses from stables in a fire. The panels which form the side of the stable, together with the mangers, collapse outwards, leaving the horse an exit straight in front of him. The panels are released by an arrangement of steel wire rope, which is worked from some distance away from the building. A lever is used for operating the rope and a pull on this lever causes the fall of all the panels with their mangers and at the same time releases all the horses tied to them.

A Type of Roof for Buildings which appears Suitable for the Sahara. In view of the opening up of new routes across the Sahara by means of motor cars the type of building suitable for erection along these routes, where material and labour are scarce, is considered. The one-storey house is simple to erect with the materials at hand (clay, stone and sand), but the lack of wood and steel presents a problem in connection with the construction of the roof. The article describes a method of making spherical and other types of roof with the material available.

Notes on a Detail of Construction in the Roman Arenas at Arles and Nimes.—Discusses the use of dressed stones as lintels, drawing conclusions from the effect of time on the Roman Arenas at Nimes and Arles. The Romans made their lintels too weak and nearly all are broken, but the lintels at Arles, which are placed wrongly bedded, that is, with the plane of stratification running vertically and parallel to the main axis of the lintel, appear to have resisted better than those at Nimes, where the stones are placed flat. The general failure shows that the Romans would have been better advised to support the springing of the arches of the upper gallery with arches instead of lintels, as in the Coliseum.

A Compass for Trisecting Angles. Describes a type of compass designed to trisect an angle and explains the principle and method of use.

Construction. An improvement to mangers, consisting of the addition of two iron bars is described, these bars prevent the horse from stealing from his neighbour and diminish the waste of oats due to the shaking of the horse's head in his manger when he first gets his fed.

The bars are placed across the elliptical manger and are about 14 inches apart.

A Field Exercise of the "Cadre" of the 9th Regiment of Engineers with Troops and Actual Works. This article gives a description of a scheme carried out by the "cadres" and regimental units of the 9th Engineers. Night crossings in boats, pontoon bridging, and cut rafts and engineer reconnaissance were included in the exercise, which conformed with

a tactical scheme. The exercise took place across the Moselle near Gravelotte.

Applied Science—The Andrean Motor. This is a new type of I.C. motor designed to obtain better power by altering the length of the stroke of the piston during the four strokes. The device used to achieve this result consists of a connecting rod attached at the big end to two arms, these arms are themselves eccentrically pinned to two wheels and in consequence the end of the connecting rod follows a curve giving the piston an unequal stroke. The design gives a long explosion and a full length exhaust stroke with a short inlet and compression stroke. The advantages claimed are :—

(1) Greater utilisation of energy.

(2) Less wear.

(3) Less back pressure during the exhaust.

Complete scavenging is obtained and the weakening of the mixture with burnt gas is avoided. A single cylinder model has been tried with great economy in consumption of spirit.

(*May*, 1925.)—*The Exploitation of Quarries by the Roads Service of the VII. Army.* By Chef de bataillon du Génie de réserve Verrière. The first and second parts of a description of the supply of the road-making materials required by the VII. Army on the front from Raon l'Étape to Switzerland. The upkeep of roads is of paramount importance in stationary warfare, and the exploitation of quarries must always be one of the first considerations in their maintenance. In spite of the improved methods of road making with concrete, etc., special roads will only be justified in a few cases and the large majority of roads in war, as in peace, will be made of water-bound macadam. Whatever type of road surface is used, however, stone is still the primary material. In the case of a water-bound macadam road the cost of the stone is alleged to be 70 per cent. to 80 per cent. of the total expenses.

In war, when there is a shortage of labour, the provision of machinery for quarries is important, but the installation of large plant is limited by transport difficulties, and the writer considers that it will probably not be economical to serve a large area from one quarry. The useful radius of influence of a quarry is limited to 30 to 45 miles, and, therefore, the writer considers that the maximum output of a quarry should rarely be more than 100 or 150 tons a day.

One machine which the lack of labour renders very desirable is the stone-crusher.

In the case of the VII. Army up to the beginning of 1917, the upkeep of roads was under two Directorates ; it was then taken over by a special Army Road Service. During 1917 the service developed considerably and became a very large corps. The labour available was of very different kinds, ranging from skilled engineer pioneer companies to Chinese labour. It was found convenient to form a new unit consisting of squads, each of which was constituted of men of the same trade and commanded by a master-tradesman, and in command of this company was a captain who possessed a wide technical knowledge. This arrangement proved

very satisfactory in the road service, and was well suited to quarry exploitation.

In choosing the quarries which should be exploited, the study of communications is as important as the examination of the geological map; it is essential that a large quarry should be near a normal gauge railway, for trans-shipments must be avoided.

The writer finishes this first contribution with a description of various types of stone-crusher, he proposes in the third part to describe the general organisation of a particular quarry, and in the last part the cost of transport from the quarries and the method of organising the labour.

Crossing of the Rhine by the Allies in 1814. By Colonel Normand. A description and criticism of the strategical movements of the Allies in 1814. The difficulty experienced by the Allied engineers in making a pontoon and boat bridge across the Rhine at Caub is explained in some detail.

The Organisation of Ground for Machine Gun Fire. By Capitaine Caminade. The article points out that this subject is not merely of interest to the infantry and machine gunners, but is also of great importance to sappers, on whom will devolve the responsibility of tracing the second line, and very often the front line also, in collaboration with the infantry concerned.

The rôle assigned to the machine guns is distant flanking fire on obstacles, etc., and barrage fire, the smaller rapid firing weapons dealing with the close support of obstacles. To enable the best use to be made of the M.G.'s in hilly country and to enable officers, who have not had practical experience of machine gun fire to site the guns in the most suitable positions, the article gives a formula for calculating the depth of the effective zone and the number of shots per minute covering this zone. By this means the number of machine guns required can be calculated. The only mathematics required is the addition of numbers taken from a graph.

The Rotor Ship. By Chef de bataillon Barré. A description of the theory of the Magnus effect.

Reviews.—The German 420 *cm. shells and the Fortifications of Russia.* By Colonel Jastrzebski. The author points out that the Russian Staff had kept in touch with the progress of German artillery and that the Russian Military Academy in 1912 taught that for permanent fortifications there should be 6 m. of concrete resting on steel beams, this thickness would resist two superimposed 420 cm. shells. An extract from a previous article by Pejcz describing the fortifications of Grodno, which were reorganised in 1912, is given as an example of work actually done.

Intensive Light, Lighthouses and Searchlights. By Ed. Marcotte. This book discusses the means of producing and propagating light and their application to searchlights, lighthouses, light-buoys and aerial lighthouses.

June, 1925.—*Quarry Exploitation* (continued). Chef de bataillon Verrière, Engineer-in-Chief, Ponts et Chaussées. The author describes various types of stone-crusher, pointing out that more motive power is

always required than is specified by the makers, while it is generally convenient to drive the cylinders used for grading the stone from the same prime mover. The design and method of using stone crushers is described, with tables giving particulars of the work done at the quarries used by the VII Army. Similar information is given with regard to the sifting and sorting of the crushed stone. The third part deals with the general organisation of a quarry, discussing the layout, various methods of loading, transport, disposal of spoil, etc. The reviewer does not know of any similar information elsewhere and is of opinion that this article is well worth study by any officers who are likely to be called upon to develop quarries.

