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FOREWORD

THE AMERICAN SECTION S.M.E.—As many officers of the Corps will know, an American Section was attached to the S.M.E. for just over eighteen months.

In this short period, the Section became an integral part of the S.M.E., accepted on the same level as the other individual Schools. This might have been taken as a matter of course, but the close co-operation was due in the main to the tact and understanding which the American Commanding Officers showed from the start. Comparisons between the devices and methods employed by the two forces were always freely discussed and examined with a view to furthering knowledge on common problems. This spirit of co-operation was evident throughout all ranks.

A short note on the history of the Section will be of interest. About six months after the entry of America into the war, an advance party of American Engineer Officers and N.C.O.'s arrived to study the latest information on Bridging, Mines and Demolitions.

About six weeks later, in the middle of September, 1942, the American Section, commanded by Major H. C. Trask, started its first course using its own and British instructors. In November, 1942, Major Trask left, and the Section was taken over by Major Charles T. Allen, who continued in command until April, 1943, when Lieut.-Colonel H. E. Webster arrived to command the Section, which had by now trebled its strength.

In December, 1943, the American Section left to found its own engineer training establishment as a separate entity. Major Allen remained to act as U.S. Liaison Officer at the S.M.E., and in this capacity maintains the very necessary and helpful personal contact between the two training Schools.

During the time the American Section was here approximately one thousand students of the U.S. Forces passed through the School.

Before their departure, the officers of the American Section were entertained at a special Guest Night in the R.E. Mess, when Lieut.-Colonel Webster, on their behalf, presented to the S.M.E. a handsome piece of plate as a souvenir of their stay here. This gift is a silver dish, a reproduction of a design executed by Paul de Lamarie in 1729. Two photographs of it are shown in the Frontispiece.

It is felt that officers of the Corps throughout the world would like to know that we already have a permanent memento of an association of interests and activities which has been of the greatest value at the S.M.E. and is typical of similar co-operation now being actively pursued wherever we have interests in common.

Long as may be the life of this piece of plate, may the spirit of comradeship and common interests which it represents be maintained far longer.

THE "HULL" BRIDGE ACROSS THE RIVER SHATT-EL-ARAB, AT MARGIL (BASRA) IRAQ

By Brigadier G. B. Gifford Hull, C.B.E., M.Inst.C.E.

In November, 1942, G.H.Q. Paiforce ordered the R.E. to build a bridge across the Shatt-el-Arab River at Margil, to carry the 28 ton tank on its transporter, a load of 56 T, and a metre-gauge railway, load 61 T, to connect the Iraq State Railway system, feeding the recently extended Docks, with the standard-gauge Persian railway which had been built from Ahwaz, *via* Khorramsha, to Tanooma, about 2 miles downstream on the opposite bank of the river from Margil. The bridge had also to carry road traffic, and a road had to be built through the date palm swamp into the desert beyond to connect with the desert road, or track, to Ahwaz 80 miles to the East. High priority was given to the work.

It was essential the bridge should be built in such a manner that the river traffic would not be interrupted. At the time this touched 1,000 tons per day up the Tigris to Kut, carried by paddle steamers towing barges, tugs towing barges, and local sailing craft. The paddle steamers, the biggest craft used, were 60 ft. wide overall, with their funnels some 40 ft. above water. The I.W.T. required a minimum of 76 ft. clearance between piers for these paddle steamers.

The Shatt-el-Arab is formed by the junction of the Tigris and Euphrates. At Margil it is about 1,800 ft. wide and tidal with a variable range, up to 5 ft., depending upon the water conditions in the two large rivers which feed it. The difference in water level between the low tide dry weather flow, and high tide flood flow is about 12 ft., with a current rising to 4½ knots.

The bottom is soft mud to a depth of between 20 and 25 feet, gradually hardening to a fairly stiff clay at about 35 ft. The depth of the water at dry weather low tide is approximately 35 feet.

About half way across the river is an Island, called Coal Island, which was used as a dump for Stores and personnel camps, and it was decided that the bridge should be carried to this Island and thence to the Persian side. This siting made a good railway alignment possible from the Margil Docks with a slow curve from shore to bridge.

Design

The only solution to meet the loading and other conditions imposed by G.H.Q., with the material available, was to build a piled structure, incorporating a span wide enough to let river craft through, and which could be moved by such appliances as could be made on the spot in a small R.E. workshop.

Several methods of solving the problem of the moving span were considered, and the most practicable seemed to be to lower the span into the water to a depth sufficient to clear the keels of the paddle steamers, which have a draft of 9 ft. when fully loaded, and so allow them to pass over, instead of under, the bridge. Swinging from a central pier called for double the amount of bridging material, i.e. more than was available, and to construct the moving mechanism was beyond the capacity of the workshop.

Similar disadvantages were involved in sliding the span back on the fixed part of the bridge. Lifting it on a hinge, as a bascule, involved a tower, and shop work mechanism, which could not be made quickly. Lifting it vertically on four towers, using counterweights, was practicable, but, due to the height of the funnels, required towers about 50 ft. high, and there was no practicable way of bracing them against the strains set up by a high wind acting on the span while it was at its maximum height in the air. Winds up to 70 miles an hour occur in the dust storm season.

On the other hand, if the bridge span were dropped into the water, the current, of up to $4\frac{1}{2}$ knots, would push it downstream whilst submerged, possibly hard enough to cause undue pressure against the piers, and create friction to an extent that would make it difficult to elevate the span. Further, the span would have to be strong enough as a beam to withstand the water pressure acting on its side, without deflecting. Points in favour of submersion were : the lifting towers need only be short frames, about 10 ft. high, to accommodate pulleys and lifting tackle ; the necessary shop work was simple ; the moving apparatus would be simple ; and, as the bridge span would lose weight when submerged, the strain on the ropes would be correspondingly less during the time they were under prolonged load. Also it could be lowered into the safety of deep water in the event of air attack.

The bridging material available was stock "operational" types, *i.e.*, the "Inglis" and "Mark 11 Large Box Girder" with a fair quantity of R.S.J's of various sections, and angle irons. The Large Box Girder is made up in lengths of 10 ft. 6 in., joined by pins and plates of chrome molybdenum steel having a maximum working stress of 42 tons per sq. in. Otherwise the bridge is constructed of high tensile steel with a maximum working stress of 11.25 tons per sq. in. Intermediate and shore sections are 10 ft. long, and a 2 ft. bearing is necessary at each end. Thus, the span was made up of 5 standard sections, 2 intermediate and 2 shore, making a total length of 92 ft. 6 in. and, allowing for end bearings, a net span of 88 ft. 6 in. Calculation proved that four girders could carry the vertical and horizontal loads if they were suitably stiffened and cross braced. After the necessary stiffening had been designed, utilising stock R.S.J's and angle irons, an attempt was made to calculate the effect of moving water on the various parts of the bridge during submergence, including the cumulative effect of the small vacuua which might form behind each member. This proved tedious and was not successful ; and in the end it was decided to assume that the bridge opposed a solid surface to the water, and to design accordingly. On this assumption a pressure of 9 tons could be expected to act sideways against each of the piers, and in order to reduce friction between span and piers, rollers were made from a piece of old propeller shafting discovered during a search round the docks for suitable material, and were fitted to the shore ends of the span, in 3 positions. Each roller was hinged on a vertical pin, so that it could automatically seat itself against the sheet piling forming the recess in the piers, if any of this piling were driven off a true line, which was likely.

The only suitable lifting gear, immediately available, was 6 ton hand winches, and it was decided to use these, in conjunction with counterweights which, taking friction in pulleys, etc., into account, would still keep the effort needed at each winch within two tons. The calculated time for moving the bridge with this tackle, during its period of greatest travel, was 28 minutes. This figure was important, because it involved a loss to river and bridge traffic equal to the time required for a complete "cut" or "make," and a continuous effort over this period in a temperature exceeding 120 deg. shade, when steel is too hot to touch with bare hands.

In designing the counterweights it was apparent that the vertical height of the cage should be such that its bottom would be well clear of the bottom of the river. Therefore to keep this length as short as possible, the weight must be made of a material with a high specific gravity. Concrete was ruled out on this account. G.H.Q. refused to release lead, in view of the great need of long lead-jointed pipe lines for water supply, and the first weight designed consisted of short lengths of closely packed 60 lb. rail, with the interstices filled with lead. This involved a good deal of rail cutting but was satisfactory in other respects. Fortunately before it was necessary to start making the counterweights, a better material was found. By chance a large stock of steel plates, 8 in. square and ¼ in. thick was found in a store yard, and it was decided to use these. It was thus possible to obtain the desired weight in a mass about 8 ft. high, and 30 in. square.

It was intended to defer the decision as to the precise amount of weight necessary until the optimum was discovered by practical experience. An interesting problem was created by the fact that as the bridge emerged from the water and was gaining weight, the counterweights would be entering the water and losing weight, thus either requiring undue effort to lift the bridge, or, conversely, requiring effort to lower the bridge after it was first wholly submerged, depending upon the weight placed in the cages, which could however be varied to suit actual conditions. Further, at that juncture, the weight of the bridge was not known within a ton or two.

The piling material available for the main part of the bridge was either round, roughly 12 in. in dia. or square, 12 in. by 12 in. which was surplus to that obtained, from India, for the construction of the deep water berths at Margil, Khorramsha and Um Qasr. These piles were 30 to 35 ft. long, mostly 30 ft., and it was necessary to splice three together to make up the 85 ft. lengths required. Many of the piles were unseasoned and had twisted and warped since cutting, and only rarely was it possible to make a straight pile from them.

Considerations of economy in timber, sizes available for bracing, capping bearers, etc., led to the adoption of a 10 ft. span between pile bents. It was immediately apparent that such a close structure across the river would, by reducing the waterway, increase the velocity of flow, and so cause scour, particularly at times of high flow. It was essential to provide some additional waterway ; therefore G.H.Q. released enough Inglis material to provide two 50 ft. spans. At this span, the load called for triple tube Inglis and the transomes required stiffening. Even with this additional clearance, it was estimated that the natural waterway would be reduced by 30%, but the situation had to be faced and the risk of scour accepted.

The piles were designed in bents of four, spaced 10 ft., 6 ft. and 10 ft. to suit the centrally-applied heavy loads, with a taper pile at the downstream end of each bent, and with piled counterforts also on the downstream side, at fifty foot intervals, strutted to the intermediate bents. Caps and bearers were 12 in. by 12 in., bracing was 6 in. by 12 in. bolted with two 1 in. bolts, and decking was 6 in. by 12 in., spiked to bearers and finished with a 4 in. tarmac road surface. The counterforts consisted of groups of six piles at 10 ft. centres well braced in both directions.

During the reconstruction, in the early part of 1942, of one of the old docks at Margil it was necessary to extract some of the piles driven some 20 years previously. The pull required to move them was measured, and gave a friction value varying between 9 cwts. and 15 cwts. per square foot of pile per linear foot of penetration. This was for sound, firmly embedded piles. From this data it was assured that for newly-driven piles the value was nearer 5 or 6 cwts. per cu. ft. provided the piles are driven reasonably vertically and well braced and this value was taken in assessing the probable load-carrying capacity of the piles in the bridge. It was decided that all piles should have a minimum penetration of 30 ft. or driven to a set of 10 blows per 3 in. with a 3 ton drop hammer.

The piers for the moving span were formed of a cluster of piles spaced to provide a surface 60 ft. long and 20 ft. wide, with semicircular ends. In the centre of the inner face of each pier a recess was formed 8 ft. into the pier and 15 ft. wide, to accommodate the moving span; to prevent floating debris from massing up against the piles (and against the ends of the moving span) the piers were surrounded, and the recesses lined, with No. 5 Larsen sheet piling in 60 ft. lengths, which was obtained from Middle East. The top of the piers was floored with reinforced concrete 2 ft. 6 in. thick with the object of providing suitable foundations for towers and winches, and of tying the piling securely together.

The recess of 8 ft. into the pier may, at first sight, seem unnecessarily deep; but as this type of bridge is made up in sections 10 ft. 6 in. long, the next smaller recess possible was 2 ft. 9 in., which brought the load too close to the outside of the pier. This, in fact, was the chief consideration in making the span 92 ft. 6 in. instead of 10 ft. 6 in. less, which would still have provided the I.W.T. with the 76 ft. clear opening between piers.

In its made position, each end of the span was supported across the recess by a box girder made up of two pieces of 24 in. by 9 in. R.S.J. These rested on 12 by 6 R.S.J's laid longitudinally on the concrete forming the top of the piers. Before lowering the span, it was lifted slightly, and the two box girders were drawn back, by a locally made ratchet-operated turnbuckle device sliding on the surfaces of the longitudinal girders, which were kept greased.

As finally designed, on the alignment selected, the bridge consisted of approximately 1,100 ft. of the piled structure crossing the west channel from Margil to Coal Island; then approximately 300 ft. of piled structure from the Island into the East Channel, followed by a 50 ft. Triple tube Inglis span, a 20 ft. pier, the submerging span, a pier, another 50 ft. Inglis span, and approximately 300 ft. of piled bridge to the Tanooma side of the river.

The date palm swamp on the Tanooma side, through which the railway and road had to be built, becomes flooded in the high water season, consequently both railway and road had to be built on a fill 5 ft. to 6 ft. high at the river, gradually decreasing for ¾ mile until the desert was reached; and in order to coincide in level with the beginning of the fill, the bridge across the East Channel was built on a rising gradient of approximately 1 in 250, except for the moving span which was kept level.

To assist sailing craft to pass through the gap, at periods of contrary tide, warping piers were designed, both up and downstream of the west pier, and flush with its inner face. These were 150 ft. long and 12 ft. wide, with bollards at 10 ft. intervals.

Construction

Having regard to the good opportunity this work gave for training soldiers of Engineer and Pioneer units and their usefulness when trained, in work of this kind in other and future campaigns, it was decided to do the work entirely with military personnel. Men with no previous experience in piling were selected from various Indian Engineer and Pioneer Units, and from one British Unit, and were put to work, first on the erection of floating and cantilever land plants, and splicing piles, and later on pitching and driving, bracing, decking, etc., the instructors being various Officers and N.C.O's who had had the necessary experience.

The first floating plant was at work in the West channel in December, before the designs of the more complicated work in the East channel were settled, and by January piling work was well in hand with three plants. Due to the intelligence of the selected crews, and the patience of the engineer officers, who were responsible for training, the men soon became proficient and progress was good.

Early in 1943, six weeks before normal, the river made an unusually early rise and prevented much of the low bracing from being fixed. As much as possible was done during the period of slack water at low tide, and special parties were turned out for this purpose, both day and night, within a few minutes of low water being reached; but in spite of that, much of the bracing had to be fixed at a higher level than was designed, leaving sometimes 35 ft. of unsupported pile, and thus introducing an element of instability into the structure. Later, a method was devised under which low bracing could be pre-fixed to the pile before driving. This was tried; it proved satisfactory and was adopted for such piling as had not then been driven in the East channel. But much of the piling in both channels remained unduly high until low water arrived in the autumn of 1943, when it was lowered.

From the Margil side to Coal Island, the alignment of the bridge was 12 degrees off a line normal to flow. This was in order to provide the curve demanded by TN from shore to bridge. The pile bents were, naturally, driven parallel to the line of flow, to offer as little obstruction to flow as possible. Thus, it followed that only in one direction could the bracing fit flush to the side of a pile; it was considered that this condition was more important in a direction parallel to the flow, and that bracing should embrace firmly a complete bent. Longitudinal bracing therefore had contact only with a corner of a pile, which was adzed down to give a 4 in. bearing.

Triangular wooden chocks were first fitted between bracing and pile, to give a better bearing, but this involved great accuracy in cutting and fitting the chocks, costing valuable time, and was not successful. As an experiment a reinforced concrete junction-box, enclosing pile and bracing, was tried instead, and kept under observation. It proved to be successful, and had the advantage of reducing the demand for carpenter's labour.

As piling and bracing proceeded, and greater impediment to flow resulted, the current increased, and the accurate pitching of piles became more difficult. Sometimes it was necessary to pitch them as much as three feet upstream of their true position, as they might well be carried thus far downstream from the time they left the leaders until they ceased sinking into the silt under their own weight; and it says much for the patience and gradually acquired skill of the piling crews, who possessed no previous experience, that so few of the piles were driven out of position. In no case was the error great enough to affect the bracing adversely.

As the timber decking was completed, and before rails and road surface were laid, the taper piles were driven, starting from the Margil end. To drive these a land frame was tilted back to an angle of 30 deg. to the vertical by building it up on a wedge-shaped framework of 12 in. baulks. The longest piles which the frame could handle were used for this work, but the set generally obtained was disappointing. After driving, the taper piles were braced to the bents of the main structure.

Piles forming the counterforts were driven with a float-plant with the frame erected at the end of a pontoon. These piles were vertical.

Normally the decking of the Large Box Girder is of timber. The difference between the weight of timber in air and its weight, or lack of it, in water, caused a wide variation in effort at the winches, because if the counterweights were light enough to allow the timber-decked bridge to sink under its own weight in water, too great an effort was required at the winches to raise it in air. It was therefore decided to deck the moving span with 5 in. by 3 in. R.S.J's laid longitudinally and touching each other, and clamped transversely to the bridge at appropriate intervals by flat steel bars. Wooden sleepers were used only for the railway track. In its finished state, with stiffening and steel deck, etc., the moving span weighed about 61 tons.

While piling was in hand, the necessary work to stiffen the box girder was being done, the lifting frames were being built in the R.E. workshops, and preparations made for testing the completed span. It was decided to test the bridge, under its full tank and railway loading, also the lifting arrangements, before final erection. For this purpose a trench, big enough to accommodate the span and allow for a downward movement of 3 ft., was dug at a site convenient to the railway system of the Shaiba Base, 12 miles in the desert from Margil, and the bridge erected in it, with a 50 ft. triple Inglis span at each end of it. An existing railway line was diverted across the bridge, and the lifting frames with counterweights suspended in a temporary manner from wooden tripods, were erected. The four winches were bolted to concrete blocks, two at each end of the bridge and sidelong to it.

A Sherman Tank on its Transporter and a railway engine drawing loaded trucks (61 tons) were driven across the bridge several times in each direction at speeds of about 7 miles per hour, and the deflections in each case were measured. Each girder deflected an equal amount, 2⅝ ins., thus proving that the lateral bracing had effected equal distribution of load. The girders regained their normal position when the load was taken off.

The bridge was then lowered into the trench, first by lifting it 6 in. and sliding back the bearers on which it rested, and then, when they were clear, by slackening the winch brakes and checking the speed of travel by two men on each winch handle. The operation was repeated several times, while N.C.O's stood by at each end to keep winch men turning evenly to ensure reasonable horizontality of movement. During this test, the speed of travel, both up and down, with winches in low gear, and with no undue straining by the winchmen, was 6 in. per min., which was considered somewhat slow. The test gave what were considered to be entirely satisfactory results, with promise of improving the speed of travel later. In actual practice, after the bridge was in operation, the time required for each " cut " and " make " was 20 minutes.

After the test, the span was dismantled and taken to Margil for re-erection at one end of one of the wharves, from whence it was proposed to float it to the bridge, assembled and painted and to set it in position in one piece with the 100 ton Port floating Crane. In re-erecting, rivets were used instead of bolts. Each rivet was inspected by an Officer and any faulty ones removed and remade. The triple tube Inglis spans were also re-erected at the wharf, placed on pontoons and floated to the bridge.

Early in July, 1943, and just as the piles forming the East abutment of the Eastern Inglis span had been driven, but not braced, the Euphrates, in a sudden rise, reached the highest flood level recorded for 17 years, causing a current in the Shatt which exceeded 5 knots. It carried away the 4 unbraced piles. One of them behaved in a most unusual, if not unique, manner, by moving 6 ft. downstream and remaining vertical, thus indicating movement of the bottom. Soundings showed that the river bed adjacent to the eastern pier was scoured to a depth of 20 ft. below its original level. The situation was stabilized by replacing the scoured material with some 2,000 tons of stone, through which the piles forming the abutment were driven when the current had sufficiently subsided three weeks later.

Following this flood, tests were made to ascertain if the flood had affected the piles forming the pits in the piers, into which the counterweights would be suspended when the bridge was in its "made" position; and they showed that two of the piles, one in each pit, had moved at the bottom and had inclined to such an extent that the counterweight cage could not be lowered to its full length of travel, but fouled the pile some 15 ft. below bridge level.

It might have been possible to withdraw and re-drive these piles, but apart from being a troublesome operation, it was considered to be risky, as the piles might have broken, causing other complications; and it was decided not to attempt it. This decision forced the abandonment of the original plan of lowering and lifting the span from short frames, and it was necessary to substitute towers sufficiently high to make up for the lost length of counterweight travel. These were built up of $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ angle iron, each pair being connected at the top laterally by a framed truss, also of angle iron.

The target date for the completion of the bridge was June 30th. That part of the bridge between Margil and Coal Island had been completed, with rails and road surface, some weeks before that date, and was in use. The part from Coal Island to the first Inglis span was also complete, together with both piers, and except for the bent which had been carried away, the bridge to the Tanooma side was also complete. G.H.Q. had completed plans for the diversion of Russian and other M.T. convoys to the bridge route to begin on July 10th, but the set-back described above made it impossible to complete the work in time for G.H.Q's plans for the 10th to be put into action. That fact forced the construction of a boat bridge, to carry a Class 24 load (heavy M.T. etc., up to 24 tons) as a temporary crossing of the East channel, with a movable section of 100 ft. in the middle of the channel, which was cut and made by a tug towing the boats as one unit. This was completed in five days by troops of an Indian engineer battalion, and no interruption of "Q's" plans resulted. The boat bridge was removed after the piled bridge had been completed the following month.

At this stage in the construction it was necessary to make a programme of the various operations required to make the bridge ready for use. The placing of the submerging span would, of necessity, stop river traffic until the mechanism for moving it was in operation, and it was essential that once the final closure was started, every phase of it should proceed expeditiously and without a hitch, in order that the river traffic should be interrupted over the shortest possible period. The necessary operations were:—

1. Placing the bearers for the moving span and making the turnbuckle connections for moving them.
2. Placing the two Inglis spans.
3. Placing the four towers, with top lateral bracing and with counterweight cages inside; filling counterweight cages each with approximately ten tons of steel plates; fixing pulleys and placing wire ropes for later connection.
4. Placing submerging span, with footwalks and hand rails, and making wire rope connections to counterweights and to winches.
5. Testing lifting gear and making final adjustments.

The Officer in charge of the Port Goliath crane undertook to place the big span with one Inglis span and three towers already in position without damaging them. This was a great help, as it meant that only part of operation No. 2 and 3, with 4 and 5 need be taken into account in preparing the programme of work to be done with a closed river. A consideration of the details of these operations showed that four days were required for the whole job. I.W.T. were so informed and they accordingly made arrangements for the transfer of sufficient stores to the upstream side of the bridge, while

General view of bridge across East Channel. Shows part of emergency boat bridge, and also warping pier.

Placing the submerging span with 100 T. floating derrick.

The Hull bridge - opp p82

the gap was still open, to enable their Tigris fleet working to Kut to maintain its usual schedule over that period.

After the river had been closed, the schedule of operations proceeded smoothly and expeditiously. After the submerging span and the second Inglis had been placed, men could work on the decking, and railway track, while others worked on the completion of lifting gear, etc.

Upon completion of the above work, the bridge was lowered into the water and held submerged for half an hour, then raised and re-seated. After that the bearers were withdrawn and the bridge left suspended by its ropes for a night, with the idea of taking out the initial stretch common in new wire rope. Next day, the bridge was taken into use.

A conference was held between the heads of Rail, Water, Dock, and Road Departments of the Directorate of Transportation, the Port Authority, and the R.E. to determine the periods during which the bridge should be cut and made, who was to operate it, and the signals, etc. The R.E. did not need any form of correlation between times of submergence and the state of tide. The conference decided that the bridge should be in its made position from 05.00 hours to 12.00 hours for M.T. convoys and rail traffic, and in its cut position for river traffic from 13.00 hours to 19.00 hours, and in its made position for the rest of the night; this time-table to be subject to alteration if necessary in the light of further experience. It was also decided that R.E. should operate the bridge until men from I.W.T. were trained, when I.W.T. would take over.

Notes Written after Five Months' Operation.

Scour. It has been shown that an unusually big restriction of waterway was inevitable, and that the possibility of scour had to be faced. Regular soundings taken from the time the bridge was finished showed that scour started on a small scale within a month of completion, and increased as the river rose on the early spring rains to an extent which demanded remedial measures. Accordingly, stone was dumped at the rate of four to five hundred tons a day on the upstream side of the bridge, and as divers reported that the stone remained in position, the method was continued until stability was reached. The big test, however, will occur with the next flood caused by the melting snows on the mountains at the headwaters of both rivers, and information about that is not yet available.

Lifting Arrangements. Was the decision to use short lifting frames, and to allow the whole travel of the counterweights to take place below bridge level, correct?

It involved careful driving of the piles forming the two wells in each pier in which the weights would travel, in unfavourable water conditions, to ensure that the weights would hang perfectly freely and that there should be no obstruction to travel. The difficulties were well recognised before taking the decision, and the dimensions of the wells, and the spacing of the piles forming them, were designed with ample lee-way to cover the driving conditions envisaged. Further, splices in these piles were made with steel plate to avoid the intrusion which a normal timber splice would give; and, in fact, a test made before the June-July flood, by lowering a template into the wells, showed that the piles had been correctly driven and that no impediment to the free travel of the cage existed.

The flood moved two piles, one in each of two pits, inclining them to an extent which prevented full travel of the cage; but if the piling in the piers had been designed differently, as could easily have been done, the piles forming the well need not have been driven at all. In fact, there need have been no wells, and the counterweights could have hung in the water several

Span in position; and towers completed.

The Hull bridge - opp p 83

feet clear of the nearest pile. (In this case, the counterweights would very likely have had a tendency to rotate, causing additional wear on ropes.)

The change-over from short frames to towers was therefore due to the design of the piers; and possibly, if more knowledge of the river had been available, the piers would have been differently designed and no trouble would have ensued.

The main question therefore is; did the extra time and cost involved in the construction of towers, and taking into consideration such risks as may come from high winds or air attack, show a balance in favour of the short frame, when the latter involved a change in weight of the counterweight between water and air, which, in turn, causes a marked variation in winch effort? The answer, of course, depends entirely on the type of winch used.

The real solution would have been to divide the counterweight into two unequal parts, a. and b. with the lighter part b. above the other; and so to design the weights that a. and b. together weigh slightly more than the bridge, but a., by itself, weighs slightly less. Thus, from its made position, the bridge will sink slowly by itself if weight b. is not attached. With the bridge lowered, the counterweight is at or near road level, and as the span is submerged for some hours, there is ample time to attach weight b.; and when the span has to be brought up, the combined weights will do it without winch effort. As the bridge is in its made position also for some hours, there is ample time to bring up weight b. to its position to the top of the frame, ready for its next journey, with a light winch.

Unfortunately, this solution did not emerge until construction on the towers had proceeded too far to permit its adoption.

Submerging the Span v. Raising it. Since the cutting and making of the moving span has been regularly made to a time-table over a period of five months with no trouble, it can perhaps fairly be said that the decision to drop the span, instead of to raise it, was not unsound. While it can truly be observed that, in the event of a high wind-storm occurring while the bridge was suspended 40 ft. in the air, the river traffic could be stopped and the span lowered to safety, it nevertheless might not have been possible to do it quickly, and before it began to sway and to set up such severe strain in the towers as to cause a collapse. It is more consistent with engineer principles to keep the centre of gravity of a structure as low as possible.

The bridge is purely a war-time work, and several features of its design and construction would not be tolerated in normal conditions. All that can be claimed for it is that it meets satisfactorily, for the time being, the military demands for it. It is a useful, perhaps a valuable, link in the great aid-to-Russia chain between the Persian Gulf and the Caspian Sea; and has simplified, to some extent, the movement of the vast amount of military and other stores which, every day, leaves the Gulf and is in Russia a week later.

It is the result of the combined effort of a number of engineer officers and men, who, each in his own task, tried to solve problems and to overcome difficulties by improvisation and by expedient rarely necessary in peace time. There is no special point in mentioning the contribution of all the officers concerned, but it should be stated that the main credit for the bridge belongs to two of them. One is Major R. M. Garvie, I.E., who was given the responsibility for all construction work. He, with the assistance of Sgt. Redpath, R.E., organized the training of the men at the start, and met with skill and courage the several major difficulties which arose during the construction period. The other is Capt. P. P. Seaston, R.E., who was responsible for all steel work, moving apparatus, etc., and who, assisted by Capt. P. C. Glegg, R.E., met and solved his difficulties in the same efficient manner.

THE USE OF GEOLOGY IN THE WAR EFFORT*

By Dr. N. F. M. Henry, Dr. N. E. Odell (late Major, R.E.) and Major W. A. Macfadyen, M.C., M.A., R.E.

1. Summary

IN the Empire at present, the part that Geology can play in war time is undervalued on account of lack of appreciation of its potentialities.

The Report on the Work of the Royal Engineers in the War of 1914-18 states: "Should the British Empire in the future become involved in another war, there can be no question but that the existence of an adequate Geological Staff from the commencement would be the means of much saving of expense, labour and life" (Ref. 1, p. 88).

Geology is not one of the sciences which occupies a dominating position in the war effort, but is of great value to engineers, both in home base countries and at the fighting fronts. The lessons which were learned by bitter experience in the last war have not yet been applied in this, and they, with the uses of Geology in war, are set out in this Memorandum.

In view of the size and varied nature of the fronts on which our troops are fighting or may be fighting, it seems essential that an adequate Geological Section of the Army should be set up.

2. The Uses of Geology in War

1. *Strategical :* The survey of new resources of raw materials for industry to replace those lost; to increase output and reduce transport by developing alternative sources.
2. *Tactical :* To give advice on problems concerned with water supply and the use of rocks and soil (*e.g.* the construction of fortifications and foundations, sites for aerodromes, camps and positions, drainage tunnelling, roads and dams).

As has been well summarised by Prof. W. J. Mead (Ref. 4), a study of terrain for military purposes calls for all available knowledge of surface and sub-surface geological features. The nature and depth of surface soil and sub-soil, its moisture content, and the position of the water table are fundamental to movements of troops etc., away from paved roads and railways, to trenches, dug-outs and earthworks in general; to effects of artillery fire, and in many other important connections. "Solid" geology is needed for deeper sub-surface operations, defensive and offensive, and for all foundation problems. Ground-water geology is vital to water supply problems. Seismology has important uses in artillery ranging. The intelligent use of maps of all kinds—aerial, topographical, and geological—calls for men trained in interpreting surface and sub-surface conditions from maps. Military operations demand all the geological services of peace-time engineering with the added factors of magnitude and speed.

The general lack of knowledge of the use of Geology is clear from the "Fifth Report of the House of Commons Select Committee on National Expenditure" (dated 28/5/40). In 1939 the Air Ministry acquired 160

* A practical example of the value of Geology, as regards water supply, in the El Alamein campaign can be found on page 107.

acres of land adjoining an aerodrome in Scotland for building purposes at a cost of £26,637. This land was "an undrained bog with a covering of peat to a depth of seven feet lying upon a bed of clay . . . and it would be difficult throughout the length and breadth of this country to find any site more difficult and expensive than this." Work on this site was eventually abandoned after £250,000 had been wasted.

3. Work in the War of 1914-18 (Ref. 1)

Early in the war of 1914-18 geological information about northern France and Belgium was urgently needed. It was at first entrusted to the new general section of the Royal Engineers known as F.W.5. In April, 1915, Lieut. W. B. R. King* was appointed as geologist to the Army and for a year he worked alone in this capacity. In May, 1916, Major T. W. E. David, (later Sir Edgeworth David) of the Australian Mining Corps, was put in charge of the work, and later on three more officers were added, making a total Geological Staff in France of five. This was the strength of the section at the end of the war.

In September, 1918, a revised establishment for the Geological Section was proposed. It was to be under the Engineer-in-Chief with a status similar to that of the Camouflage Section, R.E., and others, and was to include seven geologists.

In the United States Army in 1917, Lieut.-Colonel A. H. Brooks, Director of the Geological Survey of Alaska, was appointed as Geologist to the U.S. Army in France, and in course of time he was given an assistant. After consulting with the British Army, the U.S. Army decided to increase their Geological Establishment with the A.E.F. in France to a total of seventeen geologists. Most of these had been appointed before the Armistice.

By December, 1915 the Germans had begun in different parts of the front to include geologists in their Army organization. A Geological Staff, under a former Professor of Geology, was sent to one of the divisions on the western front. A number of handbooks on the geology of the war areas and on problems of war geology were written. By 1917 the German Army had geologists established at each Army and Corps H.Q. A captured German document of that same year declared that geologists had proved of particular value during the first reconnaissance of an area, apart from otherwise in their technical advisory capacities.

4. The Present Position

When the B.E.F. went to France in September, 1939, one Geological Adviser was attached to the Engineer-in-Chief's Staff. Shortly afterwards the French Army, which had previously no Geological Staff, appointed a chief Geological Adviser at H.Q. and one to each Army Group. A second geologist was appointed to the British Army 18 months after the beginning of the war, and he served until recently in the Middle East. Moreover, in that theatre, a South African Section of Engineers has been employed on geological and geophysical work. In addition a geologist was engaged by a Well-boring Company, R.E. Unfortunately there are still too many people who believe in a divining rod, rather than a geologist, as a means of obtaining water!

In Great Britain the Geological Survey is very busy giving assistance on geological problems to various official bodies. The War Office and Air

* Lately Lieut.-Colonel King, O.B.E., M.C., R.E., Geological Advisor on Staff of Chief Engineer, 21 Army Group.

Ministry are now in constant touch with the Geological Survey on matters connected with water supply, drainage, new aerodromes, etc. The Survey has recently produced a small pamphlet indicating to Army Engineers how geological knowledge can be used, but this can only be regarded as a start in this important and many-sided job. The recently formed I.S.T.D. now has a geological section.

In India work is hampered by lack of financial support adequate to the size of the tasks which face a Geological Survey having but 20 geologists in this large country. In 1940, however, the Geological Survey of India produced a good set of "Geological Lectures for Military Engineer Officers" distributed to all R.E. Groups. The intention was to supplement the lectures delivered at the three Engineer Schools of the Sappers and Miners by field work and practical study. The Geological Surveys of Colonial Africa have also been seriously starved of men and money, and it is doubtful if the total number of official geologists in these reach twenty. The contribution to the war effort which they can make is limited by their lack of personnel and funds. Many of their geologists were called away to non-technical service.

5. Measures Necessary for the Efficient use of Geology in our War Effort

In order to give our Army the maximum scientific assistance on all fighting fronts, an adequate military Geological Staff is essential. Out of the hard experience of the last war came the proposal for such a staff, but we are now, in this respect, in the same position as we were in May, 1916. Allowing for the rapidity of movement, common to warfare to-day, questions of water-supply, aerodrome and camp sites, raw materials, etc., are still all-important. The lapse of military mining (tunnelling) in this war should not mean the cessation of all geological advice and direction. It is suggested that a Geological Staff should be set up which would provide geological advice at G.H.Q. and at each front, and all base areas. In view of the scope of modern war this will require an extension of the 1918 proposal.

It is imperative, also, that adequate training in engineering geology be included in O.C.T.U., and advanced or "refresher" courses for military engineers, as similarly it is, or should be, in the case of civil engineers. The American Army, incidentally, now considers it necessary that officers of the Army Engineer Corps, who take a course on the "control of soils in military construction," should attend lectures on "rocks and minerals." This can only be regarded as a minimum requirement.

In Great Britain a great deal of information is in the hands of the Geological Survey, but more positive steps and much more publicity are needed, and only the appointment of Geological Advisory Officers to each Army Command will ensure that full use is made of geological knowledge. In the Dominions, India, and the Colonies which are now, or are rapidly becoming war bases and raw material suppliers, considerable increases in the allocation of technical men, and of money, are urgently required at the present time.

A small number of trained geologists would make a great difference to our scientific war effort. A hundred would set up an adequate Geological Staff in the Army and double the Geological Surveys of India and Colonial Africa. These should be experienced men from the universities or members of the geological staffs of oil and mining companies, who are now in the Army engaged on non-geological work. With the help of the Central Register, the universities, and representative bodies—the Geological Society of London is one example—men could be found for the necessary jobs.

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AERODROME ABSTRACTS

(36. Floating airports in mid-ocean : ANON. : *Sci. Amer.*, 1943. 169(3), 118-20 ; *Engineer, London*, 1943, 176 (4578), 293-4.)

An account is given of floating aerodromes or seadromes designed by E. R. Armstrong to serve as refuelling stations moored in the North Atlantic, at distances of 800 nautical miles apart. The seadrome will have a total displacement of over 100,000 tons, will be 3,550 ft. long, 400 ft. wide at the centre and 280 ft. wide at the ends, and will be capable of handling an aircraft of some 100,000 lb. gross weight.

The landing deck, 70 ft. above sea level, will be supported by 72 buoyancy tanks, giving a draught of 160 to 180 ft. The whole will form a deep truss composed of tubular struts and steel cable ties encased in iron pipes. As the wave motion of the sea is scarcely perceptible at 30 ft. below the surface, the depth of the buoyancy elements and the open truss structure of the seadrome keep it steady and unaffected by movement of the waves.

(*Compiled by the Department of Scientific and Industrial Research, Road Research Laboratory*, March, 1944.)