The Lighting and Ventilation of Mine Galleries. Chef de bataillon Barré. This first article deals entirely with the lighting of mine galleries. An electric light installation is described and all the calculations are given in considerable detail (*to be continued*).

A Serious Accident which happened in Germany during a River Crossing Operation.—A copy of an extract of the report of the official enquiry, taken from the *Deutsche Tageszeitung*.

The accident took place during combined operations of the German 6th Division, which included the passage of the R. Weser by a mixed force.

A flying bridge loaded with 160 men sunk and 81 passengers were drowned. The river here is about 330 ft. wide with a 3-knot current and on the day of the accident was comparatively calm. The flying bridge used consisted of a raft designed for 175 passengers and made of 4 boats lashed together in pairs. The raft was well made and did not fail in any way, it was found intact some 6 miles down stream after the accident.

The mishap occurred during the fifth crossing when the raft, carrying 160 men, was 80 feet from the further bank; and was caused by the bad discipline of the troops on board. A sapper in one of the boats shouted to the officer in charge that water was coming in. The officer satisfying himself that it was of no importance reassured the passengers; in spite of which several men moved over to one side where a N.C.O. of sappers was examining the boat. This somewhat increased the inflow and the N.C.O ordered the infantrymen to go to the bow and stern; the order, however, was not understood and a large number of men rushed to the side of the raft nearest the bank. The raft tilted, the two boats nearest the shore were immersed, and the men on this side were tipped into the river. Many of them having their packs and their steel helmets on sank at once, but the greater number were saved by a salvage party from the bank. Meanwhile, the engineer officer, who had also fallen into the water, but had managed to reach the bank, gave the order to loose the cable, so that the raft drifted downstream. Two of the boats were water-logged and the raft had a severe list, but it still carried some 60 men who had remained on board. This officer then sent a rescue boat to take off the men remaining on the raft. A second officer (of engineers) who had remained on the raft took charge and endeavoured to make the men enter the boat singly as directed by him and without rifles or equipment. But, following one man who led with his equipment and rifle, there was a rush for the boat,

with the result that it was capsized, while the raft was tilted to such an extent that all were thrown into the water; very few were saved.

The *Revue du Génie* draws attention to the following points which arise from this accident:—

(1) The personnel ferried across in a raft should be made up of complete units under their own officers and N.C.O.s and the instructions of the technical staff should be given to the passengers by their own officers.

(2) In this case it would probably have been better to tow the raft ashore after the first accident, rather than try to load the men on to a boat.

(3) It is expedient to provide life-belts for crossings of this kind, in spite of the delay which must be caused by the limited number of belts available.

(4) A selected rescue party well supplied with material should always be detailed.

The advantage of having a mechanically propelled boat at hand is also remarked on.

Données Numériques.—Figures are given for a road construction in mountainous and rocky country, requiring blasting and large revetments.

H.C.K.W.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1925. *Nos. 4 to 6 inclusive*).—The account of the operations of the Belgian Army during the Great War, 1914-1918, is continued, events taking place on October 6 and 7, 1914, being dealt with in the numbers of the *Bulletin* under notice. It was the question of the assistance that would be forthcoming from the Allies, and its extent, which at this time was the most important factor to be borne in mind by the Belgian High Command in connection with the plans under its consideration for the further operations of the Belgian Army. The position of affairs in the camps of the Entente Powers is, in consequence, briefly reviewed (in No. 4). At this period, the transfer of the British Army from the Aisne to the line of the Lys had just begun and two divisions of French Territorials were being transported from Havre and Paris to Dunkirk; the latter troops, together with Admiral Ronarc'h's brigade of Marine Fusiliers, had been formally promised by the French Cabinet to the Belgian Government for the purpose of relieving the situation at Antwerp. However, the French Generalissimo was entirely opposed to the idea of sending French troops into the Belgian fortress and appears to have formed the opinion that the Belgian Field Army should without further delay leave Antwerp and aim at joining up with the left of the Franco-British line as quickly as possible. The special mission assigned by Joffre to the British Army, and concurred in by its Commander, was now that of prolonging the left of the Entente line with a view to enveloping the German right and putting out a helping hand to succour the Belgians. Certain important communications were passing between the British and French authorities, but the Belgian

High Command was, it is stated, ignorant of their tenour, nor was it aware that General Pau, who had left Paris on October 4 for the Belgian G.H.Q. was the bearer of a message which contained the suggestion that the Belgian troops when withdrawn from Antwerp should retire on Deynze and Thielt and not on Bruges and Ostend. The Belgian High Command was, however, cognisant of the measures taken for the transfer of the British Army from the Aisne to the Lille region and had also been apprised of the intention of the British Government to send the 3rd Cavalry Brigade and the 7th Division to Belgium, and that Zeebrugge and Ostend had, in view of the destination of these troops being Antwerp, been chosen as ports of disembarkation for them. The Belgian High Command expected that the "corps de secours" provided by the British and French authorities would be constituted not later than October 6; it seems to have felt, however, that this "corps" could not reach Antwerp in time to save it. The review of the situation contained in the original article discloses the fact that at this time serious differences of opinion existed in the highest quarters as to what should be done to meet the situation in Antwerp. Having learnt of the arrival on Belgian soil of the first of the reinforcements from England, King Albert summoned a meeting of the *Conseil Supérieur de la Défense Nationale* at his Palace in Antwerp and invited the British First Lord of the Admiralty to be present. The *Conseil Supérieur* met at once under the presidency of the King and its members proceeded to examine the situation, which is fully set out in the original article (in No. 5). The line of the Nèthe having already been forced by the enemy, the *Conseil Supérieur* was unanimously of opinion that the bulk of the Belgian Army should without loss of time cross to the left bank of the Scheldt with a view to making good its escape from the menaced citadel. The situation was a critical one, and it is evident that the Commanders of the British 7th Division and of the Royal Naval Division did not intend to allow their commands to be placed in such a position as would lead eventually to their being cut off by the Germans besieging Antwerp, and they regulated their movements accordingly; it is made evident in the original article that its author disapproves of the measures taken by and the conduct of the British Commanders in question. At this time, two groups of enemy troops were threatening the Belgian Army; one of them had been attempting for three days to force the passage of the Scheldt at Schoonaerde, whilst the other, being the main body of the besieging force, had already broken through the front of the 3rd Sector of Defence and was advancing through the Belgian line in the section along the Nèthe, between Forts Duffel and Broechem. In these circumstances, the Belgian High Command issued directions for the following policy to be pursued: the second, or inner, line of forts and the ramparts of 1859 were to be defended *à outrance*; the forts of the first, or outer, line still capable of resistance were to be defended as isolated works; when the second line of forts and the old ramparts became untenable their garrisons were to be withdrawn into the retrenched camp on the left bank of the river and to hold out there as long as possible. At 8 p.m. on October 6, orders were issued for the withdrawal of the main body of the Belgian Army to the left bank of the Scheldt; these orders are set out at length in the original article and provide for the movement to