UNITED STATES MILITARY ENGINEERS IN PEACE-TIME CIVIL WORK

An Address given by MAJOR-GENERAL (now LIEUT.-GENERAL) JOHN C. H. LEE, U.S. Army, to the Institution of Civil Engineers on the 11th May, 1943.

(Republished by kind permission of the Institution of Civil Engineers.)

IT has long been the privilege of the Corps of Engineers in America to work in close co-operation with your sister Institution in the United States, the American Society of Civil Engineers. Since the arrival of the United States Forces in Great Britain it has been a source of great satisfaction to us to receive many evidences of friendship and co-operation from The Institution of Civil Engineers. We have long had a very high regard for The Institution and its many achievements. It has been the pioneer, and the world has profited from its work.

I have been asked to describe to you the civil works functions of the Corps of Engineers, United States Army. It is a pleasure to me to discuss this phase of the responsibilities of the Corps of Engineers, because it has been my fortune to spend a number of years on this, to the United States important, and to me very interesting, work. It may seem strange to you that army engineers are engaged in the construction of projects of a civil nature, but the historical background of this policy, which has been in effect for more than one hundred years, was at first a matter of necessity, and later a matter of choice. This war emergency, and previous emergencies, have seemed to prove the wisdom of the arrangement, as I shall endeavour to point out later in my remarks.

I do not want to create an impression that the Corps of Engineers is the only agency engaged in constructing public works financed by the national government. As a matter of fact, in our country such activities of the Federal Government are distributed among a number of governmental departments and agencies, but the improvement of harbours and navigable waterways of the United States has been entrusted to the Corps of Engineers by deliberate Congressional action. Congress has always reserved to itself the authorization of improvements on our navigable waterways under the powers delegated to it by the United States Constitution, and the execution of the work is by law a responsibility of the Chief of Engineers under the immediate direction of the Secretary of War, rather than through the direct command channels of the War Department.

A moment ago I said that the Corps of Engineers was selected a century ago as a matter of necessity for this assignment. When our country was very young, and before the founding or expansion of colleges and universities for the purpose of training civilian engineers, the army engineer was almost the only source of engineering talent. There was much survey and reconnaissance work to be done. From the ports on the coast, the routes by natural waterways were the primary means of access to the interior, and both ports and waterways had to be improved or developed. As a consequence, officers of the Corps of Engineers were assigned these duties, and the character of their work resulted in confidence, on the part of the national government, in their ability. For a number of years the planning and construction of many roads and railroads and some major public buildings was also performed by officers selected from the Corps of Engineers. In time it became necessary to supplement the services of the small number of officers from the Army engineers by civilian assistants, both professional and clerical, until an organization developed which was called the Engineer Department. It should be noted that this organization was composed of officers and civilians, and was not a military force. The officers were re-detailed from time to time, to resume their military assignment with troops, but the civilian personnel continued on. I would emphasize the important place of the civilian engineer in our Engineer Department, because much of the success of our civil works programme over the years, and in the present emergency, is due to his professional skill, his devotion to duty, his pride in the organization, and his loyalty to the traditions of the Corps of Engineers.

From a meagre beginning, when a few officers without much assistance were engaged on undertakings sponsored originally by the Federal Government, the Engineer Department has developed into a nation-wide organization, which now consists of eleven Divisions covering the entire continental United States, and sub-divided into approximately fifty Districts. Since the beginning of the present war, and the assumption of military construction as a new responsibility, which I shall mention later, Divisions and Districts have been created outside the United States where the work is not in a theatre of operations. In the European Theatre, for instance, we have no Divisions or Districts, as it is only a Military Command. Engineer Districts are the basic units charged with the field planning and the execution of projects. Owing to the fact that navigation and flood control projects were the normal assignments before the present emergency, the District boundaries were generally chosen to embrace complete water-sheds, and yet adjusted in size so that large overhead expense could be avoided and the maximum efficiency obtained. Districts are grouped into Divisions, the boundaries of which cover large geographical areas. Our Districts and Divisions function as closely knit but self-contained units, responsible successively to a single administrative authority and operating under the traditional policy of the Corps of Engineers, which provides for delegating adequate authority to its executive personnel. Standard procedures prescribed by the Chief of Engineers are employed in handling tenders (we call it "advertising for bids"), awarding contracts, reporting for funds, and the employment of personnel and other administrative matters. Engineering design and specifications are given only general supervision by the Office of the Chief of Engineers, these matters being de-centralized to the greatest possible extent to Division and District Engineers.

The officers of the Corps of Engineers in the Regular Army enter the service through graduation from the United States Military Academy, or from selected technical schools, colleges, and universities, which include military training in their curricula. After the last war many engineer officers holding emergency appointments were commissioned in the Regular Army and in our Corps of Engineers. Whatever his source, the young officer is given a well-rounded general training period, usually of six years' duration, which includes two years with troops, one year at a civilian university for a post-graduate course in civil, mechanical, or electrical engineering, one or two years on civil works, and one year at the Army's own Engineer School for a course in military engineering designed for officers below field rank. Upon completion of this six-year general training period, the officer is eligible for assignment to any type of duty, military or civil, devolving upon an officer of the Corps. The assignment to civil works after the initial training period is usually for a tour of two to four years at a time, followed by one or more tours on military activities. The young officer thus gains experience through his actual participation in construction operations in the field, where he is frequently called upon to use his hands as well as his head; later his capabilities and responsibilities increase, and he is charged with planning and he actually executes work of considerable magnitude. Such experience in peace-time is obviously a tremendous asset to the officer in war, when vision, confidence, and ability to manage large undertakings, not necessarily limited to construction, are qualities so vital to good leadership. In our country, this peace-time experience of the Corps of Engineers, together with the fine organization of competent civilian personnel and the whole-hearted co-operation of the construction industry, enabled the War Department to construct completed training facilities and some very important manufacturing facilities for war purposes, valued at approximately 2,000 million pounds, within two years of effort.

As a technical group, perhaps you will be interested in the types of construction operations in which we were engaged before this war emergency, and which we are carrying on even now where the projects are vital to the war effort.

The public works that have been and are being constructed by the Engineer Department may, for convenience, be grouped in two categories—namely, navigation improvements and works for flood-control. In many cases, however, the adopted project provides for the improvements of a stream for both navigation and flood-control as well as other allied purposes.

When navigation is mentioned, one's thoughts usually turn to the ample harbours which indent the ocean and gulf coasts and lake shores of the United States. These harbours are the gateways through which moves the tide of our foreign and inter-coastal shipping. Most of our major harbours on the east coast have been in use since Colonial times, when their natural advantages attracted the shipping of that day and stimulated the growth of cities on their shores. To-day these harbours, together with more recently developed harbours on the Gulf of Mexico and the Pacific Coast, have been improved to provide channels and anchorage-areas ranging from 30 feet to 40 feet in depth. In the case of New York Harbour, work is under way which will provide depths of from 45 feet to 48 feet, stimulated primarily by the British shipping programme of majestic "Queens" which are proving so useful in this war emergency.

Next in importance are the harbours of the Great Lakes, which handle vast quantities of basic commodities such as iron ore, grain, limestone, and coal. The Great Lakes connecting channels, Canadian and United States, which carry a steady parade of shipping, are the busiest waterways in the world. These harbours and channels have been improved so that they can be used by the most modern type of lake carriers, which draw about 21 feet when fully loaded.

In addition to these larger harbours, there are hundreds of small harbours on our sea-coasts, on our tidal waters, and on our freshwater lakes. Such harbours, with their improved channels and anchorages ranging from 6 feet to 12 feet in depth, support useful fishing industries, provide transportation of bulk commodities, and serve as the focal points for recreational areas.

A group of British people need hardly be reminded that a seaport is the link between land and sea, connecting the inland ways of rail, highway, and river with the ocean lanes of maritime commerce; and, as you will also realize, the planning and execution of improvements that will facilitate this change from sea to land and from land to sea, often involve complex problems. For us who are charged with such harbour work and planning, it is a question of utilizing hydrographic and topographic conditions to provide entrance channels that are safe and usable in all weathers, interior channels which will permit the movement of crowded shipping to terminals without congestion, and anchorage-areas which are protected from storms. All this involves careful consideration of existing structures and utilities, such as railroad terminals, bridges, sewers, pipelines and cable crossings, the location of piers and warehouses, and the planning for future growth and expansion.

The improvement of our harbours has been accomplished primarily by dredging and by the construction of breakwaters. Well suited to such work of excavation are the pipeline dredges which pump out material to make new land in spoil-disposal areas; dipper dredges and drill boats for the removal of rock ledges and shoals (we do not use the ladder dredge which we find mostly in Great Britain); and seagoing hopper dredges which are able to carry large quantities of material within their hull for disposal out at sea. The development of this last-named type of dredge in the United States has been accomplished mainly by the Engineer Department. Dredging, or wet excavation, has been the customary solution, but dry excavation has been used also when found more economical. In the Detroit River, which connects Lake Huron with Lake Erie, a large part of the 22-foot channel work was done "in the dry," behind earth and rock cofferdams.

The construction of protective jetties and breakwaters has been a major item of harbour improvement in a large number of cases, particularly on the Pacific Coast and on the Great Lakes, where naturally protected harbours are rare. Types of breakwaters include rubble mounds faced with heavy stone, stone-filled timber cribs with concrete caps, all-concrete structures, and breakwaters utilizing steel or timber sheet-piling. Such massive structures are, I believe, similar in many respects to those built in Great Britain, and are designed to receive the impact of storm-driven waves and to withstand the grinding action of ice floes.

Closely allied with harbour works are the deep-draught canals for ocean shipping, such as the Cape Cod and the Chesapeake-Delaware canals, and the intercoastal waterways for vessels of lighter draught. These waterways provide shorter protected routes between harbours and natural bays. As such canals usually cut across established rail and highway routes, the provision of bridges with horizontal and vertical clearances to ensure an unobstructed waterway for shipping has been an important feature of construction.

An outstanding navigation development in the United States has been the improvement of the inland waterways. These streams, which initially provided somewhat hazardous pathways for the pioneers who developed our country, have been gradually improved to carry the bulk cargoes of an industrial civilization. In the Mississippi river basin alone there are now more than 11,000 miles of authorized navigation projects under the jurisdiction of the Engineer Department. Large parts of these are only now being completed at depths suited to modern demands.

Of course, invaluable experience with navigable streams of the Old World was available to the Army Engineers of a century ago, when they first began work on American rivers, and European methods were generally given careful study. The methods applicable to the waterways of Europe, however, were not always suited to the untamed rivers in America, and the practice of pioneering in navigation work was necessary from the beginning. Our first river improvements consisted of removing snags—old tree trunks that had floated down and had sunk and become embedded in the river, and which punched through the bottoms of steam-boats—which could be accomplished with limited funds and equipment. At present, our river improvement work falls into two general classes—open channel regulation and canalization.

Open channel regulation has been found best suited to rivers with alluvial characteristics, such as the Lower Mississippi and the Lower Missouri. This method of river improvement can be defined as the continuous, progressive control of a river—contracting it where necessary, giving it proper direction, and securely confining it in place. The design of such an improvement is complicated by the fact that, whilst the whole valley is the natural domain of a wild river, the designer must consider and conserve the development by man that has taken place in the valley. Although the river itself, by its scouring and cutting action when properly directed, becomes the main agent of constructive open channel improvement, this usually involves the dredging of channels through bars to connect the deeper pools of the natural river, and to achieve the improvement of its alignment and hydraulic section. Training dikes of piling or timber cribs must be constructed at points where the river meanders through several shallow channels, in order to direct the flow through a single channel. And, since alluvial rivers are prone to destroy their banks and change their courses, the protection and stabilization of the banks are essential in certain places. Such protection is accomplished by covering banks subject to attack by the current with heavy mattresses of stone, concrete, willow, timber, or asphalt.

The other method of improving a river for navigation (frequently used in Europe, I believe) is canalization and the provision of navigable depths by the construction of locks and dams. By such structures, the natural river course is converted into a series of slack-water pools. Such method of improvement has been used on the Upper Mississippi river and on the Ohio river and its tributaries—streams which are characterized by relatively narrow valleys, well-defined banks and occasional rapids. The first developments of this type constructed by the Army Engineers and by private enterprise on American rivers were small masonry locks, with hand-operated wooden gates (actually some of these locks were of timber construction), which either by-passed rapids or were constructed in conjunction with rock-filled timber crib dams. From these rather primitive structures we have progressed to standard concrete locks 600 feet long between gates and 110 feet wide, with steel gates electrically operated. Navigation dams now in use include the movable wicket-type structures of the lower Ohio river, which permit open river navigation during high water; and the concrete-fixed dams which have been built on the Upper Mississippi, the Upper Ohio, and the Kanawha, a tributary of the Ohio. The latter have wide spillway sections with steel Tainter or rolling-drum gates to control pool-levels and to permit the passage of ice and flood flows.

Planning a canalization programme for a large river requires a thorough knowledge of the stream. The pool-levels, channel-depths, and types of structures that will best serve the needs of prospective commerce must be determined, and the plan must be such that it will fit in with the municipal and industrial developments and with improvement of the river for flood-control and various other purposes.

The improvement of our coastal and inland waterways has proceeded slowly in keeping with the country's need and our means, but the Department has had as an objective a long-range interconnecting development, and to-day we find our nation the possessor of an extensive water transport system actually in operation, not yet complete, but sufficiently advanced to ensure the future prosperity and the security of our people. In times of war those projects pay for themselves many times over.

The Engineer Department began planning and constructing flood-control works more than fifty years ago, when the first "levees" were built on the lower Mississippi with Federal funds. The science or art of flood-control, however, is not new, and many, or perhaps all, of the methods in use to-day may have been developed and used in ancient times; but they have been applied rather extensively and on the whole successfully in the United States during the past half-century.

In executing the flood-control projects which have been authorized by Congress, the Engineer Department must deal with floods which range from the slowly-rising, wide-spreading overflow of the Mississippi to the torrential, debris-laden waters which sweep down the barren slopes of our western mountains. Obviously there is no simple panacea for the control of such diverse forces. This control is usually complicated by the fact that man invites destruction by building his homes, cities, and communications in the valleys which are the natural paths of the flood waters. Thus each river presents an individual problem, to the solution of which the Engineer Department applies the methods of control which careful study indicates as the best and most economical.

The flood-control plans which are being executed by the Engineer Department are sufficiently comprehensive in scope and design to develop effectively the water resources of the river basin. They include reservoirs for flood-control, or for multiple purposes, whose effects in controlling floods and conserving water will benefit wide areas. They also include levees, floodwalls, channel improvements, and floodways or diversion channels, which are generally constructed to protect some particular locality.

Levees, as now constructed by the Engineer Department, differ widely from the small earth embankments originally built on the Mississippi and other rivers. The 2,000 miles of levees which now form the main line of defence against Mississippi river floods contain 1,000 million cubic yards of material. These levees are, in effect, low artificial ridges, which are built like earthen dams. They are as much as 40 feet high in some localities, and have top widths of 10 or 12 feet, whilst they may be as much as 300 feet wide at the base. These cross-sections vary with the material available for construction, which is carefully deposited by the latest earth-moving equipment. Draglines with long booms and buckets of large capacity have been used on levee construction with considerable success, whilst tower excavating-machines, supplemented by tractors and dump wagons, are also used extensively. In fact, the American advances which have been made in earth-moving equipment, together with our increased knowledge of the use of earth as a material of construction, are largely responsible for the present standard of levee and dam construction, and vice versa.

The construction of adequate earth levees often requires a wide right-of-way, and in cities where land is valuable floodwalls are often more economical. Reinforced-concrete walls with steel sheet-piling cut-off features have proved a satisfactory design. Floodwalls are being used extensively for the protection of cities and towns along the Ohio and the Connecticut rivers, where industrial developments crowd to the river banks.

There are numerous incidental design and construction problems connected with levees and floodwalls. For example, interior drainage must be cared for; entrances for streets, railroads, and highways must be provided; and on alluvial rivers, banks must be protected to prevent bank caving that would undermine and destroy the protective works.

Diversion channels and diversion floodways are used to provide auxiliary outlets for flood waters in excess of the carrying capacities of the natural channels. In projects now under construction, diversions generally take the form of excavated earthen channels; concrete storm sewers and conduits; or overbank floodways with guide levees where flood waters are permitted to escape over lowlands normally subject to overflow. Such channels and floodways frequently involve the raising of railroads and highways so that transportation will not be interrupted during flood periods.

The improvement of natural channels to increase their capacity is a useful flood-control method, but must be handled with care. In numerous cases ill-advised local efforts at clearing the upper reaches of rivers have aggravated flood conditions on the lands below. For some flood problems, however, channel improvement is the best solution; and the actual work may be quite varied. For example, on the Conemaugh river at and below Johnstown, Pennsylvania, (the place of the famous flood many years ago), the Engineer Department is re-aligning the river to provide a more efficient flood channel and is paving the banks with heavy monolithic concrete. On the Big Black river of Mississippi, channel improvements to reduce flood heights on farm lands consist of removing accumulated drift and over-hanging trees, channel excavation, and dredged cut-offs across sharp bends.

Flood-control by means of reservoirs is, of course, nothing new, but it is a subject which causes much confusion to the layman. Briefly, pure flood-control reservoirs are artificial basins, kept empty except during the flood periods, when they hold back flood waters so as to reduce flood heights in the rivers below. The effect of reservoirs in reducing flood heights is, of course, most valuable in the river valleys immediately below the dam, and the benefits become progressively smaller as the distances from the reservoirs increase.

In the construction of reservoirs we build dams of earth or of the various types of concrete, depending on such factors as foundation conditions and available materials. Reservoir control works may be automatic, where culverts without gates are provided to carry the normal stream-flow, permitting the reservoir to fill when that flow is exceeded; or of a type permitting control at will. In either case, emergency spillways are provided to prevent dam failure and other damage in case of excess flows. A special form of flood-control reservoir is the debris basin, which is constructed to intercept the debris-laden flood waters discharged by mountain torrents. The project for the protection of Los Angeles, California, includes a number of these basins.

It has been said that the use of a reservoir for flood-control is generally antagonistic to its use for other purposes, as a flood-control reservoir is normally kept empty and ready to store flood waters, whilst a reservoir for power development or water-supply is maintained as full as possible. This is generally true, but there are numerous cases in America where the planned developments warrant, and the physical conditions permit, the building of multiple-use reservoirs large enough to store destructive flood waters, and yet at the same time provide a combination of water storage for navigation, power development, irrigation, municipal water-supply, pollution abatement, and recreation. Often these additional values of a reservoir site are so great that a multiple-use reservoir becomes the most desirable and the most economical project (provided the money is available!). In preparing its flood-control plans, the Engineer Department makes every effort to use and conserve water resources to the best interests of the public. As a result, we have recommended and constructed many multiple-use projects. The larger reservoirs now under construction generally provide recreational pools and facilities for future power development in addition to their primary flood-control functions.

The settlement and development of the greater part of the United States cover a relatively brief period of time, and the records of stage and discharge for most of our rivers cover an even shorter period. Therefore, all engineers who have had occasion to design and construct works dealing with water have been confronted with the scarcity of stream-flow records, and have had difficulty in computing maximum flood flows. Consequently, in the past, engineers have had to do their best with the data at hand and to use large factors of safety to guard against failure of structures. When the Engineer Department began the nation-wide flood-control work, it was realized that many reservoirs would be located on streams where adequate flood records were not available, and that some rational method of securing hydrological data for design purposes would have to be developed. Co-operative storm studies which are being carried out by the United States Weather Bureau and the Engineer Department fill this need.

Briefly, these storm studies are an attempt to analyse rainfall records and any stream-flow data that are available, in the light of weather conditions which may affect the river basin in question. Application of meteorology to flood studies, particularly the air-mass theories which have been developed recently by foreign as well as American meteorologists, provides a useful basis for estimating probable floods and flood expectancy for a drainage basin. We have to compute how often the damage caused by flood may be expected, and Congress always wants us to commend only those works that we regard as financially worth while in the long run.

A large number of the dams included in the nation-wide flood-control programme of the Department are earthen dams, a type of construction that has always been of great interest to the engineer. Earthen dams represent one of the oldest types of engineering works known to man. They were constructed by the ancients because their usefulness was so apparent and their effectiveness so certain. Earth was the convenient material, as it could be borrowed close at hand and carried by man in baskets. That this type of construction should have been undertaken so early in human history is, therefore, not surprising, but the size of the dams, known then as tanks, and the fact that many are still in use may well arouse our interest.

Until recent years, the progress of modern science in connexion with the construction of earthen dams was slow, and it was not until plant and methods of handling large quantities of earth were improved that earthen construction was resumed in the United States. Wherever practicable, the hydraulic fill method began to replace the older dry fill method. Unfortunate experiences with construction slides caused discouragement, but the lessons learned from such accidents and the substitution of science for empirical design have encouraged the engineer to persevere, with the result that earth is now being used in a greater percentage of dams than ever before in modern times.

I referred earlier to the fact that the Corps of Engineers is now engaged in a huge widely-spread military construction programme. Congress enacted legislation in 1940, and again in 1941, which authorized our Secretary of War to transfer all work pertaining to the construction, maintenance, and repair of buildings, structures, and utilities for the Army from the jurisdiction of the Quartermaster-General to that of the Chief of Engineers. These new responsibilities are executed under the general direction of the Commanding General of the Army Service Forces rather than the Secretary of War, as in the civil works programme. However, the same field organization, which was well established as the result of many years of navigation and flood-control work, was the framework for the tremendously expanded operation. Many of the proven civilian engineers were given temporary commissions in the Corps in order to facilitate their direction of the work due to close association with the branch of the military service for which the facilities were being constructed. Our excellent relations with the contracting industry and their respect for our fairness have been quite an asset. They knew how we did business, and our de-centralized organization knew them. Formal advertising was dispensed with and most contracts were negotiated promptly on a lump sum or unit price basis, to save time. At times it was necessary to adopt the cost-plus-a-fixed-fee type of contract where construction plans could not be completed prior to the initiation of the work.

On the whole, the Corps of Engineers is now a long way from the day when a few engineer officers were pushing through the wilderness, exploring, mapping, planning, and probably spending a good portion of their time avoiding being scalped by the Indians.

The time available will not permit of my going into detail with respect to the military construction programme. It may be of interest to you to know that, as has always been our policy, the great bulk of the emergency war work has been done by contract, that we have engaged architectural engineering firms to do much of the engineering, except for the preparation of standard housing plans, and that the value of the programme, which is now well on towards completion, is approximately 9,000 million dollars. Peak contractors' employment was approximately 900,000 men in July, 1942, whilst the forces of the Engineer Department numbered approximately 50,000 men at that time. Operations included construction of the new bases outside the United States, such as on British territory that we have taken over by lease, cantonments, and training areas, tactical aerodromes, schools for pilots, aerial navigators, and gunners, storage depots of all kinds, port facilities, aircraft assembly plants, arms and ammunition plants, chemical and explosive plants, and many other special facilities too numerous to mention, all of which you undoubtedly have built also.

We feel that many advantages, both to our Military Service and to our Federal Government, are derived from the participation of the Corps of Engineers in civil works. I have mentioned the obvious advantage of having a strong and capable technical organization, on a geographical basis, ready to undertake the necessarily wide expansion in facilities required by the increase in our armed forces to meet the war emergency and to provide the special manufacturing facilities necessary to produce the munitions of war.

The very best training for the responsibilities to be carried out by Engineer officers in time of war is obtained from their work in peace time. Our officers learn to develop organizations, and to handle large projects; and they learn to deal with men and materials and construction plant on a practical rather than a theoretical basis. Another military advantage of our port, harbour, and flood-control work is that it places us in close contact with the engineering and contracting organizations and personnel throughout the United States. When an especially difficult job arises in time of war, we know from personal acquaintance the man or organization most capable of handling the problem. Our peace-time Army is small. Therefore we are dependent upon the engineering profession for the expansion of our Corps of Engineer officers. These are drawn from engineers in civil life. It is a tremendous military asset to be well acquainted with their individual qualifications and capabilities. Our officers are drawn, not only from the engineering contracting organizations in private practice, but also from the Civil Service employees of other Governmental agencies, as well as the Engineer Department, who provide a large and capable group of engineers already familiar with the procedures of our Federal Departments, especially the Engineer Department charged with this war work.

We find that it is also a matter of importance to the Army to have officers who are thoroughly familiar with all parts of the United States, with the terrain, the climate, and indeed the official atmosphere of the city, country, and state governments. The problem of finding suitable sites for many new military establishments is solved much more simply and expeditiously because of this knowledge. Our Engineer Districts have been of real value to all branches of the service in locating their establishments in the most suitable areas. The military experience of each Engineer officer is thus of value in our river and harbour work in ensuring the appreciative consideration of the problems of the Navy and of harbour defence and port operation.

Our civil work brings us into close touch with many leading citizens and civil officials in the country in times of peace. It gives us an active and constructive life which is the best preparation for the big job when it comes. Getting the job done has to be a habit. This is the contribution which our Corps has to offer the country in time of war.

As I have said before, our civil work has been continued where the project is vital to the war effort, but of course only a small proportion of the projects fall in this category. From what I have been able to learn, I can assure you America has gone "all out" in an effort to provide the means to win the war, and the non-essentials have been, or are fast being, eliminated from our national life. However, we shall be ready with a large number of planned civil projects which can be undertaken when the war is over in order to help relieve any slack in employment.

As Engineers, we all have an instinct for creating rather than destroying, and you will agree with me, I am sure, that the future holds much promise for constructive engineering. One great asset of modern war is the technological advancement which is inspired by the necessity of self-preservation. Much has been destroyed in the world which will have to be re-built, and I trust that as engineers we shall find ways of using our increased knowledge and experience for building a better world and a better life. I believe I can assure you that the United States Army's Corps of Engineers in its civil works field is anxious and reasonably ready to resume constructive work when the present necessity for helping to win the war is over.

Lieut.-General John C. H. Lee, United States Army, by whose courtesy the preceding address has been reprinted, has kindly added the following interesting facts for publication in *The R.E. Journal*:—

"Such work as that described in the preceding pages, has provided the training ground for not a few of the American Officers now holding positions of administrative responsibility. In addition to General Brehon Somervell, who commands the United States Army Service Forces, assisted by Major-Generals Wilhelm D. Styer, Chief of Staff, Charles P. Gross, Chief of Transportation, and Lucius Du B. Clay, Chief of Procurement for the War Department, there are in the field:—

Major-General David McCoach, of the Western Service Command in America, Lieutenant-General Raymond A. Wheeler, Chief of Administration for the Allied Forces in India, Major-General Thomas B. Larkin, Commanding the Services of Supply in North Africa, Major-General Donald H. Connolly, Commanding the American Service Forces in Persia.

General Douglas MacArthur was an engineer officer prior to his being made a general officer in World War I.

In this Theatre we have at Supreme Headquarters, Major-General R. W. Crawford. As Chief Engineer, Major-General Cecil R. Moore, with Colonel John R. Hardin as his Deputy. My Chief of Staff is Brigadier-General Royal B. Lord. Two of the important Chiefs of Staff are Colonels James H. Stratton and James M. Franey. In the field we have my Communication Zone Deputy, Brigadier-General Harry B. Vaughan, and his Chief of Staff, Colonel Frank M. Albrecht; and as Base Section Commanders, Brigadier-General E. G. Plank and Colonel R. W. Grower.

It is most satisfying to have experienced administrators such as these seasoned officers with long service in the Corps of Engineers; experienced in organizing work and handling men and equipment against time and the elements. The scores and, indeed, hundreds of other officers through all the grades are carrying heavy responsibilities, both with troops and on administrative duty, making a valuable return on the investment the United States Government has made by their use through the years.

Thus the American Congress, through this Federal Agency in the War Department, is assured professional competence both in sound engineering and administrative fidelity.

It also provides a certain insurance value in coping with national emergencies."

OPENCAST COAL

By Major-General Sir G. Brian O. Taylor, K.B.E., C.B., M.Inst.C.E.

General.—The slow but continuous drop in the production of coal has brought into prominence the importance of developing to the maximum extent the production of Opencast Coal, i.e., of coal obtained by surface methods of working. There is nothing new in the idea of working deposits on or near the surface of the ground. In this country they have never, in the past, been systematically worked, although at various times, particularly perhaps during coal strikes, mining communities have often obtained their local supplies by working surface deposits spasmodically by hand or "gob" working, as it is called. The coal so found was generally of poor quality but helped to keep local home fires burning during the period of scarcity. In other countries, however, very extensive deposits have been systematically worked for many years, notably in America with its vast bituminous coal deposits in Indiana, Illinois and Kansas, and smaller anthracite deposits in Pennsylvania. Up to the beginning of the war over 35 million tons of coal a year was being obtained in this way in the States.

Japan is working very extensive deposits in Manchukuo, where an output of some 15 million tons a year has been achieved. These deposits are probably the largest in the world, the coal reserves being estimated to be over 10,000 million tons. One mine is literally an "opencast paradise" with a coal deposit covering some 25 square miles and of an average thickness of 130 feet.

Similarly in Germany extensive lignite deposits are also worked by surface methods.

In England such conditions cannot be expected. Workable deposits are generally of small extent, containing anything from 10,000 to a quarter-million tons, and those of one million tons or more are few and far between. Nevertheless, the total deposits considered workable by surface methods have been estimated to contain between 60 and 80 million tons, and it is possible that prospecting which is now proceeding, on an active and ordered programme, may bring to light further resources.

Estimates recently published show that the coal requirements for this country are roughly 220 million tons a year at present, and that these may increase as more of Europe falls into our hands and has to be supplied with fuel. Production of mined coal is estimated at 200 million tons, leaving a deficit of 20 million tons to be met by economies in consumption and production of opencast coal. Another disquieting fact is the recent disclosure that American production next year is likely to be well below requirements. Coal, which used to be available for the asking from one's coal merchant, must now be carefully conserved as a vital necessity for the war and for the immediate post-war period.

Home produced opencast coal can, and no doubt will, be worked up to form a more than useful contribution towards making good the deficit. Production is steadily increasing and the quality is also improving. In 1942 production was 1,300,000 tons : in 1943 4,500,000 tons, and in 1944 it will probably be between 10 and 15 million tons, with the latter figure as the target. These figures have not been achieved, and will not be achieved, without difficulty and effort. The path of opencast coal production has not been an easy one. Owing to lack of adequate records, both geological and mining, there was a wide diversity of opinion as to the amount of coal which could be won by opencast working; estimates varying from 6,000,000 tons to 60,000,000 or over. It was also asserted that the coal won in this way from seams too near the surface would not be of good enough quality for industrial use: finally, both County Agricultural Committees and Land Owners were hostile to the proposal, on the grounds of putting land out of production for a year or more, and the destruction of amenities. Persistent advocacy finally had its way, and the Board of Trade, who were then the responsible Ministry, sanctioned the prospecting and development of any suitable sites and set up a small Control Branch in the Autumn of 1941.

A leading firm of Civil Engineering Contractors put its energies into the task and from this moment progress was rapid. At the present time both the Ministries of Fuel and Power, and of Works are responsible, the former for disposal and marketing, the latter for the actual production. Each Ministry has its own Director of Opencast Coal, with considerable staffs, and the effort started by a single firm of Contractors now occupies most of the leading Civil Engineering Firms in the country.

It is remarkable that the most optimistic estimate of this coal, viz.: over 60,000,000 tons, is now being borne out by the results of systematic and detailed survey. It is of interest to record that the firm, first in the field, celebrated last September the "getting" of its first million tons of coal.

Plant

The economical production of opencast coal depends entirely on the employment of suitable plant and methods of excavation. Coal seams seldom lie at an even depth below the surface; they are almost invariably found to dip at various angles, sooner or later reaching a depth at which opencast operations are beyond the capacity of the plant employed. It follows therefore that soon after exploiting the shallow outcrop (or Bassett edge as it is termed) the problem becomes one of dealing with progressively larger masses of overburden down to a depth of perhaps 60 ft. or more before the coal seam itself can be reached. At times the seam may consist of a series of thin streaks or layers of coal separated by "partings," of many feet of rock or clay. It is then purely a matter of determining the depth at which working is no longer economical, which is governed almost entirely by the extent of the workings and hence the size of the machine which can be employed usefully. The larger the machine the more economical the working; but really large machines are very expensive, take a long time to erect, are difficult to move and can, therefore, only be justified on sites where there is sufficient excavation to keep them employed continuously for some months. Since a 9 yd. Bucket Machine will shift 350 to 450 or even 500 c. yds. an hour; a 16 yd. 700 c. yds an hour, and a 32 yd. twice this, it is obvious that comparatively small deposits would be rapidly worked out and the cost of big machines, £100,000 or more, weighing up to 1,500 tons, and taking several months to erect—could never be justified.

The development of excavating machinery generally has followed the needs of large scale engineering projects. Thus, large canals, e.g., Suez, Manchester Ship, and Panama, each, in turn, had a marked effect on this development. In the last twenty years it has been intensified by the demand for machinery to deal with the many types of open workings, such as ironstone, copper, bauxite, phosphate, and coal, on an economic basis. Naturally, development has been far more rapid in the States than in the U.K., mainly because there the vast scale of the various deposits has justified the production of ever larger machines. Again, the type of machine has tended to alter. The earliest type of single-bucket excavator, apart from the clam-shell, is the power shovel, where the whole digging or cutting power is concentrated on one bucket held firmly to its work. For this reason it will work in heavy soils, and in many classes of rock, without the need for extensive preliminary blasting; although in the U.S.A. it is never expected to dig any stratum which can be broken more economically by explosives. The disadvantage of this tool is that it sits down on the base of its work, demanding, therefore, a series of improvised level platforms from which to work until the bottom is reached, and, owing to its comparatively short jib, it can only cast short distances. It is, therefore, primarily a tool to be used in conjunction with vehicles to carry away the spoil. These shovels are now made in sizes varying from ¼ c. yd. to 33 c. yd. capacity, and with a considerable range in boom sizes, many of which are of sufficient length to allow direct casting. The limitations in their use has in many instances led to their steady replacement by the dragline. These can sit on the surface of their work, and can be equipped with booms up to 250 ft. in length, thus providing very large dumping radii. Because they cast their buckets on to their work they cannot work in such hard soil as a shovel, unless that soil has previously been broken up. Draglines are now made in sizes varying from ¼ c. yd. to 20 c. yds. capacity.

Other additions to excavating machinery comprise various types of equipment combined with tractors. These include Graders and Scrapers, Bull and Angle-dozers, etc. Of these, tractors and scrapers have proved their worth in opencast working. They are made in a large range of sizes from 2½ c. yd. to 45 c. yd. Scraper capacity. Bull or Angle-dozers, Skimmer-scoops, and other specialised plant or equipment find their value in such processes as the final cleaning of the surface of the coal bed, levelling off mounds of overburden where sites have to be reconditioned, etc.

Method of Development

The special factors influencing the working of opencast coal deposits in this country, as opposed to the U.S.A., Manchukuo and Germany, are briefly as follows:—

1. The average extent of the workable deposits is seldom sufficient to justify economically the installation of plant larger than, say, the walking dragline of a 5 c. yd. bucket capacity.
2. The comparative smallness of the country, the necessity of retaining in cultivation all possible areas, and the desirability of preserving all amenities, demand the restoration of the surface to its original texture and approximate contour.

These two factors largely govern the method of exploitation and system of development of any particular project.

The method of disposal of the coal produced from a site also needs consideration.

The steps taken to develop any particular site, therefore, comprise:—

(a) The proving of the field by adequate boring. This involves: the establishment of the line of the bassett edge, if any; of the 40 ft. contour, i.e., the line along which the overburden averages 40 ft. in depth; the thickness of the seam; the taking of occasional spot borings to verify the continuance of the seam of coal between the bassett edge and the 40 ft. contour and finally the verification of the existence or absence of any considerable fault in the seam. The latter is most important, as the existence of a large fault, a not infrequent occurrence in this country, may completely alter any preconceived ideas.

(*b*) As the result of (*a*); an estimation of the amount of coal which can be obtained economically from the site, and the amount of overburden which will have to be removed.

(*c*) A decision as to the amount of coal which can be handled daily or weekly from the site. Since all coal requires screening and the bulk, if not all the coal, eventually requires moving by rail, screening plants should be erected preferably at rail sidings, which may require building or extending to deal with the volume of traffic expected. Another factor is the desirability of avoiding double-handling caused by the accumulation of coal in dumps, which may catch fire by spontaneous combustion.

(*d*) On the results of (*b*) and (*c*) the correct planting up of a site can be decided, and the proper balance between overburden excavators and coal-getting machines established. Sites are usually planted up in accordance with the availability of machines by the particular contractor concerned, other factors being regulated accordingly, but the proper procedure is outlined above. The reverse is due to the present universal shortage of adequate excavating plant.

It is difficult, at the present moment, to establish the limiting depth of a coal seam beyond which further working is uneconomical. As stated before, it depends almost entirely on the size of excavator employed, which is subject to the availability of the larger machines, and on the extent of the workings on any one site. At present, with excavators not exceeding $2\frac{1}{2}$ yd. bucket capacity, it is seldom justifiable economically to work a site where the ratio of overburden to coal exceeds 10 to 1. The actual texture or composition of the overburden has little bearing on this ratio. Even rock strata, needing extensive blasting, and sometimes additional breaking up with rooters prior to removal, can be dealt with relatively cheaply.