take place in three columns. These operations were carried out with complete success; the enemy being busy in carrying out bridging operations on the Nèthe and in preparing emplacements for his heavy artillery, in view of the attacks projected for the morrow, does not seem to have become aware of what was passing in the besieged fortress. The duty of defending the "second line," i.e., the inner line of forts, was assigned to General Dossin, and orders for its occupation reached him at 9 p.m. on October 6; for this purpose, there were placed at his disposal, in addition to the garrisons of the forts and redoubts, 3 Belgian mixed brigades, 3 brigades R.N.D., 2 fortress regiments, some siege artillery and an armoured train. A description of the "second line" and the steps taken in connection with its defence are given in some detail in the original article (in No. 6); the armament of the forts was no match against the German heavy artillery, and the garrisons of the forts, it is made clear, were of exceedingly poor quality. On the morning of October 7, the Germans, being ignorant of the fact that the Belgian Field Army had escaped from the fortress and was already concentrated in the *Pays de Waes*, continued in somewhat leisurely fashion the movement which had been in progress for some days for the purpose of completing the close investment of Antwerp; so weak, indeed, was the effort that the enemy was making at Schoonaerde with a view to forcing the passage of the Scheldt at this point—breadth of river here varies from 1000 to 1500 m.—that the Commander of the Belgian 4th Division was able to hold his own without calling on the 6th Division, which had been placed at his disposal, for assistance.

Among other articles of interest in the numbers of the *Bulletin* under notice are those by Lieut.-Gen. Joostens entitled *Voyage au Maroc* (in Nos. 4 to 6 incl.) and by "I.C.M." entitled *La cartographie pendant la guerre.*

W. A. J. O'M.

REVUE MILITAIRE SUISSE.

(1925. *Nos. 1 to 3 inclusive*).—The article by M. J. Fleurier entitled *Une légende. La faillite de la fortification permanent pendant la grande guerre* is continued in Nos. 2 and 3, and the operations in the neighbourhood of Antwerp are dealt with therein.

The suggestion is made that the defence of Antwerp might have been prolonged beyond the date on which the surrender was made had the British force, i.e., the R.N.D., co-operated effectively with the Belgians.

In an article entitled *Pro Jomini* (in No. 2), Colonel Lecomte takes up the cudgels on behalf of his famous compatriot, and repels with vigour the suggestion that, in view of the changed conditions of war, Jomini's writings have lost their value, as alleged by Lieut.-Col. Mayer in an article entitled *Grandeur et décadence de Jomini* which appeared in the numbers of the *Revue Militaire Française* for November and December, 1924. Colonel Lecomte agrees that the *Traité des grandes opérations* no longer contains lessons of value for the present day military student; he contends, however, that other works by Jomini possess a special value at

the present time, this being particularly so in the case of the *Précis de l'Art de la Guerre, édition* de 1894.

A description of the Swiss light automatic rifle, *Le fusil Furrer* (1924 model) is contained in No. 3 of the *Revue*.

(1925. *Nos.* 4 *to* 6 *inclusive*).—Major C. Shaffner contributes an article entitled *Le bataillon de pontonniers I et les ponts lourds* to No. 5 of the *Revue* under notice; a short history of the pontoon troops of the Swiss Army is given therein and a summary thereof may be of interest to Sappers. About 1820, the Diet voted a credit for the creation of a *train fédéral de pontons*; it was provided with sufficient equipment for the construction of a light pontoon bridge 120 m. in length. Some years later a second *train fédéral de pontons*, with an equipment identical in every way with that in possession of the first "train," was formed. A further development of the bridging troops took place in 1850, the Swiss Army being at this date endowed with a new organisation; six pontoon companies were then created, the equipment provided for them being sufficient for a light bridge (max. load 3000 kg.) 232 m. in length. The Swiss Army was again remodelled in 1874, and at the same time the engineer arm was reorganised and formed into 8 battalions, viz., one battalion per division, consisting each of a pontoon company, a company of sappers and a company of pioneers—the bridging equipment of a battalion was sufficient for a pontoon bridge 53 m. in length. About 1890, a further change was introduced, owing to the Swiss Army being re-organised on an Army Corps basis; the engineer battalions were now broken up and the pontoon companies grouped together, each of the bridging units so formed was now known as an *équipage de ponts* and consisted of 2 pontoon companies and a "train" detachment. One such *équipage* was allotted to each Army Corps and was provided with material sufficient for a pontoon bridge 132 m. in length; this organisation continued in existence for 20 years. A change was made in 1911, when the *bataillons de pontonniers*, each consisting of 3 pontoon companies and a "train" company, were formed. In 1914, when, on the outbreak of the Great War, the Swiss Army was mobilised, the first company of each battalion was split into two, each half-company—provided with material for a pontoon bridge 40 m. in length—was named an *équipage de ponts divisionnaire*, and allotted to a division. In the case of the *bataillons de pontonniers I*, the battalion staff, the 2nd and 3rd pontoon companies and the "train" company were formed into an *équipage de ponts d'armée* and placed directly under the Commander of the 1st Army Corps. In December 1917, a fourth pontoon company was allotted to each battalion and, in consequence, a complete company was then attached to each division. The original article, which is illustrated, gives a brief description of the present day bridging equipment of the Swiss Army; therein is also recorded the part played by the pontoon units attached to the 2nd Division during the manœuvres which took place in Switzerland in September, 1924.

The article by M. Jean Fleurier entitled *Une légende. La faillite de la fortification permanente pendant la grande guerre* is continued (in No. 5). In this part of the article the third phase of the operations for the capture of Antwerp is examined; the epilogue (Oct. 7 to 10) can, M. Fleurier

says, be summed up in two short sentences; (1) the Belgian Field Army escaped from the Germans, and (2) no stand was made behind the ramparts of the entrenched camp thrown up in 1859, nevertheless, to the existence of these defences was it due that the enemy's advance was held up for 24 hours; in consequence, the greater part of the permanent garrison was able to make good its escape from the fortress and a portion of it managed to join up with the Belgian Field Army, the balance only becoming neutralised on crossing the frontier into Holland. In the original article, details are given of the troops left in the fortress after the Belgian Field Army was withdrawn therefrom, and the military situation which the Governor of Antwerp was called upon to deal with is also briefly discussed. M. Fleurier finally seeks an answer to the question: Could a more effective defence of the fortress than actually took place have been put up? An interesting examination is made of the course of events, and tables are given in which is set out the damage done to the several Belgian forts by the German artillery, the dates of construction of these forts is stated, the numbers of shell of the different calibres fired at each of them, the numbers of hits, the duration of the bombardment of each of them, the causes and dates of the evacuation or surrender of each fort and the casualties suffered by its garrison being also recorded in a concise and clear form. It would appear that M. Fleurier is of opinion that false hopes were raised at the Headquarters of the Belgian Army as to the assistance which would be given by the British in connection with the defence of Antwerp; the final conclusion at which he arrives is that the reason why the defence of the principal line broke down so quickly was due not so much to the defects in the fortifications and the armament of the place as to the poor quality of the troops told off to hold the fortress; their *morale* was not of the quality which enables troops to fight to a finish. For this reason, so far as the siege of Antwerp is concerned, it is a *leçon morale*, says M. Fleurier, rather than a *leçon technique* which is to be learnt from the study of the operations in connection with the defence of Belgium's citadel in 1914.