Under the Essential Work (Building and Civil Engineering) Order, 1942, Payment by Results Scheme, a schedule has been drawn up of the basic output and bonus rates for all types of excavating and tractor and scraper plant. Although the basic figures given in this schedule are absolute minima, they form a very useful guide as to average performance over an extended period when time lost on repairs and overhaul is taken into account. Thus, although a $2\frac{1}{2}$ yd. bucket machine will average 160 to 180 cubic yards an hour, when discharging direct on the ground, at full work, and may work for 70 hours a week in the summer; over the period of a year one would be quite content with a consistent performance of 110 yards an hour for 48 hours a week, for say 50 weeks in a year. These basic figures, therefore, form a very reasonable yardstick on which to determine the planting up of a particular job.

Similarly, the Control of Rates of Hire of Plant Order, 1941, provides an equally reasonable guide as to the costs of operation of each type of plant. These plant hire rates include depreciation costs, overheads, owners' profit, etc., and the supply of spare parts, but not cost of fuel, lubricating oils and grease, drivers, operators, or labour on repairs, all of which are borne by the hirer, and due allowance must be made for these items. For all existing contracts the Ministry of Works have established rates per c. yd. excavated according to the classification of the plant employed. These rates vary in inverse proportion to the capacity of the machine employed, and at the present moment three rates have been established, the highest for machines of $\frac{5}{8}$ c. yd. capacity: an intermediate one for machines between $\frac{5}{8}$ and $1\frac{1}{4}$ c. yd. capacity, and the lowest for those over $1\frac{1}{4}$ c. yd. capacity. As and when machines of much larger capacity become available, still lower rates will no doubt be instituted.

It is obvious from the foregoing that work is much more economical with larger machines.

Tractors and scrapers are all classified at the intermediate excavator rate.

Method of Work and Procedure

When a site has been proved, and surveyed with reasonable accuracy, an estimate of the total yield prepared, the daily or weekly output decided, and the schedule of plant to be installed agreed, proper working plans can be prepared. These comprise a decision as to the method of opening up the site, how it is to be worked, where top soil is to be stacked, where dumps of overburden are to be placed, etc.

Opencast coal working is muck shifting on a large scale, consequently, careful study and planning is required to ensure that no material is run an unnecessary distance and only the minimum amount of material is double-handled. Owing to the necessity of reconditioning the whole site, the top soil, which includes not only the top spit but the sub-soil to a total depth of 1 ft. 6 in. to 2 ft., must first be removed to, and dumped in, an area or areas where it can remain undisturbed till the end of the work. This is eminently tractor and scraper work, and, as the cost of operation of these machines varies in direct proportion to the distance they have to carry the top soil to dump, stacks must be as close to the work as practicable. Having cleared the top soil, the next step is to open up one or more first cuts down to the coal strata. These can be made either along the bassett edge or roughly at right angles to it. Spoil from the first cuts must be dumped close to, but clear of, the workings, and the coal then dug and carted away.

As this spoil from the first cuts will usually be required for the filling of the final cut, the dumping area should be settled with this in mind. On one large site, where the first cuts have involved the removal of over half a million cubic yards of overburden, it has been found more economical to instal standard gauge track and to remove the overburden with locos. and tipping wagons. In this particular case, some 2½ miles of track are being laid and six locos. and some 40 to 50 tipping wagons employed. Normally, however, the first cut would be removed partly, at least, by tractor and scraper, the balance by excavator loading into tipping lorries, dumpers, etc.

Subsequent cuts are dumped successively direct into the previous cuts. Access roads to coal faces must, of course, be left open until the coal has been removed.

A typical plan of an opencast coal site is given on Fig. 1, which shows the extent of the working, the line of the bassett edge, and the successive cuts to be opened up numbered in sequence. Other points to note are the dumping areas, the access roads, plant yard, etc.

The final stages are; first level off all the series of dumps in the various cuts by tractor and scraper, bulldozer, etc., to the original contour of the land, and secondly, spread the sub- and top-soil over the whole area. The decision as to whether the original opening cut should be along or at right angles to the bassett edge depends entirely on the configuration of the area. Generally, perhaps, opening the bassett edge is the better.

The factors to bear in mind are:—

1. That an adequate face or faces must be opened up to enable all the plant to be put to work.
2. That the cut must be wide enough to enable coal-getting machines to swing easily when filling coal trucks. This usually demands width of cut not less than 45 ft.

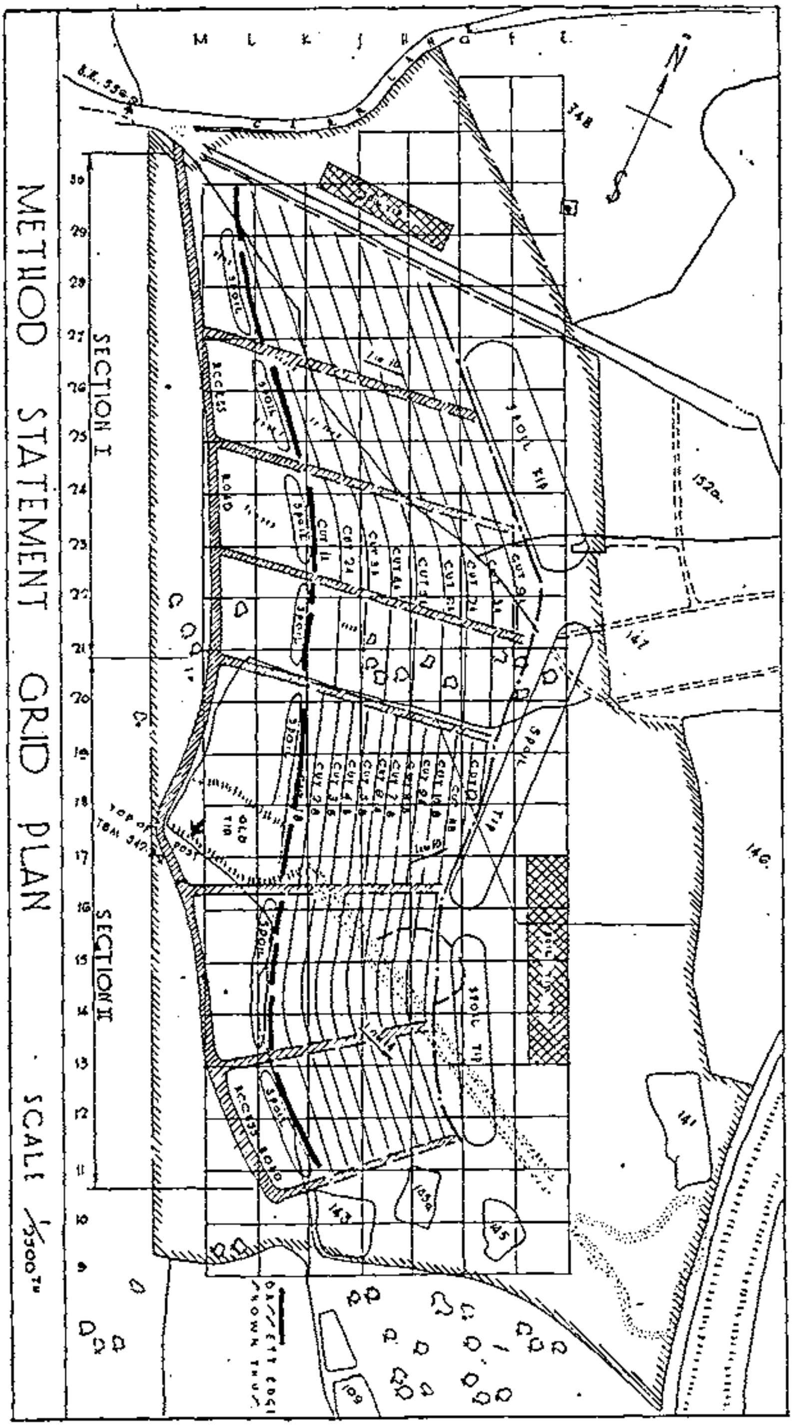

METHOD STATEMENT GRID PLAN · SCALE 1/2500TH
SECTION I
SECTION II
SPOIL TIP
OLD TIP
ACCESS ROAD

FIG. 1

3. That double-handling of the overburden must, for economic reasons, be reduced to a minimum. In practice it should rarely exceed 30% of the total removed, and in normal cases be reducible to 20%-24%.
4. That all coal traffic routes must be planned from the start, and, until no further coal is required along a route, it must not be closed by dumping.

It is evident from the foregoing that opencast coal working is pre-eminently a dragline operation, because of the longer booms fitted to these machines, and thus the greater casting area commanded by them. The limiting depth for working a dragline bucket can be taken normally as half the operating radius, and in consequence increases with the size of machine and length of boom. In many cases depth of overburden exceeds the working depth of the machines installed, or available, and the overburden then has to be removed in two stages. When conditions permit, the first few feet can be removed by tractor and scraper, or, if equipment is adequate, draglines can be worked in echelon at different levels. Figures II and III show the working of machines in echelon.

Work on partings always presents difficulty, as it introduces one or more subsidiary operations which can only be carried out by machines in echelon. The processes in order comprise :—

(1) Remove all top soil,
(2) Excavation of first layer of overburden,
(3) Cleaning off top of coal face (usually a skimmer or scraper operation),
(4) Removal of top seam of coal,
(5) Excavation of upper parting,
(6) Removal of second seam of coal,

and so on until the bottom layer of coal considered worth getting is won.

Experience has shown that excavation of partings is done more economically by tractor and scraper than by any other means. In one site known to the writer, there are no less than five layers of coal separated by partings of varying depth. The Ministry recognizes the difficulty and expense of such work by granting an extra rate for excavation in partings.

It is unfortunate that many sites are shaley or rocky—in some cases 60% or more of the overburden is rock—and that navvies are far better fitted to work in rock than draglines. The remedy is blasting and more blasting. By adequate blasting, even of shale or stiff clay, wear and tear on machines and particularly on ropes and buckets, can be greatly reduced. This involves both horizontal and vertical drilling on a properly drawn up plan and adequate equipment such as ; compressors fixed or mobile, wagon and percussion drills, suitable drill steels, etc. Unfortunately again there is a general shortage of suitable equipment of this type in the country.

In conclusion, it cannot be too strongly emphasized that opencast coal-getting is entirely a machine operation and that its success or failure, as regards economy of output, depends entirely on the efficient working of the machines themselves. The essential measures to attain and maintain this efficiency are ; first, the reduction of the overburden to a consistency which enables full buckets to be drawn up with the minimum mechanical effort and expenditure of time, and secondly, the reduction of time spent in repair and overhaul of plant to a minimum by adequate lubrication, daily and periodical maintenance, and supervision of machines at work. A sound method is by the introduction of printed daily tasks and machine log books for each machine. If ever the statement that " a stitch in time saves nine " was true, it is when applied to excavating plant of all kinds.

FIG. II

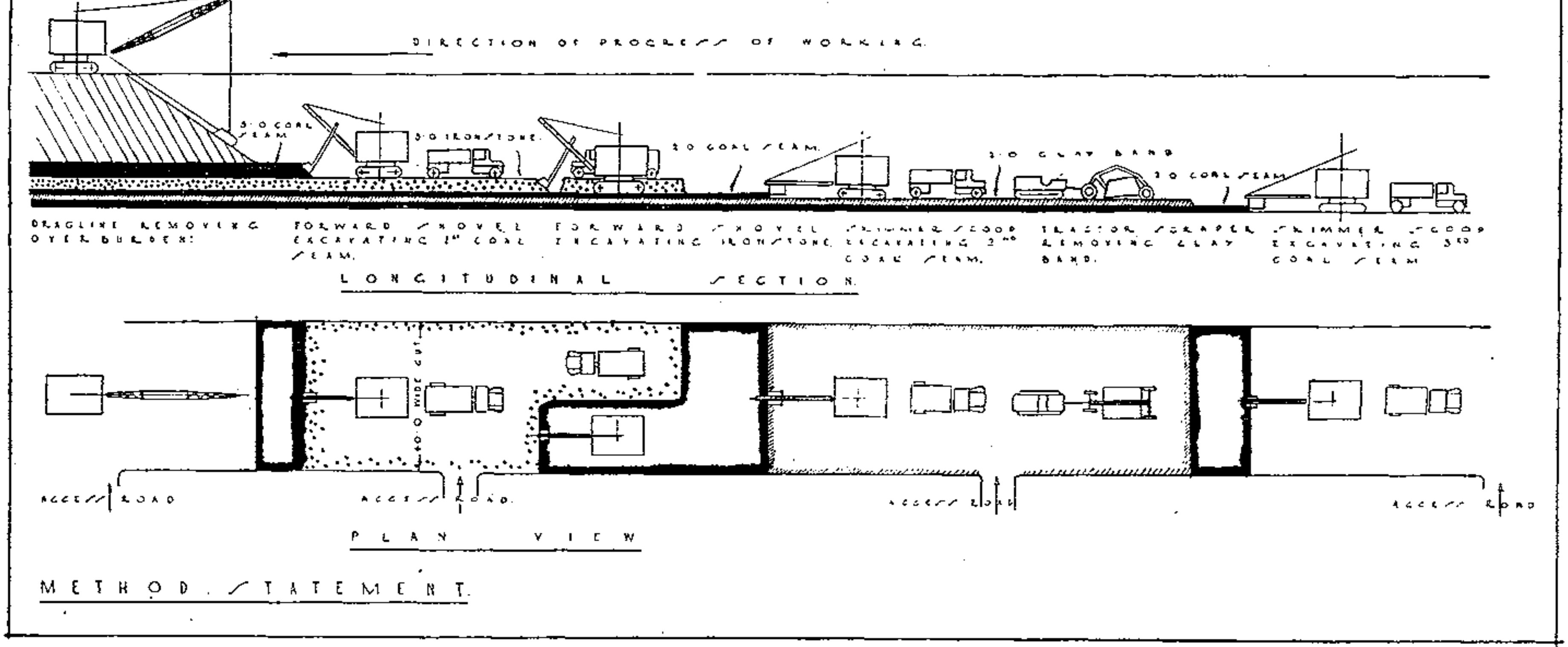
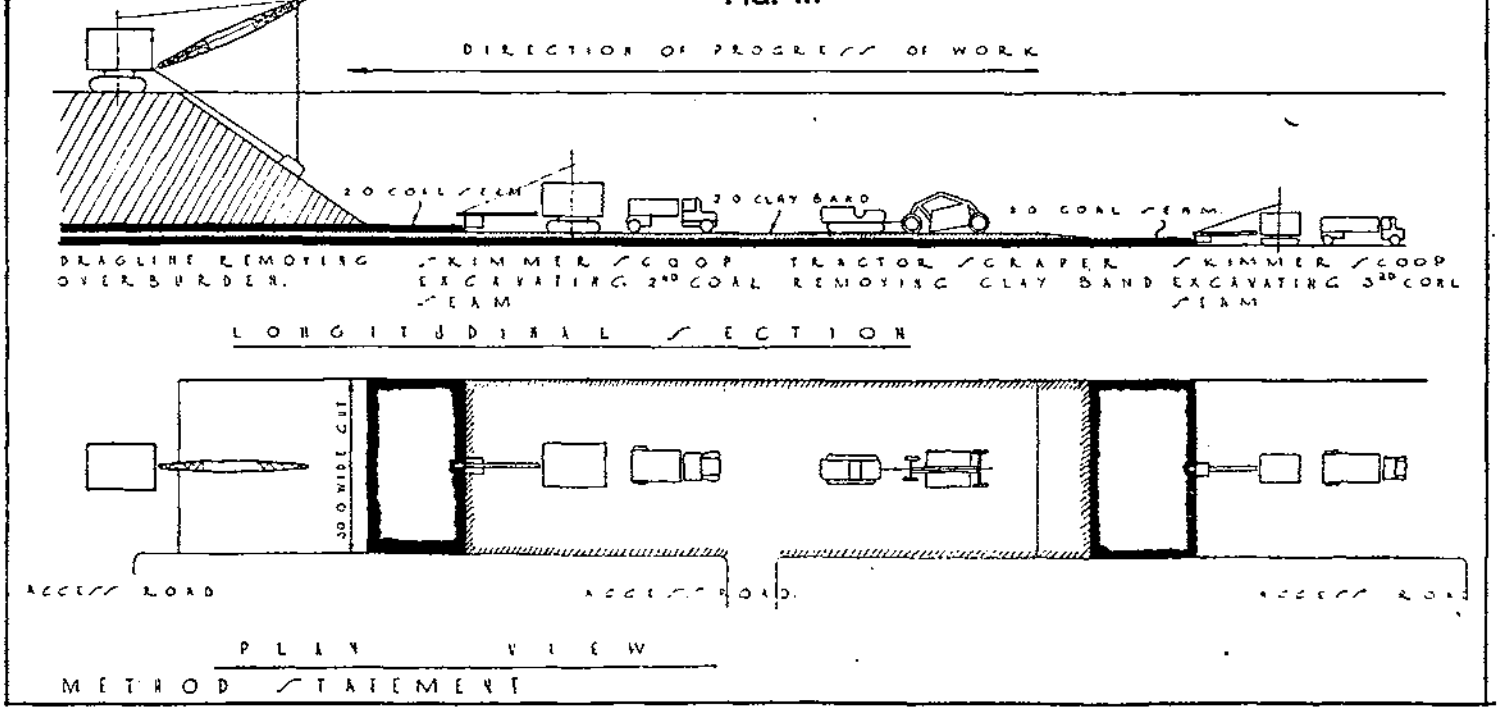


FIG. III



THE FUKA BASIN

By Major F. W. Shotton, R.E.

THE use of the place name " Fuka " in the title of this article may mean nothing to many, although it will conjure up vivid memories to all who took part in the Western Desert campaigns. For the benefit of those to whom it is only a name, it may be said that Fuka is a point on the desert railway line which now joins Alexandria to Tobruk. Lying about seventy miles east of Matruh, it has a station, two or three railway buildings and sidings, but no village and no vegetation ; in peace time therefore one would wonder why the station should be there at all. During this war it attained an importance dependent upon the camps and airfields which grew up in the vicinity.

The purpose of this article is to give an illustration of the value of scientific exploration in the development of water supply. The author was the geologist on the D.W's staff in the Middle East Command, and was more concerned with water supply than with any other problem. To summarize the scope of the work that was done throughout that widespread command would take up far too much space. The case of Fuka has therefore been selected because it is a concise example which became rather a classic in the desert campaigns. It proved what can be done when careful work by an Engineer Boring Section is combined with an appreciation of geological principles, backed up by careful records of pumping, change in water level, and variation of water quality. It also brings out the value of a scientifically-minded O.C. in a boring section, for undoubtedly most of the credit for the Fuka results belongs to Captain (now Major) G.R.S. Stow, R.E.

Before the development of supplies at Fuka itself, the nearest water point was thirty miles on towards Matruh. Along the 110 miles of desert road which stretched back to Alexandria, there were only two military sources of supply, both small. The desert pipe line ran from Alexandria, conveying purified Nile water to Matruh and ultimately to Capuzzo, but the increased demands of locomotive traffic left little or none of this water available for personnel, and the need for an additional supply in this arid stretch of the desert was great. There was no difficulty in finding water, since any boring down to sea level would meet it, but usually it proved to be almost as salty as the sea, and quite unfit for drinking. In the two cases already mentioned, where a potable water had been found, the yields were small, and if attempts were made to increase them by heavy pumping the quality rapidly deteriorated.

Attention was first directed to the Fuka area because of two Bedouin wells (Sanyet Fuka and Sanyet Gineishiya) which were abnormal for two reasons. They yielded drinkable water when boreholes only a mile away had struck salt water, and the standing level was thirty-eight feet above the sea, i.e., about thirty feet higher than the normal water table. Here, then, appeared to be what is known as a " perched " supply. Major Stow embarked on a series of exploratory boreholes, and it soon became apparent that water was being held up in a folded limestone bed, quite independent of the deeper normal water table ; but about sixty holes were sunk before the structure could be said to be fully determined. Such a programme of boring is not as formidable as it sounds, for a single rig could complete an unlined hole in less than a day.

The Plate shows the structure that was proved. It comprised a bed of limestone, about 50 feet thick, with clay in places on top, while beneath it lay another stratum of clay, 28 feet thick, separating it from the lower limestone. The whole was masked by a thin veneer of sand. The contours (see Fig. 1), drawn on the base of the upper limestone, show that it was folded into an elongate curving basin with the lowest point of its rim at A, 38 feet above sea level. The upper limestone thus formed an underground reservoir with an impermeable base, capable of holding water in its fissures up to the level of the " spill-over " lip of the basin (see Fig. 2). Its water was, therefore, quite independent of any normal supply that may have existed below. That a lower supply did exist was proved by a boring deliberately taken down into the lower limestone. It struck water with a salinity of 880 parts of sodium chloride per 100,000, compared with an average value of 75 for the Fuka supply.*

It was apparent that the native wells were not in ideal positions, so for production purposes, six boreholes were fitted with pumps, and five of these were located along the axis of the southern half of the basin. Of these six, one supplied local needs and five fed into the pipeline. The question then arose as to how much could be taken from this reservoir without fear of its running dry. By keeping exact figures of pumping output, measuring the drop in water level, in a hole kept open specially for that purpose, and knowing the exact shape of the limestone bed, it was a simple matter to correlate output with the amount of rock that had been drained—and hence to calculate what proportion of the limestone was represented by waterfilled fissures. Similarly, when the rainy season was on, and underground replenishment was taking place, one could calculate how much new water had found its way down into the basin. The following summarizes the main conclusions that were reached :—

1. The limestone had 7½% of its volume occupied by fissures yielding water—an unusually high figure for limestone in this desert.
2. The total amount of water held in the basin was 210,000 tons.
3. The annual replenishment by rainfall could be placed at about 40,000 tons.

The importance of these figures, from a peace-time viewpoint, is obvious, for they proved the practicability of a settlement where none previously existed ; with a permissible average of 25,000 gallons a day for drinking and irrigation without fear of failure, and with a reserve equal to five years' supply at this rate to tide over any winter seasons of low rainfall.

For a period of seven months, from September, 1941 to March, 1942, the Fuka boreholes had a busy existence, averaging 225 tons (50,000 gallons) a day and attaining the peak figure of 500 tons a day. Then, as modifications were made in the pipeline, and the front swept forward into Cyrenaica, the wells became unimportant as the demand dwindled. But the usefulness of Fuka had not yet ended. Completely demolished as the wells were in the retreat back to El Alamein, the area lay in enemy hands—used by him, though not fully appreciated—but standing out as the first locality of importance which must be brought back into production when our advance got under way. Owing to the detailed knowledge which had been accumulated, this was simple ; the borehole sites had been pinpointed and records showed exactly how deep the new boreholes would have to be, the lengths of casing needed to seal off the upper clay, and the yields that might be expected. Hard work by a boring section and the quick installation of air lifts gave all the water that was needed within 48 hours of the area returning to our hands.

* A salinity figure of 100 is perceptible to the taste, and 350 was the upper limit accepted as drinkable in the desert. The sea has a salinity of 2,800.

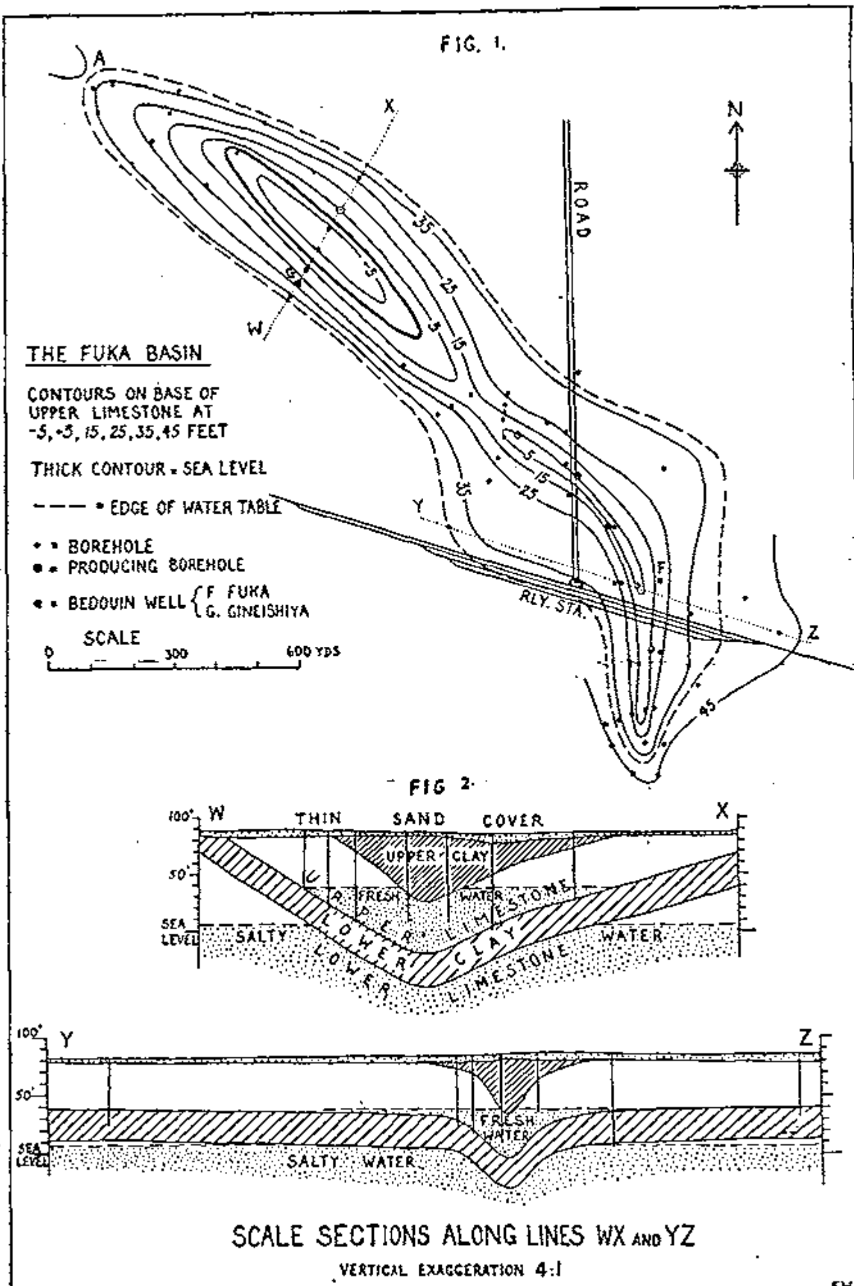


FIG. 1.
THE FUKA BASIN
CONTOURS ON BASE OF UPPER LIMESTONE AT -5, +5, 15, 25, 35, 45 FEET
THICK CONTOUR = SEA LEVEL
EDGE OF WATER TABLE
BOREHOLE
PRODUCING BOREHOLE
BEDOUIN WELL { F FUKA G. GINEISHIYA
SCALE
0 300 600 YDS
ROAD
RLY. STA.
N
A
X
W
Y
Z
F
G
FIG 2.
THIN SAND COVER
UPPER CLAY
FRESH WATER
UPPER LIMESTONE
LOWER CLAY
LOWER LIMESTONE
SALTY WATER
SEA LEVEL
100'
50'
FRESH WATER
SALTY WATER
SCALE SECTIONS ALONG LINES WX AND YZ
VERTICAL EXAGGERATION 4:1
F.W.S.

TRANSPORTATION IN INDIA

By Lieut.-Colonel F. D. Ogden, R.E.

1. Introductory

FROM ancient times the progress and prosperity of any nation has depended on its facilities for transportation. The Romans, for instance were pre-eminent in the art of making roads. India has now arrived at a stage in her internal development when she must seriously consider the most economical means of transport suited to her vast areas and the resources at her disposal: viz., rail, road, inland waterways, air, coastwise traffic by sea, or a co-ordination of these services. The purport of this article is to draw attention to this important question, and express an opinion as to the trend of post-war re-construction.

2. Existing Means of Transportation

Judged by Western standards, India's transport is only at the threshold of development, and considerable use is still made of the more primitive means, e.g., coolies, pack animals, and the almost universal bullock cart.

Human transport will always be used in mountainous districts, even when roads are far more developed than at present, because such districts are so sparsely inhabited that the construction of roads, to provide complete communication, is impracticable. For the same reason pack transport will never entirely disappear. Further, both men and animals can ascend gradients far steeper than are possible for wheeled vehicles. On the Frontier, camels and donkeys, with reduced loads, can negotiate mountain tracks, which are little better than staircases, whilst the nature of the terrain precludes roads except at a prohibitive cost. (Mules are confined almost entirely to the army.)

Railways have made good progress in India, and there are some 42,000 miles of track in an area of 1,805,000 square miles. Half of this mileage is on the (Indian) standard gauge of 5 ft. 6 in., 42% on the metre gauge and the remainder odd and smaller gauges. This density of railways, one mile to every 43 square miles, is little more than one-tenth of that in England; but England is mainly an industrial country, whereas India is mainly agricultural.

Before the war India had approximately 90,000 miles of roads, good, bad, and indifferent; an average of one mile to each 20 square miles—again only one-tenth of the road density in England—but the position has been improved by the construction of military roads since the outbreak of hostilities.

Prior to the War, air transport was not much used in India, though the air mail from England had been satisfactorily inaugurated and interest in civil aviation was increasing. This promises well for the post-war era, and India should ultimately draw level with the rest of the world in this form of transportation.

3. Present Roads Inefficient and Insufficient

The following quotations from the introduction to Mr. Hilaire Belloc's book *The Road* with reference to English roads may be applied perhaps to a lesser degree to the highways of India:—

"We are arrived at a chief turning point in the History of the English Highway. New instruments of locomotion, a greater volume of traffic, a greater weight in loads, and vastly increased rapidity in road travel have between them brought us to an issue: either some very considerable and immediate change in character of the road or a serious and increasing handicap in our rivalry with other nations through the strain and expense of an outworn system . . . . The Road is one of the great fundamental institutions of mankind. We forget this because we take it for granted. It seems to be so necessary and natural a part of all human life that we forget that it ever had an origin or development or that it is as much the creation of man as the city and the laws. . . . It is the Road which determines the site of many cities and the growth and nourishment of all. It is the Road which controls the development of strategics and fixes the sites of battles. It is the Road which gives its framework to all economic development. It is the Road which is the channel of all trade and, what is more important, of all ideas. . . . The Road moves and controls all history."

India's first road is reputed to have been constructed between Calcutta and the Punjab about the 16th century, and roads subsequently built vary from the earth or *kutcha* road to metalled (*pukka*) roads constructed according to modern practice. Except in the larger towns and cities, a road in India generally consists of a strip 16-18 ft. wide, with earth berms, bounded on each side by open drainage channels deep in dust or mud, and devoid of either foot-paths or kerbs. Some of the older *pukka* roads have absurdly excessive camber, while the bridges and culverts are in the main unsuitable for modern axle-loads. In the larger towns it is now realized, as in Western countries, that roads must be planned and constructed on up-to-date lines and such towns can now boast of roads which compare very favourably with roads in England.

4. Effect of Roads upon Social Life

The lack of roads and transport facilities in general is responsible for the narrow outlook of millions of the population of India, in that means for leaving their particular villages, and getting in touch with the outer world, were, until quite recently, almost entirely lacking.

The far-reaching effect which efficient transport has upon economic and social life has been amply proved in the case of the Western Nations, and one of India's greatest social problems at the present time is transportation. When this has been improved the whole outlook on life of the villagers will be changed, the standard of living and education enhanced, and greater progress assured.

5. Effect upon Agricultural Development

Some two-thirds of the population of India rely for their livelihood upon agriculture. A large proportion of these spend their whole lives in their native village, where their holdings are generally small and in many cases barely sufficient to maintain a family. There are some 500,000 villages of which many have neither convenient road nor rail facilities to enable the cultivator to take his surplus produce to the larger centres of population at a reasonable cost. The result is that such villages are more or less airtight compartments.

6. Taxation

In this respect India could profit to a large extent by the experience of the United Kingdom, where the necessary capital has been provided largely by grants from the Road Fund, which has been accumulated from taxes on motor vehicles. In India the roads at present derive very little benefit from the motor taxes, of which the bulk are used for other purposes. Here is one source from which funds could be drawn to finance the construction of more and better roads.

7. Comparison of Road and Rail Transport

It is not suggested that road transport is the only reliable and economic means suited to all cases. The construction of railways, however, involves a capital charge of tens of thousands of pounds per mile, which is not justified except for heavy traffic over long distances in fairly flat country, and between large centres of population or industry. Motor Transport presents a different picture, since it does not usually have to provide such enormous capital for its own track, and considerations of gradient are far less important than when railways are in question. Over short distances, both for goods and passenger traffic, motor vehicles are more economical, quicker, and safer, than rail transport, since they eliminate double-handling, sorting, damage in shunting, and delay while sufficient wagons are collected to form a train. For these reasons the four railway companies in England have applied to Parliament for powers to operate road transport services on a larger scale.

8. Department of Communication

It is, no doubt, for the above reasons that the Roads Development Committee, appointed by the Government of India, have *inter alia* recommended the setting up of a Department of Communication to deal with and co-ordinate all forms of Indian transport.

9. Road Development

(*a*) *Bridges.* The question of suitable bridges and culverts plays an important part in the problem of transportation, no system of which is complete until rivers and valleys have been adequately spanned. At present no standardised system of axle loading and impact exists on which to form a basis of design for road bridges, and the proposed Department of Communication might well give early consideration to this important point. Such structures need not be devoid of grace, as is unhappily the case in many road bridges in India, nor on the other hand need they be unnecessarily elaborate; they should be economical both to construct and maintain, with reference to their surroundings and the purpose for which they are designed.

(*b*) *Formation and Surfacing.* For this policy of road construction and improvement, as forecasted, it is necessary to consider carefully the following points :—

> Volume of traffic; nature of the foundations of existing roads; formation level; materials available and the anticipated speed; axle loads and spacing; new vehicles.

Much may be learned from the experience of Highway Engineers in England, who have been experimenting for a number of years to produce a road reasonably safe for traffic under all conditions. The causes contributing to a dangerous surface are many and varied, including the design of tyres, climatic conditions, and the dropping of lubricating oil by vehicles. The engineer must design his road without excessive camber or gradients, with correct super-elevation, and proper drainage; so aligned as not to impede vision, and provided with the most suitable surface. The need for footpaths and kerbs on most country roads is often overlooked.

(c) *Roadside Drains.* At present the major portion of the roads of India are skirted by open roadside drains, some roughly-cut channels, whilst others are open conduits of concrete or brickwork. It is suggested that the proper covering of these drains, which are the haunts and breeding ground of mosquitoes, etc., would amply repay the money expended, by safeguarding the health of the inhabitants. In Rangoon, as in many other cities, a determined effort was being made on these lines.

10. Inland Waterways

Canals and navigable rivers form a very economical means of transporting much of the bulky produce of an agricultural country. In parts of India greater advantage could be taken of existing waterways, supplementing them by canals, as connecting links, or as independent units. The irrigation departments of the various provinces are doing a good deal of valuable work, directly and indirectly, on inland waterways.

11. Conclusions

India's particular needs call for the co-ordination of the various forms of transport discussed in the best interests of the country as a whole, and much might be done to achieve this by the setting up of a Department of State similar to the British Ministry of War Transport.

It is reasonable to expect that, in times of peace, the monies to be derived from motor taxation would meet a major portion of the capital cost of the required new roads, improvements, and maintenance. As the roads improve so would the number of road users increase and funds accumulate for further development. Nor must the value of such communications in war be minimised.

In general it is suggested that the transport requirements of an essentially agricultural country like India can be met by, roughly, one mile of railway to each 40 square miles, provided roads were so developed as to afford an average of one mile of road to each 8 square miles.

By this means the amenities of village life would be considerably increased; the villages would be in closer touch with the larger cities and the outside world, and, through them, with education and all that it provides. The standard of living would advance, and progress would be effected in the direction of utilizing the vast resources of the country in the best interests of its people.

THE ECHELON SYSTEM OF MAINTENANCE FOR CONSTRUCTION EQUIPMENT

By Lieut.-Colonel Robert Lee Richardson
U.S. Army Corps of Engineers

"FOLLOW-THROUGH" is an old axiom among the rules of successful combat tactics. It has its place too in the highly-developed system of maintenance which is to-day enabling the U.S. Army Engineers to keep their huge forces of construction machines in constant fighting trim.

While U.S. mass-production methods have contributed construction equipment of vast size and capabilities, each new machine rolling off an assembly line constitutes the beginning of an entire new problem—the problem of exploiting that machine to its fullest capabilities. This is the problem of "follow-through," met by what the U.S. Army Engineers have developed into the Echelon System of Maintenance.

Under this Echelon System, there is a staggering of responsibility into five stages or echelons, proportionate to the personnel, tools, and replacement parts available to each. These echelons range from the individual operator of a piece of Engineer equipment—who is expected to provide preventative care, frequent lubrication, and minor adjustments—to the Engineer Heavy Shop Company, which can undertake almost any repair project short of manufacturing an entire new item of equipment.

Here in England the widespread U.S. Army Engineer construction programme, which was to make ready the invasion jumping-off points—the big bomber aerodromes, the sprawling depots, and the giant camps—required an influx of large-sized, heavy-duty construction machines never previously needed in Britain.

Mechanization had already been carried to its most advanced stage in the U.S. Army by the Corps of Engineers where even the tedious task of trench digging, which can rouse many sore memories among veterans of World War I, had become the job of a power-driven apparatus (The Barber Greene) driving a trench 8 feet deep through the ground. But the U.S. Army Engineers had been mechanized for little more than normal combat construction.

The programme they had to face in England required mechanization on a far greater scale. The biggest construction machines available in the United States had thus to be rushed here to help in the mass-production of the widespread engineering works required for an invasion. Large concrete mixers, sleek finishing machines, powerful bulldozers, and whole fleets of graders, dump trucks, and assorted American construction machines were loaded into convoys and shipped to British ports. See page 116 for the "Complete Asphalte Plant."