Among other articles of interest in the numbers of the *Revue* under notice are two relating to defence against aircraft; one by Lieut. Vaucher entitled *Artillerie contre avion* (in No. 5), and another by M. R. A. Jaques entitled *La défense contre avions* (in No. 6).

W. A. J. O'M.

HEERESTECHNIK.

(*April, May and June Numbers.*)

THE motor engineer will be the most interested reader of these numbers. The articles which deal with this subject are as follows:—

The tasks in front of the German Motor Industry.

The Problem of the Multi-Axle drive.

The "Servo" Brake.

The three-cylinder double action motor.

The improvement of the explosive mixture by an automatic air inlet and by the heating of the mixture.

Spray or compressor motors.

The articles quoted above all deal with points of construction, and the following articles deal with the use of the vehicles :—

(i) Dr. Teubner describes the activities of lorries in supplying the Occupied Territories on the Rhine during the French control of the railways. Very efficient systems would appear to have been inaugurated for supplying foodstuffs, milk, coal, etc., and the moral is drawn that the existing railway system could and should be considerably amplified by auxiliary motor systems in peace.

(ii) The mechanicalization of the modern Army. This is a lengthy summary of Colonel Fuller's lecture to the Royal United Service Institution—a lecture which meets with the reviewer's warmest approbation

In the April number, in addition to its motor construction details, there is a short article on Primary and Secondary Cells and Accumulators. It is one of those short, descriptive articles meant for the education of all arms in the principles and instruments of the technical services. There is nothing of particular interest for the English reader.

In the May number, an unsigned article giving an extract from a letter from one of the Directors of Krupp's shows the amount of machinery which has been destroyed as directly serving gun manufacture, and estimates the damage at 102,000,000 gold marks.

In the same number, Mr. Baumgart has an article on the Military Map of the Future, which is taken almost direct from the *Military Engineer* of September and October, 1923. The idea of this article is that the map of the war of the future shall portray the features of the ground, not only by contours, but by a form of shadow shading. Such arguments are, of course, based on the idea of a protracted trench warfare, because in any other form of operations the reproduction of such maps with the necessary rapidity would be quite out of the question.

Major Geyer continues the discussion on Tactics and Technique, which is part of a controversy beginning with a half-hearted attack upon the General Staff for its lack of technical knowledge and sympathy. This attack was somewhat paternally reproved and the author is now explaining that he did not mean it.

Major Klingbeil, who contributes a good deal to this magazine on matters of fortification, has a short notice on Part 3.A. of the *Manual on Bridge Building*—" Heavy Bridges."

In the June number, Major Klingbeil summarises the main features of the new *Manual of Field Fortification*, Part 1, and their tactical use. He describes the subject in this way :—" Field fortification is tactics dug into the ground." German pre-war notions of defence dealt mostly with a single line, but one improved in every possible way. Distribution in depth is now established, and a great deal of emphasis is laid upon camouflage and concealment. Splinter-proof is, of course, cover against splinters of light and medium artillery. Shot-proof is proof against

several direct hits from the 15 centimetre or single hits from a 21 centimetre; and bombproof is cover against several direct hits from a 21 centimetre and single hits from heavier calibres. Storm-proof applies to a position in which shot-proof gun positions are provided and which is guarded by sufficient obstacles to tanks. Field fortification in the attack is very much emphasised. "An infantry attack over fairly open country against an enemy equipped with modern weapons is bound to be most costly in life, even when covered by a superior artillery, without entrenching. The use of a spade lightens the approach to the enemy, makes it possible to hold what has been won against heavy counter-attack, and provides opportunities for a further attack." In moving warfare the attacker must be content with ordinary trench work. Artillery and heavy infantry weapons (trench mortars and heavy machine guns) are busy from the first in improving their cover and camouflaging themselves. Rifle and Lewis gun sections dig themselves in as soon as enemy fire prevents further advance. They dig themselves in at varying distance and in depth. Against important and fortified field positions all arms dig themselves in deeper, but after the same general pattern. Possibly under these conditions shallow communication trenches are made. In position warfare, the procedure is exactly the same, or, at any rate, follows exactly the same principles, which are that protection against enemy artillery fire is not in the strength of the actual field work, but in its distribution in depth and breadth, and in its camouflage. In the defence, this distribution is even more emphasised and camouflage made more important. The position of the infantry line of defence is labelled as comparatively unimportant with regard to field of fire, whereas the view for the field gun and the heavy machine gun is insisted upon. In certain cases where observation may be got from higher ground behind or to the flank, the infantry may even be withdrawn to the reverse side of a hill. In all cases, it is the artillery observation which is emphasised. This article is to be continued.

Mr. Heyer has an article upon Explosives in Mining Warfare, illustrated by one or two diagrams and explaining the tactics of mining in the War. There is nothing in this article of importance to English readers.

H. ST. J. L. W.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*May-June Number.*)

The Question of a Decisive Victory East of the Tagliamento in October 1914. General Krauss thinks, very definitely, that such a victory could have been won as would have put the Italian Army out of action. The failure was due to the lack of definite determination and to the "sector" tactics of the war. If each Army is to go straight ahead in a pre-arranged strip how can you roll up and destroy the enemy? The Marne Battle was a case in point.

As evidence of the lack of will, he quotes H.M. Kaiser Carl, who said to him, "We shall have to prepare for that in its turn (the crossing of

the Tagliamento). Even so we shall have got too far, for our railways cannot manage more. We simply want to get to the Tagliamento." The right wing should have been pushed forward and then swung left to push the Italians to the sea. The German group on Krauss' left (26th and 200th Divisions) got going faster, however, and over easier country. They could have, and wanted to, swing left and cut the Italians off from the Codroipo bridges. But to every request from whatever commander to exploit the victory by a "right shoulder up" the higher command objected. The will to win was not there, and the tactics were all wrong.

The Second Investment of Przemysl is continued by Major Stuckheil. The sortie of the 15th-18th December, 1914, left an unquiet front, which "stabilised" just before Christmas. During Christmas an unofficial truce gave everyone three days' quiet, and then the Garrison were called on for another sortie on the 27th and 28th. The Russians meanwhile had very considerably strengthened their defences. Altogether 18 Battalions, 2 Squadrons and 15 Batteries were told off for this sortie—but the account breaks off here.

Instruction in the Military School, by Colonel Anton Kainz, gives some very practical advice on the bearing and programme of the officer instructor (or, as he should rather be—teacher) and the analysis, partition and presentation of his subject. A short example of instruction on hand grenades is added.

Tactical Exercises; No. 1. In the last number this first tactical exercise was explained and worked out up to a certain point. It is now concluded. The exercise is worth studying.