Engineer troops, however, had been in England several months before the arrival of those heavy construction machines. In some instances, it was several weeks before any construction equipment, even that normally assigned to an Engineer unit, caught up with an organization at its new location here in England. This delay, however, was not to be reconciled to the high priority of the construction programme, and many an Engineer unit was forced to improvise to get its operation started.

Trees were felled and the necessary lumber cut for rough, hand-hewn

The pick and shovel of old wars has given way to such modern equipment as the power-driven ditching machine (Barber Greene) manned by U.S. Army Engineers. The ditcher crawls forward at a steady pace, digging two-foot wide trenches to a depth of more than 8 feet for the construction of fortifications, drainage, and utilities. It is shown above putting down drainage ditches on one of the new American bomber bases being built in England by Aviation Engineers.

The echelon system of maintenance opp p 114

screeds, substituting them for the big finishing machines which were later able to complete more than a 1,000 foot strip of concrete in a single day's operation. These hand-hewn, wooden screeds, which incidentally often put the Engineers into difficulty with the British Timber Control, required a crew of four men, two tugging laboriously at each end, levelling off newly-poured mounds of concrete and putting a surface finish on to the strip. It was a slow, weary process, but it enabled the concrete-pouring operation to get underway with little delay.

Then the big machines arrived. The 34-E Paver and Concrete Mixer was brought in ; it mixed concrete in batches of 34 cubic feet at approximately one minute intervals. The finisher was shipped, too, as its working team mate ; it replaced the hand screeds and rode over the mounds of newly-poured concrete like a giant, steel raft, smoothing and finishing strips of concrete 20 feet wide. Large 8 cubic yard capacity Tournapull scrapers were brought over, too, to speed up the earth-moving job, see page 117. It was a busy Engineer picture with numerous, monster-like machines, and it had to operate on a round-the-clock basis. With a minimum number of machines and maximum production required from each, an especially great emphasis had thus to be placed on proper maintenance.

The weather did not help much. Mud hampered construction operations in every sense, but it placed an especially heavy burden on the problem of keeping the big machines going. There was mud everywhere—and seemingly in all parts of the machines too. It seemed an almost hopeless job for equipment operators who set to work, removing mud and carefully fondling every machine part at the end of each working shift.

This was first echelon maintenance. Here the operator, or driver, of a piece of equipment is charged with the responsibility. And it is a round-the-clock responsibility, starting with a thorough inspection prior to use, correct operation throughout the period of use, and then a thorough going-over at the end of the day's run. The individual operator cleans, services and lubricates. His tools come only from the chest furnished with that respective piece of equipment, and his spare parts come from the small kit furnished with each machine. These are the small parts frequently broken or rapidly worn and which can be installed by the operator himself with the tools available. These might include sparking plugs, fan belt, bolts, nuts, cotter pins, and lock-washers, etc.

Beyond that stage, however, maintenance enters into the second echelon. This is the responsibility of organization mechanics assigned to an Engineer unit. Their job is to establish a centralized servicing installation for that unit, and to undertake field repairs normally beyond the scope of the individual operator. Tables of Organization provide for such mechanics and maintenance specialists to be assigned to Engineer units. They work with hand tools and light portable equipment. Some may have one of the new general purpose mobile repair shops which are mounted on standard 2½-ton lorry chassis and are equipped with a full range of hand tools, wrenches, and sockets, 10-ton hydraulic press with accessory attachments, portable power drills, power grinder, and gas and electric welding equipment.

Second echelon spare parts sets furnished to these organizational mechanics include minor sub-assemblies that can be readily installed with the organizational maintenance tools available there. The highly mobile nature of these Engineer units, however, makes it necessary that these spare parts should be boxed for carrying in standard cargo lorries. As a result, no bulky or infrequently used parts are included in the second echelon sets. In addition to the small items included in the first echelon sets, the second echelon kit carries minor sub-assemblies such as carburettors, fuel pumps, oil pumps, water

Round-the-clock aerodrome construction by U.S. Army Engineers during the past two years has made possible to-day the round-the-clock bombings by the Allied air forces. Spotlights illuminate the night operation as the big 34-E concrete mixer and the XC finishing machine turn out strips of runway in the photo above. Lights go out only when enemy raiders cross the Channel. Since the summer of 1942, U.S. Army Engineers have been mass-producing aerodromes in England on a 24-hour-a-day, 7-day-a-week basis.

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pumps, distributors, gaskets, and various non-bulky clutch, brake, and chassis parts.

For complete field repairs and the replacement of major unit assemblies, the job of maintenance is passed on to the Third Echelon. This is operated by what are known as Engineer Mobile Maintenance Companies, providing centralized mobile repair facilities and decentralized support by mobile shop trucks which are dispatched to organizations requiring repair services at the site of disabled equipment.

Within the United States, however, this Third Echelon maintenance is also provided by regional shops set up by the Corps of Engineers and by commercial shops whose services are charged to Engineer Maintenance Funds appropriated for that purpose. These Third Echelon maintenance organizations are equipped with mobile shop trucks of various types, including electrical repair shops, emergency repair shops, general purpose shops, light machine shops, heavy machine shops, tool and bench shops, and small tool repair shops. All equipment is portable but nevertheless of the heavy-duty variety.

Major unit assemblies and spare parts necessary for complete field overhaul are included among the parts kits allotted to these Third Echelon Engineer Maintenance Companies. Two-and-a-half ton cargo lorries, equipped with spare parts bins and one-ton cargo trailers, are used to carry these kits. To maintain full mobility, however, bulky items such as motor blocks, large crankshafts, crankcases, and transmission cases are not included.

Last link in the maintenance organization—providing every service short of the manufacture of an entire new piece of equipment—is provided by the fourth and fifth echelons. These are either mobile shops of the heavy duty variety or large, fixed shops centrally located.

Included among the mobile variety are emergency repair shops, general purpose repair shops, and welding shops, all truck mounted and ready to keep pace with the advance of the armies. The heavy-duty fixed installations include electrical repair shops, forge shops, general repair shops, pattern and wood-working shops, and welding shops. These are installations of the largest variety, capable of undertaking any repair job.

To provide the necessary parts for these repair jobs, central depots, operated by Engineer Parts Supply Companies, have been set up throughout the Theatre. Stocks for one year's maintenance of every item of Engineer equipment here in this Theatre are available there. These depots normally operate in conjunction with the Engineer Heavy Shop Companies, which are generally stationed immediately adjacent to the supply depots.

There are, furthermore, special field maintenance sets of spare parts which are furnished to small bases or minor theatres of operation in lieu of the large depot stocks available here. From these sources, the fourth and fifth echelon organizations draw their necessary parts for their repair projects. If a machine cannot be repaired by either of these two top echelons, there is no alternative but the salvage heap.

To keep a sufficient stock of spare parts available here in the European Theatre, it is estimated that 100,000 different parts items must be stored in Engineer supply depots. Because of the difficulties resulting from wide variations in nomenclature between British and U.S. supply catalogues, it has been necessary to devise new methods of cataloguing, applicable to both Allies, in order that these 100,000 different items might be stored and issued here in this Theatre without confusion. Not all of the spare parts needed have always been available, but the situation has been generally good.

To keep this widespread maintenance organization at its peak efficiency, the Corps of Engineers has found it practical to issue several series of publications dealing with the work of these maintenance crews and intended to heighten their interest, and sharpen their abilities, in the problems of equipment maintenance. These publications range from informal, often humorous, magazines to the very formal and official technical manuals.

Eleven such publications are issued. First and most popular is *The Maintenance Engineer*, a monthly magazine published by the Supply Division of the Office of the Chief Engineer at Washington. It discusses latest maintenance doctrine and recommends short-cuts, and is used generally as the journal and meeting ground of all maintenance men.

Engineer Field Service Bulletins are of the more formal variety. They deal mainly with the lubrication programme and are intended for filing in regulation binders. Also dealing with the lubrication problem is the bound volume, *Lubrication—Corps of Engineer Equipment*. Included in the remainder of the list are Engineer Maintenance Circulars, which may cover any one maintenance problem; Engineer Export Manuals, which are for use in processing and packing equipment for overseas shipment; Engineer Equipment Data Books, which contain photographs and technical data on heavy Engineer equipment; and Corps of Engineers Equipment Lists, which are compiled periodically to indicate availability of spare parts.

There are also Engineer Technical Manuals; these are published by the individual manufacturers of a piece of equipment and contain all pertinent operation instructions; Part III Corps of Engineers Supply Catalogue, which is issued in separate sections for each model of standard Engineer equipment; and finally, the War Department Corps of Engineers Lubrication Guides, which provide extensive information on proper lubrication methods.

With this widespread maintenance organization, the huge stocks of spare parts stored in Engineer depots, and the extra attempts to keep maintenance personnel keenly aware of their large responsibilities, the problems of Engineer equipment maintenance have been well met in this European Theatre. The Chief Engineer here, Major-General C. R. Moore, has assigned special Maintenance Officers to each Base Section area, corresponding roughly to the geographical limits of the British Army's Command areas. These Maintenance Officers co-ordinate the work of the Engineer Maintenance Companies, Heavy Shop Companies and Spare Part Depots.

A painstaking network had thus been devised to take up every possible loose end in the maintenance scheme. The results, moreover, are now apparent in the equipment records compiled by the U.S. Army Engineers during the past two years here in England. All this complex maintenance organization had been geared to the problem of "Follow-Through"—the problem of getting the maximum from the minimum. And it worked!

A complete asphalt plant brought to England by the U.S. Army Engineers for the construction of aerodromes is shown in operation by Aviation Engineers. The plant is used for rapid construction of stabilized base or surface course mixtures by mixing in place on the runway or mixing at a central location. The equipment will produce stabilized mixtures of natural materials, soil-cement mixtures, and bituminous mixtures.

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Earth-moving made easy by the large Tournapull scraper is shown above on a depot construction project. The machine was brought to England by the U.S. Army Engineers to help speed the giant construction programme underway here.

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THE SYBARITE

By Lieut.-Colonel W. E. Britten, O.B.E.

"WHEREVER possible, requisitioned property will be used."

These words proscribe the unnecessary building of hutting for the troops, to conserve valuable timber and metal, which in the main have to be imported from overseas. But it must not be assumed that the phrase "Requisitioned property." covers only the hotels and country mansions which house so many of our troops in Great Britain. There are other less delectable forms: great gaunt warehouses of many floors, low squat country barns, empty shops, tenement buildings, deserted mills, in fact almost any shape in bricks and mortar which will protect the troops from the rain, snow and freezing fogs of an English winter.

My lawful occasions led me recently into one of the strangest requisitioned properties, a country gaol disused for many years but still possessing all the grim characteristics of a prison—small heavily-barred windows set high overhead, cold dank walls of forbidding thickness, resounding stone-flagged passages, and over all a sense of loneliness, gloom and much past misery.

The troops had just moved in, and were joking *more suo* about their accommodation—two men to a cell containing only one pallet of hard boards, and a tiny window high up in the wall.

"Toss yer 'oo 'as the Waring and Gillow," I heard one man say, and I knew where he came from. The cavernous kitchens were beginning to fill with smoke and steam from long disused ranges and boilers, tended by grimy men who were obviously thoroughly enjoying themselves.

Down still further in the depths of the building, two men were stoking the fire under a rusty boiler, alleged to be connected with the Central Heating.

The fire was burning well, but nothing much else seemed to be happening, even to the pressure gauge. "Gie it a bit knock with yer shovel," said one man, and I knew his country of origin too.

I did not stop to talk to him. Boilers with pressure gauges requiring a "bit knock" were definitely not in my line of scientific investigation.

Luckily the Warders' quarters offered some better accommodation for dining-rooms and the like, but the best and largest room of all, the old prison chapel, dry, boarded, well lit, and, one would have thought, an ideal "NAAFI," had been appropriated by the Quartermaster for his valuable stores—"Guns before butter."

The chilly atmosphere was beginning to soak into my bones, and I made for the gate. But then I noticed a cheerful little room with almost a normal window and no horrid spy hole in the door. A real bed, albeit rusty, covered with Army blankets, stood in one corner, and there was even a little table with books on it. It looked almost home-like.

"Who's the lucky man in there?" I asked.

"Oh!" said my guide, "that's the Quartermaster—he's got the condemned cell!"

THE 1ST A.A. BATTALION, R.E., AND THE ITALIAN-ABYSSINIAN WAR, 1935-36

By Major (now Major-General) A. M. Cameron, M.C., R.E.

MANY of us considered that the party began on a wet night near the South Coast where we had gone for an Anti-Aircraft Exercise. We were having a so-called dinner, in rather more than the usual discomfort, when a certain Company Commander, presumably by way of cheering us up, started offering long odds that within a month some or all of us would be overseas. He was unanimously howled down and to this day it is not known whether he had inside information, was merely guessing, or was the only one of us who had correctly appreciated the situation. Anyhow, thirty-six hours later the C.O. had been summoned to the War Office, and at 12 o'clock on a Saturday morning he telephoned down that "A" and "B" Companies were to be re-called from leave. In the interests of secrecy no telegrams were sent, and it was not until Monday that the men started turning up. This made things difficult, as the technical equipment of both Companies was on loan to "C" and "D" Companies and had tobe taken over and packed ready to go to Portsmouth on Wednesday. One Company Commander suffered agonies of apprehension from the loss of his mobilization scheme, which he swore his predecessor had taken to Bermuda; this turned out, however, to be a blessing in disguise because this particular mobilization departed from all preconceived ideas. Eventually the equipment left Blackdown on Thursday for embarkation in S.S. *Bellerophon*, and the personnel sailed in H.T. *Neuralia* five days later on Tuesday, 3rd September, 1935, twelve days after that wet night near Romsey.

The 1st Anti-Aircraft Searchlight Group R.E., later to become the 1st Anti-Aircraft Battalion R.E., was just entering on a period of expansion from which it suffered greatly. Increased establishments of overseas garrisons were calling for exceptionally heavy drafts, each trooping season, unprecedented numbers of Permanent Staff Instructors were under training for the new Anti-Aircraft units of the Territorial Army, and the Battalion itself was in process of expansion from two Companies of twelve lights each and one Company of six lights to a new establishment of four Companies of twelve lights each.

Hardly were "A" and "B" Companies safely out of the way, than a further demand was received for the despatch of six more sets of searchlights and a Company Headquarters. "C" Company was selected to provide the personnel and they sailed on 15th September. This left the Group with practically no equipment and they were issued with a quantity of antique Petrol-Electric lorries and 36-inch Naval pattern M.C.D. Projectors made in 1914.

For training purposes "A" Company Headquarters, which had been left behind, took over the class of 60 T.A. Permanent Staff Instructors, whilst the remnants of "C" Company were transferred to "D" giving the latter three Sections of six lights each. In October "D" Company gave birth to a twelve-light Company which sailed for Aden and in November its remaining Section left for Port Sudan.

Thus in ten weeks the original four Companies had been despatched overseas in five separate consignments, each with a different establishment; and at Blackdown there remained only Battalion Headquarters and a few miscellaneous officers and men. They were not idle, however; plans were prepared and equipment earmarked for the training of three companies of Reservists, if the necessity arose, and in November a fresh batch of recruits was posted from the School of Electric Lighting. These were taken over by the old "A" Company Headquarters, and organized into a 12-light Company. All through December and January they attempted to hold night runs, but the weather was against them and on 26 occasions, out of 30, the aircraft declined to fly. Nevertheless, on 5th February, 1936, they also departed overseas.

This ended the series of departures. In five months the Battalion, with an establishment of eight Sections, had sent ten Sections overseas and not a single reservist had been called up. A period of reconstruction now set in. By the summer of 1936, "D" Company of the 1st A.A. Battalion had been reformed and "E" Company of the 2nd A.A. Battalion had been created. In August "B" Company and the Headquarters of "C" Company returned from overseas; they were followed shortly afterwards by the remnants of the original "A" Company from Malta, and before Christmas, 1936, the second "A" Company also returned. The Sections at Aden and Port Sudan had passed on to Singapore, but once more the 1st A.A. Battalion had its full complement of four Companies at Blackdown.

Malta Reinforcements

That portion of "A" Company which sailed from Southampton on 3rd September was a headless trunk. Company Headquarters remained at Blackdown and the two Sections were sent out to provide third and fourth sections for the 16th (Fortress) Company. They disembarked at Malta after breakfast on 11th September expecting to be greeted with enthusiasm as the heroes who had come to save the island. They were greeted with enthusiasm all right; but were somewhat disillusioned when they were told the reason:—"You will be available for Church Parade." However, there was little time to develop grievances. S.S. *Bellerophon* carrying their equipment arrived the same evening; unloading started at once and continued throughout the night and until 1 p.m. next day. By sunset on 12th September every detachment was in position and ready for action.

For a week detachments bivouacked on their positions at night. Two sentries were posted at each position and the remainder of the detachment nominally slept; but as it was their pride that they could come into action from "sleep" to "expose" in twelve seconds, the sleep cannot have been of a very restful nature. At daybreak every detachment returned to barracks, breakfasted, and slept till dinner-time. The afternoon was devoted to maintenance and soon after 5 p.m. they were off again to their positions.

After a week this extreme state of readiness was relaxed somewhat and only 50% of the positions were manned each night, but the "Guy" Searchlight Lorries of the Malta Reinforcements, lumbering through the narrow streets, left their mark on the Island, at least one village having a main street distinctly wider than it had been before the 11th September.

On 29th September, all night manning ceased and thereafter both Sections reverted to normal peace-time employment. One of the officers became engaged to be married and applied to remain in the station for a full tour of duty. Eventually in August, 1936, the two Sections were broken up; some of them were incorporated permanently into 16th (Fortress) Company and the remainder returned to Blackdown.

"B" COMPANY.

"B" Company was selected for a role which, it is believed, created two historical precedents. For the first time a complete company of the 1st A.A. Battalion was sent overseas for active service; and for the first time a Company of Royal Engineers became an integral part of a Naval organization and was placed under the Command of Naval Officers.

When the Mediterranean Fleet left Malta in August, 1935, the Admiralty sent out defences necessary to establish a temporary base elsewhere. The organization so created was known as "Base Defences" and consisted mainly of Royal Marine personnel; but, the Admiralty had no Anti-Aircraft units, and borrowed from the Army the 1st A.A. Battery R.A. (6 guns), "B" Company 1st A.A. Searchlight Group R.E. (12 lights) and a Cable Section, Royal Signals. These three units formed the 1st Composite Air Defence Brigade under a Lieut.-Colonel R.A., part of the "Base Defences" commanded by a Brigadier, Royal Marines, with a Major R.E. on his staff as Works Officer. "B" Company personnel disembarked at Alexandria on 14th September, but their equipment was retained in S.S. *Bellerophon* and the Company was at short notice to re-embark. The Army in Egypt was still sending officers on leave to England, but the Navy was actively preparing for a possible war and "B" Company followed suit. By a happy chance, "B" Company found itself in possession of ammunition surplus to establishment and was thus able to stage Rifle, Lewis-Gun and Revolver courses for such men as had not fired recently. Searchlight positions were reconnoitred round Alexandria. An Internal Security Scheme was prepared and rehearsed, and plans were made on the map for the A.A. defence of all likely ports in the Eastern Mediterranean.