Mountain Troops. By Colonel Schubert. This article is partly historical and partly propaganda for the mountain troops of the present day. There is nothing of importance for English military readers.

The Progressive Education of Officers of Different Armies. This point has already been discussed (in 1924) in this journal. French, Italian, Czecho-Slovakian, Roumanian and Swiss institutions are described, and it is of a certain interest to see them written up together and compared.

Artistic Smoke Screening. By Captain Fritz Heigl. In preceding numbers this subject has already been dealt with in very interesting fashion. The author now turns to the question of the smoke screening of the "home front." To awaken the proper interest in matters, the author starts by picturing England and France in the usual way as composed of men of ruthless disposition, who are systematically planning the extinction of life in Central Europe by gas, the total destruction of their cities, and the burning of crops and even of woods. Having reached the proper atmosphere, he proceeds to take as an example the city of Budweis (the capital of Southern Bohemia), and he works out very interestingly and with good illustrations how this town could best be camouflaged by smoke screening, with a view not only of hiding the town itself, but of deceiving the airmen as to its true locality. He then works out how much personnel and material he wants to carry out his

smoke screen and bases his figures on Colonel Chédeville's article in the *Revue Militaire Française*. He does this because he considers that Czecho-Slovakia, like other countries of the Little Entente, would be persuaded in the event of war to purchase French material dating from the last war. He makes an interesting little suggestion in the course of this article as to the use by civil inhabitants of some sort of smoke-producing material, which could be thrown upon the ordinary fire or kitchener. One feels that he might have gone a little further.

The author then discusses the question of smoke-screening on river lines and other natural guides to marauding airmen. He thinks that they could be not only disguised, but apparently shifted in position by putting a thicker smoke screen along a fictitious line, whilst the river itself was screened less heavily.

Captain Fritz Heigl is full of ideas and we commend his article to those cold-blooded schemers to whom allusion has already been made.

Camouflage Painting of Field Guns. By Captain Ludwig Heindeman. The value of this article lies mainly in the good little illustrations which he gives of different types of painting employed on Austrian field guns. The subject is evidently attracting a good deal of attention, and this article will be of interest to those who deal with camouflage and with the interpretation of air photographs.

Tanks in Mountain Warfare. By Captain Fritz Heigl. It would appear that in Austria the danger of a tank attack has been discounted to some extent in view of the mountainous type of Southern Austria. The author thinks that the danger does exist and that there are few places in the Austrian Tyrol which could be reckoned immune from tanks with their astonishing powers of climbing; but he points out that defence will be the easier because the avenues of approach are much more clearly defined than in flat country and the tanks would naturally be confined, in many cases at any rate, to Indian file. Artillery should, therefore, have an easier target, whilst the construction of obstacles could be undertaken with some expectation of their being in the right place.

The performances of *Austrian ropeways* in the higher mountains are described by Colonel Edward Lacom. The article is historical rather than technical, and the ropeways proved themselves astonishingly efficient. It is stated that although the number of people who actually travelled on these ropeways runs into hundreds of thousands, there were only 13 accidents and 30 casualties. Since the War some 50 new ropeways have been constructed.

On Military Aircraft of the Present Day. Captain Hans Hännerle writes a short article on modern types, classifying them under the three factors, aero-dynamic, weight, and motor power. The discussion on aero-dynamics leads to a short discourse upon wings, and in particular those made of metal. There is a short table which gives the different motors in use, and under the heading "weight," he describes the different types of scout, reconnaissance, and bombing machines of the present day.

H. St. J. L. W.

THE MILITARY ENGINEER.

(*May-June*, 1925.)—*The Panama Canal after Ten Years.* The early years at Panama were disappointing. The canal was opened on August 15th, 1914, and it was not until two years after the Armistice that any considerable volume of shipping was restored to the routes which it served. Tonnage during 1917, 1918, and 1919 averaged 7,000,000 tons. For 1920, 1921, and 1922 it averaged 10,000,000 tons, and then jumped to 19,000,000 tons in 1923, and to 26,000,000 tons in 1924. By way of comparison, the Suez Canal in 1924 handled 25,500,000 tons.

The capacity of the canal is limited by the locks. It is estimated that these can handle three times the present tonnage. Each lock has a width of one hundred-and-ten feet, a depth of forty feet, and usable length of a thousand feet. For commercial purposes these dimensions are ample. But it is possible that additional wide locks may be required for naval purposes. The latest American battleships have a beam of one hundred feet. It is interesting to note that H.M.S. "Hood," which passed through the canal in July, 1924, had a beam of one hundred-and-five feet two-and-a-half inches, allowing a clearance of under two feet five inches on either side.

Up to 1924, the canal did not pay its way. In that year, however, its earnings were more than twice the annual interest figure, leaving a surplus to be applied to wipe out the deficit of previous years.

The future of the canal is bound up with that of the Pacific Coast. Eighty-five per cent. of the tonnage is destined for or originates from these ports. The wealth of this territory has scarcely been tapped. The canal is destined to reap a rich harvest from the developments which will ultimately come.

The Problem of Roads in Campaigns. The author estimates the number of men needed for road maintenance under fair average weather conditions and the traffic of a Division, as a hundred men per mile. A Division would thus require some six hundred men permanently employed on road work, under service conditions. The importance of early reconnaissance and close co-operation with the General Staff during operations is emphasized.

German Crossing of the Duna River. A detailed study of General Von Hutier's crossing in April, 1917. The initial attack was carried out by three Divisions, troops being ferried across in pontoons under a smoke screen barrage. The construction of three pontoon bridges was undertaken simultaneously with the ferrying operations, one of them being for heavy traffic. At the point selected, the river was some four hundred yards in width, the current being sluggish. The whole operation was carefully rehearsed, and proved entirely successful. The writer draws the conclusion that the two principles of war—mass and surprise—are especially important in operations of this kind.

Camouflage Service in the A.E.F. No amount of artificial screening will compensate for indifference to the ordinary principles of concealment. Unless supported by strict discipline in the area in which he is working, the camoufleur can do little good. The Camouflage Service soon

discovered that its principal rôle was to instil into commanders and troops the very real importance of considering natural concealment in taking up positions, the avoidance of regularity, of massed bodies and concentrated dumps, and the necessity for track and road discipline. As these lessons were gradually learnt, it was found possible to leave forward troops to look after themselves and to concentrate the Camouflage Section on road screening, concealment of headquarters, ammunition and engineering dumps.

R.I.M.

VOINA I MIR. No. 16.

AN article entitled "Our Strategical Chances in 1914 (reviewed after 10 years)" by General Sergius Dobrorolski, an officer who held high staff appointments during the War, is of some interest. He propounds the question, "Was it possible for the Russian Commander-in-Chief in 1914 to obtain a decisive victory in the situation in which he took over the mobilised armed forces of the Empire?"

He begins by considering the deployment of the Russian Armies on the western front, which was carried out, in accordance with the War time table of 1910, in from 21 to 26 days, that is, by August 20th to 25th, the first day of mobilisation being July 31st. Of 37 corps, 28 were ready on the western front by August 25th; of the remaining nine, which belonged to distant Asiatic areas, two were left in Trans-Caucasia and seven arrived late on the western front. Besides these, 28 corps, there were 31 second line infantry divisions and 31 cavalry divisions. All these troops were formed into eight armies, two of which, in one group, were used on the north west front against Germany, and four, in another group, on the south west front against Austria-Hungary. On each of the outer flanks was one army, regarded as a strategical reserve.

Against Germany were deployed:

The Guard Corps, 9 corps, 11 second line divisions and 9½ cavalry divisions; in all 30 infantry and 9½ cavalry divisions.

Against Austria-Hungary:

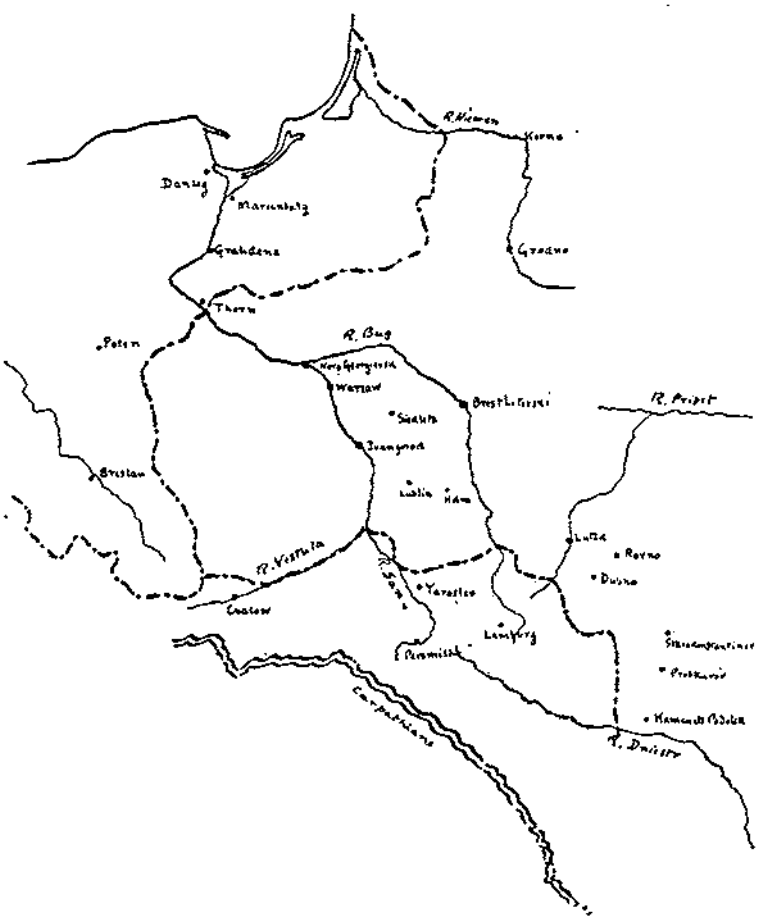
Sixteen corps, 13 second line divisions and 18½ cavalry divisions; in all 46½ infantry and 18½ cavalry divisions.

In strategic reserve there were two corps, seven second line divisions and three cavalry divisions, in all 12½ infantry and three cavalry divisions.

In percentages the distribution of the Russian forces are thus represented:—Against Germany, 33.7; against Austria-Hungary, 52.2; in reserve, 14.1.

According to "the fundamental considerations on the deployment of our armed forces in the event of war with the powers of the triple alliance" as affirmed on September 23rd, 1913, the plan of war was thus expressed: "An advance against the armed forces of Germany and Austria-Hungary with a view to carrying war within their boundaries." This implied an advance along the whole front from Kovno to Kamenets

Podolsk, on a front of 700 kilometres. Russia was actuated by motives which were really conflicting. The advance against Prussia was prompted by a desire to recompense France for her financial assistance in the years preceding the war and for her ready support in July, 1914. At the same time the Russians wanted to inflict a swift and crushing defeat on Austria, against which she had been "sharpening her teeth" ever since the Crimean War, and especially since 1908, when the annexation of Bosnia and Herzegovina took place. Moreover, defence against possible hostility on the part of Sweden, Finland, Roumania and Turkey had to be thought of.



The invasion of Eastern Prussia in which over 30 per cent. of the total Russian forces was employed was a mistake. That province is isolated from the rest of Germany by a broad river, the Vistula, with four fortresses—Danzig, Marienburg, Graudenz and Thorn—on a stretch of 150 kilometres. Eastern Prussia would not have formed a suitable starting place for the invasion of Silesia and Posen, and an advance on Berlin. Even if the occupation could have been carried out without

difficulty, there was no reason to suppose that a crossing of the Lower Vistula could have been easily secured in view of the lack of siege artillery, and of artillery resources of all kinds. If the supremacy of the Russian fleet in the Baltic could have been relied on, the occupation of Eastern Prussia would have facilitated landing operations. The French evidently had little faith in the usefulness of the campaign in Eastern Prussia, as even before it began they insisted on the desirability of a blow on the part of Russia towards Posen, and in compliance with this request two new armies—the 9th and 10th—were formed at Warsaw to operate against Thorn—Posen and Posen—Breslau.

The sixteen corps allotted to the Austrian front were inadequate for their task, namely, the complete defeat of the Austrian armies, and were incorrectly distributed. Long before the war it was known that the Austrian force in Galicia would concentrate in two groups, a large group facing Poland for an advance between the Vistula and the Bug (in touch with a German army advancing from Eastern Prussia) and a smaller group facing Kiev to cover the flank of the other group. The Russian distribution, however, allowed for an equal force against each group.

Plans are given showing the distribution on the whole front as actually carried out by the Russians, and what General Dobrorolski considers would have been a better distribution on the Austrian front using the same units, with the addition of the two corps of the strategic reserve and the Guard Corps (originally allotted to the First Army, but transferred to Warsaw as part of the Ninth Army). The idea briefly consists in massing 14 corps against the right and right flank of the Austrian attack, leaving an army of five corps between the Vistula and the Bug, with a strong cavalry force on the left bank of the Vistula. The rôle of this army would be to oppose an advance on the line Ivangorod—Brest Litovski by means of a strategical defence—a retreat step by step with a skilful concealment of its numerical weakness. Three strong armies composed of the remaining 14 corps would be located in the areas, Lutsk—Dubno, Starokonstantinov—Proskurov, and Proskurov—Kamenets Podolsk. Such a distribution would entail the preservation of the fortress of Ivangorod and improvement of its permanent fortifications, and the development of Brest Litovski into a large fortress of the type of Metz. The chief mass of cavalry must be grouped on the flanks whence raids could be conducted to the rear of the Austrian armies.

General Dobrorolski considers that if this plan had been adopted the Austrians could have been crushed by September 11th, the 43rd day of mobilisation; the gates into Silesia would have been opened and an advance to Berlin might have been possible.

The First and Second Armies in East Prussia might have been reduced to five corps, and four corps released to swell the armies opposing the Austrians. It would have been better to use five corps in a strategical defence on the line Kovno—Grodno than to make a useless invasion of East Prussia.

A. H. B.

NEUE ZÜRCHER ZEITUNG.

The Paradox of the German Offensive of 1918.—The National Assembly at Weimar appointed a Committee of 28 members to investigate, *inter alia*, the causes of the German collapse in 1918, and Dr. Ludwig Herz, one of the members of this Committee, contributes an article under the above title to the *Neue Zürcher Zeitung* of July 23rd. The complete proceedings and findings of the Committee are shortly to be published, "The Causes of the German Collapse in 1918" alone occupying three large volumes. The three chief contributors to this work are: General von Kuhl, well known in Germany for his writings on military subjects, and who during the latter part of the War held the appointment of Chief of Staff to the Army Group of Crown Prince Rupprecht of Bavaria; Colonel Schwertfeger, author of a work in five volumes entitled "Belgian Documents," and who in the present work deals with the struggle between the politicians and the Army leaders; and Prof. Delbrück, the historian, whose share culminates in a bitter attack on Ludendorff as a strategist.

Reviewing the military situation, Dr. Herz asks whether the offensive of 1918 could not have been avoided. He points out that up to the end of 1917 none of the strategical hopes of the leaders of either side had been realised. The "Russian Steam-Roller" had not crushed Germany, nor had the attempted break-through on the Western Front succeeded. The entrance of Italy and Rumania into the War had not been able to bring a decision. The Americans, then beginning to arrive in Europe, relieved the strain on the British and the French, it is true, but they could hardly influence the issue before mid-summer of 1918. On the other hand, Germany's hope of over-running France and then throwing her whole might against Russia, had been shattered on the Marne. Her last card, the unrestricted U-Boat warfare was played, and known in the autumn of 1917 to have failed. Time was fighting against the Central Powers. The War map was eloquent on their side, but they were a beleaguered garrison. The failure of Russia freed Germany's back, and the troops thus released made it possible for her to dominate the situation in the West. Stegemann,* on the 16th February, 1918, gave it as his opinion that the military situation was now more favourable than ever before—indeed, that it was not only favourable in comparison with the past, but that it was absolutely favourable.

In early 1918 many patriotic Germans addressed petitions and memoranda to the leaders of the War Party, asking that if it could in any way be avoided, no great offensive should be undertaken. To one of these, however, Ludendorff replied on 22nd February, 1918, that for the first time since the invasion of France, Germany had the choice between attack and defence, and that only action could bring success.

"This cool answer," says Dr. Herz, "put the situation in too favourable a light. The German choice lay, not between attack and defence, but

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*STEGEMANN.—Stegemann was a military correspondent writing for the *Bund* during the War. His opinions, which were always pro-German, were very widely read in Switzerland and Germany, and were regarded in many quarters as almost infallible. The *Bund* is the semi-official organ of the Swiss Government, published at Berne.

between attack and peace. The Army would endure no longer the murderous battles of position warfare. Men and materials were alike exhausted. The blockade was a strangle-hold on the country. The decision must be complete before the hordes of Americans could make themselves felt. The German General Staff had indeed won the power of taking the initiative on the Western Front, but they must note the passage of time with the same horror as before. . . . The necessity for action, then, as earlier, was forced upon Germany by her enemies. This is the first great paradox of the great offensive—that the Allies forced upon Germany an attack which she feared and wished to avoid.

"Would a break-through of the Allies' lines have brought success to Germany? Stegemann doubted whether the attacks could have progressed much farther than Amiens and Rheims. Kuhl . . . adduces many reasons for doubting whether the Army was sufficiently mobile for open warfare. But even if a break-through had crowned Germany's armies with complete success, it remains doubtful whether her enemies would have been prepared to make peace. Even if France had been removed from the list of active combatants, England would have prolonged the War; England and America would have been able to continue the economic War. They must have continued, otherwise they must have admitted defeat, political and economic, when as yet their vitality was strong, and only their Armies had been defeated in the field. This is the second great paradox of the great offensive—that the threat of it, in spite of the uncertainty as to its result, was a greater incentive to peace than its success would have been.

"This contradictory situation demanded a peace of compromise. The nations, sick of bloodshed, wanted peace. So, with few exceptions, did their leaders. But they feared, by the auto-suggestion of their own propaganda, and by offers of peace which might prove abortive, to weaken the war spirit of their peoples. As both the Anglo-Saxon races were among the combatants, a mediator was lacking. So the psychological moment was lost. Instead of a peace of compromise, without victor or vanquished, after Germany with her request for an Armistice had hoisted the white flag of surrender, came the Peace of Versailles. That has not brought the peace of the World—could not bring it, for in the words of a Frenchman, quoted by the late Lord Bertie, at one time British Ambassador to Paris, 'It contains in itself all the germs of a just and lasting war.'"

T. H. BROWN, Lieut. R.E.

THE JOURNAL OF THE SOCIETY OF ARMY HISTORICAL RESEARCH. Price 6s.

In the July-September, 1925, number Lt.-Col. J. H. Leslie, late R.A., the Editor, commences an article on "The Honourable The Board of Ordnance 1299-1855," and dates its "Origin" from two Conrads, father and son, who were *Attillators*, i.e., chief engineers in charge of the *ingenia*, military engines, at the Tower early in the 14th century. *Attillator*, from which the word Artillery is probably derived, is mentioned by Porter in his *History of the Corps of Royal Engineers* as a new name introduced

at this period for the official " to whom was entrusted the repair of permanent works and also the working of the engines of war—in fact, the duties which have hitherto been shown as falling to the lot of the *Ingeniator.*" Colonel Leslie gives an interesting illustration of the *Berfrarium,* or belfry, a moveable tower used in sieges, one of the engines. He also mentions Nicholas Merbury (1414), " Master of the Works, Engines, Cannon and other kinds of Ordnance of War." The history of the Board of Ordnance should be full of interest to Royal Engineers.

Under " Questions " mention is made of some old fire locks, buff coats, bandoleers and plug bayonets which were unearthed a few years ago in the crypt of Rochester Cathedral and are now preserved there in a glass case. Two of the muskets are marked with the badge known as the Jerusalem Arms, and one is dated 1700. The buff coats have green velvet facings.

F.E.G.S.

COAST ARTILLERY JOURNAL.

(*December,* 1924).—*Development of Anti-Aircraft Artillery mentioned in the Annual Report of the Chief of Coast Artillery,* 1924. Four new types of guns and carriages are being developed, owing to the shortage of modern armament in the United States Army.

The .50 calibre machine gun has passed preliminary tests. It has a rate of 450 shots a minute.

A 37 mm. Automatic machine gun is under test, with a muzzle velocity 3000 f.s.

The 3-inch gun on fixed mount has been approved for production. Nine guns will be built in 1925 for Panama. The 3-inch gun on mobile mount has not yet passed all tests.

Difficulty of design has delayed progress in the development of the 4.7 inch gun.

The Anti-Aircraft Artillery is without any efficient apparatus for the location of aircraft at night by sound, and without a satisfactory plotting board, though a French one is being purchased for test by the Coast Artillery Board.

Smoke and Coast Artillery. An enemy must take heed of a smoke barrage because he cannot foretell what it means. A smoke curtain six hundred feet high can be dropped from an aeroplane by the emission of a mixture of titanium tetrachloride and carbon dioxide, at a speed of a mile a minute. Any combination of length, height or shape, can be obtained by using a number of aeroplanes, flying one behind the other. Poisonous gases can be sprinkled as easily as titanium tetrachloride.

Experiments carried out by Battery "A," Sixth Coast Artillery, to test the effect of battery target practice when all ranks were protected from gas by a new gas mask proved that it was suitable for use with optical instruments and only lowered the rate of fire of series of ten rounds from 2 minutes 50 seconds to 2 minutes 57 seconds. Before the gas alarm five hits were signalled, after masks were assumed four were made.

D. M. F. H.

CORRESPONDENCE.

The Secretary, The Institution of Royal Engineers.

SIR,

With reference to the June *R.E. Journal* "Modern Scheme of Water Supply," p. 258, it is stated that sterilisation by gaseous chlorine cannot be recommended for use in a comparatively small installation, as under consideration in the essay, on account of prime cost, and need of skilled supervision. The author is apparently misinformed, as the cost of an apparatus dealing with 1,000,000 gallons per diem, manufactured by the United Water Softeners (Imperial House, Kingsway, London, W.C.2,) is £170, and that for 10,000,000 gallons £240. The cost of chlorine, allowing for transport to the tropics, would not exceed 10s. per 1,000,000 gallons. The apparatus is simple and does not need skilled supervision.

The United Water Softeners have installed at Weedon Barracks a Wallace-Tiernan Chlorinator dealing with 11,000 gallons per diem at a cost of about £170.

I enclose a list of particulars required for a quotation by the firm, in case it might be of value for R.E. officers abroad. The *D.F.W. Technical Instruction*, No. 64, of 31st December, 1924, refers to this firm.

Yours faithfully,

A. W. SPROULL, Captain R.E.

PROPOSED INSTALLATION OF "WALLACE-TIERNAN" CHLORINE GAS ADMINISTRATOR FOR WATER STERILISATION

Particulars required for Quotation.

(1) Rate of flow per hour. Maximum.....Minimum.....

(2) Is the rate of flow constant throughout the 24 hours?

(3) If fluctuating, are fluctuations from moment to moment or only by wide amounts as between different times of the day? Are such fluctuations uncontrolled or controlled?

(4) Is it proposed to treat the water in the mains or in an open trench or reservoir?

(5) If to be treated in the mains, give the maximum and minimum pressures.

(6) Is the water pumped? If so, give type and capacity of pumps.

(7) Is the water delivered direct to mains or into an intermediate reservoir?

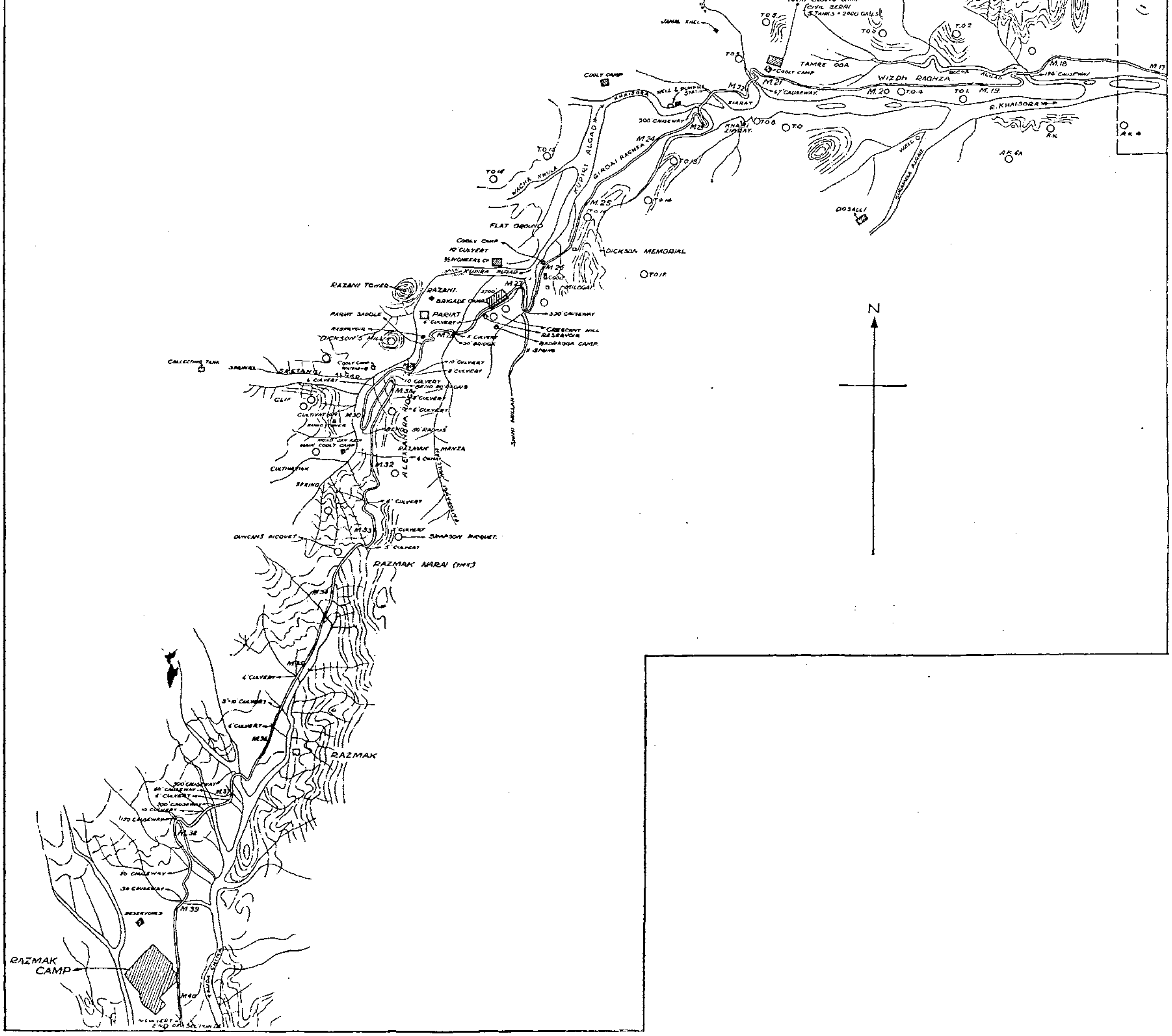
(8) If delivered direct to mains, what time elapses between leaving pumps and reaching first point of consumption? If delivered to reservoir, state its capacity.

(9) Are filter beds or pressure filters employed?

(10) Have you at the proposed point of application a water pressure in the neighbourhood of 15-20 pounds to the square inch?

(11) If possible, kindly send us a rough diagram showing the general arrangement and route of the water from its source to the distributing system.

ISHA RAZMAK ROAD. (Sheet 2.)



LONGITUDINAL SECTION OF ISHA RAZMAK ROAD.

SCALE: HORIZONTAL 1" = 1 MILE.
" VERTICAL 1" = 300 FT.