On 26th September the "Composite Searchlight Company R.E. (6 lights) disembarked at Alexandria as part of the 2nd Composite Air Defence Brigade." To "B" Company the arrival of this second company was most welcome. The 2nd C.A.D. Brigade had been sent out for the specific purpose of defending Alexandria harbour and at once landed all its equipment. "B" Company were, therefore, able to keep their hands in at A.A. work, both by loaning instructors to the Composite Searchlight Company and by occasionally borrowing the latter's equipment.

About the same time eight detachments of a Royal Marine A.A. Searchlight Section, equipped with M.C.D. 120 cm. Searchlights and Crossley Generators (replaced later on by Listers) arrived in Alexandria. They were completely untrained in A.A. Work, so "B" Company provided them with a number of instructors.

As the days passed into weeks, alarms and excursions began to subside, rumours of war became less frequent and the Company realized that they might continue to live indefinitely, on the edge of war and in a state of imminent re-embarkation. There was a final spasm in which the company packed up everything it possessed, including officers' bedding, and came on one hour's notice to re-embark; later they settled down to live permanently at six hours' notice and began to look ahead.

It is an interesting experience to try to employ usefully 173 Sappers for three and a half months when the only tools provided are jack-knives and bayonets, and all the vices of the Middle East are at their threshold.

As a start, the company took over as many as possible of the more military regimental employments in the Brigade Camp, such as guards and police. Tools were begged and borrowed to enable trade training classes to be started for carpenters and painters.

Educational Classes went on all day long. But the staple employment was reloading S.S. *Bellerophon*. This ship was worthy of a volume to herself and would have provided unlimited material for an Anthony Armstrong. She had been loaded at Portsmouth in extreme haste, her holds contained an assorted collection of guns, searchlights, lorries, clothing, ammunition, beer, cheese, matches, petrol, and innumerable other articles. At Malta a certain number of guns and lorries were removed and replaced by torpedo war-heads and palliasse straw, and the interstices filled with cement in paper bags, not a few of which burst when dropped into the holds. By her fellow-ships in Alexandria harbour, she was regarded as something of a leper, and when during a gale she spent the night bumping up and down on the breakwater, her neighbours are reported to have put to sea. Many stories regarding her were in circulation, such as that of the officer in charge of a working party who, finding the deck over the magazine unduly hot, lowered a thermometer on the end of a string down the ventilator. The reading was so astounding that he was about to sound the fire alarm when it was pointed out to him that the ventilator was the galley chimney. But to return to the reloading of the *Bellerophon*.

It was essential to restow her holds with a view to eventual unloading in proper tactical sequence, but still remain able to sail at twelve hours' notice. Some barges were therefore moored alongside and the moving of her cargo piece by piece out on to the barges and back into the same or another hold occupied working parties from all units for some two months. It was reminiscent of one of the puzzles of one's childhood.

With men on the *Bellerophon*, paying the Company was always a lengthy business. At times a picket boat might be persuaded to assist for the outward journey, but not infrequently the paying officer was compelled to hire a felucca and sail both ways. This pay problem reached its peak in December, 1935, when for a fortnight the Company were distributed over two camps, two hospitals, and nine ships, all thirteen places being in Alexandria. The need for so many R.E. on board ship arose out of the Navy's desire to experiment with sound-locators. By special authority of the Commander-in-Chief, Mediterranean Fleet, six sound-locators were unearthed from the *Bellerophon* and they and their R.E. crews were installed on the fore-gun turrets of six cruisers. Everything possible was done to reduce extraneous noises; *e.g.*, during exercises, the only boat traffic permitted in the harbour was the "dicer" in which the responsible R.E. subaltern "took passage" from cruiser to cruiser visiting his sound-locators. These exercises showed that it is definitely possible for sound-locators on board ships at anchor in harbour to detect aircraft on reasonably quiet nights, but berthing problems make it difficult to site these sound-locators so that their searchlights can pick up hostile aircraft before the latter release their bombs. In between the exercises, which were spread over a fortnight, the sound-locator crews lived on board the cruisers and went to sea with them for exercises. Visits to H.M. ships were always popular with the men, who were most hospitably entertained on these occasions, battleships, cruisers, aircraft carriers, destroyers and various miscellaneous craft, all taking part.

On Christmas Day news was received that all equipment was to be disembarked at once. The 1st C.A.D. Brigade, less one Section of "B" Company, was to be sent back to the Army for the defence of Mersah Matruh; whilst the other Section of "B" Company and the Royal Marine Searchlights were to be added to the defences of Alexandria which, up till then, had included only the six searchlights of the Composite Searchlight Company. The Mersah Matruh part of the Company went by train to Fuka, and covered the remaining 50 miles by road.

They arrived in a dust storm and lived in dust storms for most of their stay, three months. Soon after arrival the six detachments were sent out into separate camps and told to dig themselves in. Construction of emplacements for projector, sound-locator, A.A. Lewis gun, lorry and spotters, was a month's work for each detachment of nine men, who had in addition to do all their own housekeeping, take part in two night runs per week, and maintain their searchlight and other equipment in proper condition. The frequent sand storms brought to mind the old problem of the monkey who climbs two feet up a pole and slips down one; how long will he take to get to the top? One detachment certainly slipped down two feet after climbing only one for after 36 hours' continuous sand storm, the work of a month was filled in completely, and after digging out their equipment they had to move camp and start again. This was before the days when every vehicle in Egypt was fitted with an efficient air-filter, and the Company repair party was kept busy fitting new pistons and rings, to Austin Sevens, Morris and B.S.A.'s after about 1,800 miles. Probably the worst discomforts of Mersah Matruh were borne by the Section Serjeant and his Morris driver. Day in and day out, Sundays and holidays, sand storms or heat, they made their 15 mile round trip two or three times a day, delivering rations, water, petrol, and all the necessities of life to their hungry detachments. Never once did they fail and the same can be said of the donkey echelon which had to be interposed between the Maintenance lorry and one detachment. The redeeming feature of Mersah Matruh was the sea bathing, which was almost ideal.

At Alexandria, the risk of ground attack did not arise so there the Section did not dig themselves in, and ample time was available for camp ornamentation. One detachment constructed of whitewashed snails, the only available material, a magnificent R.E. crest surmounting their sobriquet "Watchdogs of the Desert," but got rather tired of replacing the watchdogs when they walked off into the desert.

By April, 1936, the war tension had relaxed and detachments of this section were concentrated in a central camp, at the same time "A" Company became available to replace the Headquarters and No. 3 Section of "B" Company at Mersah Matruh. During the Easter week-end, the whole of "B" Company was accordingly concentrated in a new camp on the sea shore at Mex Beach. This was the third successive holiday period devoted to a move; when the Italians reached Addis Abbaba, hopes therefore ran high that Whitsun would see the return of the Company to Blackdown, but they were doomed to disappointment and the return took place instead at the August Bank Holiday period.

At Mex Beach, the company was concentrated in one camp with all its equipment for the first time since it left England, seven and a half months earlier, and a period of overhaul set in for both men and equipment. P.T., squad drill, a guard mounting competition, a drill and duties course for junior N.C.O.s, annual weapon training course, vehicle and searchlight equipment competitions, etc., occupied the next two months. A curious situation had arisen as regards N.C.O.s; normal promotions had been carried out but there had been no outflow from the company at all and in consequence, 25% of the company were N.C.O.s and every rank except C.S.M. and C.Q.M.S. was over establishment. In order to give everyone a chance of employment in the duties of his new rank a general shuffle round took place and various sinecures were created for the more senior. A feature of this period was the marriage of the junior subaltern who, with his bride, was given an escort of Despatch Riders in excess of that authorized for the High Commissioner.

Back in the vicinity of the harbour it was possible to resume close liaison with the Fleet. In the small disused Mex harbour, two hundred yards from camp, " B " Company constructed a comprehensive swimming pool with the aid of a grant from the Fleet Sports Fund. It was used by a large number of ships and there were daily water polo matches between " B " Company and one of the destroyers or other ships of the Fleet. Two football grounds and a hockey ground were constructed and " B " Company was represented in the Base Defences team which won the Battle Squadron Athletic Challenge Cup. For evening occupation, two marquees were fitted up as recreation tents with darts, skittles, table tennis and other games ; and periodic concerts and entertainments were arranged.

One night run which took place at this time is worthy of record as it proved the possibility of using searchlights to " mystify and mislead " the enemy. Early in the year the Bomber-Transport Squadron R.A.F. at Heliopolis took part in an exercise in which they attacked Alexandria. All raiders were picked up with ease by the searchlights, except one who shut off his engine and started gliding just before he came within range of the outer lights. Profiting by this experience when the same squadron took part in a later exercise, every aircraft attempted to do the same thing. But the defence had now been increased by the 6 lights of " B " Company from Mersah Matruh, who unknown to the attackers, were pushed well out to the S.W. with the object of picking up gliders before they shut off their engines. In this they were entirely successful and the only unilluminated attackers were those who flew in from other directions.

After nearly a year of exposure to sea air and continuous hard work, all vehicles were badly in need of a coat of paint as a preservative. Army green not being available, an issue of Battleship Grey was made. This work was in full swing when orders to return to Blackdown were received in the middle of July. Several hectic days followed dismantling and filling in searchlight positions, handing in camp equipment, and reloading lorries and technical equipment into S.S. *Bellerophon*. On 25th July, " B " Company left Alexandria in H.T. *Lancashire* and arrived back at Blackdown on 5th August, 1936, eleven months and two days after their departure.

The Composite Searchlight Company R.E.

The Headquarters of " C " Company sailed from Portsmouth in H.T. *Lancashire* on 15th September, 1935. With them was the Headquarters Staff of the Base Defences. The atmosphere of the ship was one of serious business wrapped in a shroud of mystery.

Poor *Lancashire* ! For 10 months she suffered boredom but added grace to the Mediterranean Fleet as she lay at anchor in Alexandria Harbour, where she housed Base Defence Headquarters. Two or three times she went to sea for twenty-four hours to get a breath of fresh air and once she went into dry dock and had some eighty tons of barnacles and slime removed from her bottom.

At Gibraltar, Company Headquarters were joined on board ship by the one Section of which the company was to be composed and on that day the Composite Searchlight Company came into being. The Company Commander expected, that his men would have some knowledge of A.A. work. It gradually dawned on him, to his increasing horror, that practically none of his section had ever handled an A.A. searchlight in their lives—and the outbreak of war was thought to be imminent !

On 25th September the *Lancashire* berthed in Alexandria harbour and the 2nd Composite Air Defence Brigade disembarked. This Brigade consisted of the 2nd A.A. Battery R.A. (8 guns), the Composite Searchlight Company

R.E. (6 lights) and a Cable Section, Royal Signals. Being definitely for the A.A. Defence of the ships in Alexandria Harbour, the whole of its equipment was also disembarked as soon as it arrived on board S.S. *Ben Cruachan* (pronounced locally as Ben Kruschen). With the assistance of instructors borrowed from " B " Company, the Composite Searchlight Company at once took in hand the training of its section, and was soon ready for its first night run. This was also intended as a demonstration to impress the local population ; it was therefore essential that it should be a success. Only three lights were used ; one of them was on a breakwater, and another adjacent to a café where a loud-speaker was in action ; sound-locating by these two was impossible. It was therefore arranged that the target should not switch off its navigation lights until it had been picked up by the first beam. As an exercise the proceedings were of little value ; as a demonstration they were a huge success and drew a full house.

Four days later a second, and genuine, night run was staged. Co-operation with the Royal Navy had not, at this date, been fully established, and the Fleet were also staging an air defence exercise in which three planes took part. This was too much for the Army's pilot. His nerve was so shaken by the number of other aircraft without navigation lights, which flashed past him in the moonlight, that he made tracks for home at an early hour. But the exercise lasted long enough to establish for ever the prestige of the " shore " lights and to draw from the Naval Commander-in-Chief a general signal extolling their efficiency.

In January, the Composite Company was caught up in the same whirlwind of activity which overtook " B " Company, and the section went out into detachment camps. Two of these were amongst the soft sand dunes which border the Mediterranean Sea and only by herculean labours was it possible to get the searchlight lorries to their positions. To maintain them there by M.T. was out of the question and a camel was pressed into service, not only for delivering rations, water, petrol, etc., but also for the Company Commander's inspections.

There were now installed in the Alexandria Defences, the Composite Company (6 lights) one Section of " B " Company (6 lights) and the Royal Marine Section (8 lights)—a total of 20 lights. Plotting had therefore become feasible.

When the remainder of " B " Company returned from Mersah Matruh in April, 1936, it was decided that in the event of war they should relieve two detachments of the Composite Company for manning two lights on patches of dry land in the middle of Lake Maryut. One of these lights was put into position by means of an improvised raft and manned during an exercise, but a combined attack by mosquitoes and doctors drove it back to camp next day.

On exactly what date the Composite Searchlight Company ceased to exist is not recorded. The personnel sailed for home in H.T. *Lancashire* on 25th July, 1936, but the Company Commander had faded away the day before to the Holy Land. The subaltern and section disembarked at Gibraltar and rejoined the 1st (Fortress) Company. The personnel of Company Headquarters, the imprest account, and the office files were brought back to Blackdown by the junior subaltern of " B " Company.

A.A. Section, Port Sudan Fortress Company R.E.

The personnel of this Section were the survivors of " D " Company, They embarked at Southampton on 15th November, 1935, in S.S. *Cameronia*. which they found much more comfortable than an ordinary transport, and they disembarked at Port Sudan on 27th November after an uneventful voyage. They were at first accommodated alongside 8th A.A. Battery, R.A. from India in a large warehouse. Three tents were also available, but as these were washed down by rain on the second night, they preferred the warehouse which was at least cool and dry. For a fortnight they were without any equipment and occupied themselves with P.T., musketry, and drill when the weather was not too hot. When their equipment did arrive, there was a further delay of two days whilst customs formalities were complied with! In December the A.A. Section was joined by Company Headquarters and a Coast Defence Section, the whole forming the "Port Sudan Fortress Company R.E." They then moved into a permanent camp, but owing to the delay in the arrival of various items of equipment, the Section was not ready for action until Christmas eve. Even then one lorry was awaiting a front axle replacement as it had collided with a bridge, the only dangerous place in Port Sudan.

The A.A. layout was complicated by the fact that because of the dangers of a land attack all lights had to be sited inside the anti-tank perimeter. Also the searchlights were allotted the subsidiary role of illuminating the ground in front of the land defences in the event of a night attack, and one searchlight was allotted a dual A.A. and Coast Defence role.

January was enlivened by a visit from the Army Auditor. In February some air co-operation became available for A.A. training for the first time but only on about one night a week. However the section was fully employed on field works in connection with the local defences, and they also found time for weapon training, educational training, and the building of an O.D. boat. The nearest R.A.O.C. workshops being at Abbasia, arrangements were made for repairs to be carried out in the local dockyard, which was well equipped with plant and personnel, although M.T. was something of a novelty to it.

For recreation, hockey, football, swimming and water polo were available, whilst occasional leave parties were sent to Gebeit in the Red Sea Hills.

About the middle of August, 1936, the Port Sudan Garrison began to fade away, but the A.A. Section did not leave until 24th September, when they embarked in H.T. *Lancashire* for Singapore, having previously despatched their equipment to the United Kingdom.

"A" Company.

"A" Company sailed from Southampton in T.S.S. *Tuscania* on 5th February, 1936.

On arrival at Alexandria, the ship was compelled to cruise off the harbour for twelve hours until a heavy gale had blown itself out. The Company eventually disembarked in the early morning of 14th February and went into Sidi Bishr Camp. The equipment arrived two days later in S.S. *Matheran* and was off loaded within the next forty-eight hours.

Anyone who knows Sidi Bishr will appreciate that the deep loose sand is not ideal for lorry standings. The Company was equipped with brand new Crossley Searchlight lorries and within a fortnight the teeth in three gear boxes had been stripped and the torque rod of the stores lorry broken. It is pleasant to note that subsequent investigation by O.M.E.s acquitted the company personnel of responsibility for these catastrophies and laid the blame on the design, which was unsuitable for work in heavy sand and the scheduled load, which was too great.

Since "A" Company had had only four night runs in the whole of its existence, it was decided to retain the Company in Alexandria for a period of training before despatching it to Mersah Matruh. By the end of the month night runs were in full swing four evenings a week; this was, however, too good to last and four weeks later they ceased altogether, as the R.A.F. were experiencing engine trouble due to sand.

The second week in April, "A" Company arrived at Mersah Matruh in relief of "B" Company and found life even more unpleasant than at Sidi Bishr. Sandstorms were raging hard and it was decided to move the Company to a more salubrious camp site near the sea. Unfortunately the day chosen for the move produced the worst sandstorm yet experienced. By midday two lorries, one car and three motor cycles were *hors-de-combat;* one Morris, one D.R. and the rations were lost; and all the officers' watches were seized up.

"A" Company had not only to dig emplacements for their additional lights, but as their control arms were some eighteen inches longer than those of "B" Company, they had to reconstruct all "B" Company's emplacements.

This occupied them nearly four weeks, during which period detachments camped on their positions. The Company was concentrated again at the beginning of June and, as the R.A.F. could only provide aircraft for one night run each week, spare time was employed on the erection of steel huts under C.R.E. 5th Division.

This work came to an end on 12th July when the Company was ordered to stand by for return to the United Kingdom; but it was not to be. Nine days later they found themselves on a rail journey of thirty-five hours' duration to Palestine to assist in restoring order there. They remained until November, 1936, when they returned to Blackdown.

Conclusion.

This brief account necessarily omits much detail concerning the technical doings and plans of the various units but certain lessons were brought home to the officers of more than one Company and in conclusion some of these are recorded.

The point which appears to have struck Unit Commanders most forcibly was the lack of knowledge on A.A. matters possessed by commanders and staff, both Naval and Military. In some cases commanders gave their A.A. units an entirely free hand; in others, they made demands on their A.A. units which ought not to have been made, but were difficult for comparatively junior regimental officers to resist. Obviously both courses are wrong and both commanders and A.A. officers were placed in a false position. If in the future A.A. units are likely to be placed under the command of comparatively small formations, knowledge of their capabilities and limitations should be as widely disseminated throughout the Army as for example, similar knowledge in the case of Tanks. The situation created an added anxiety for searchlight commanders, since the latter could never be certain that their formation commanders really understood how totally inadequate were their resources in every case. In this connection it will be appropriate to quote the words of two leading authorities on Anti-Aircraft work, one a Sapper and the other a Gunner.

Says the Sapper: "It is worth emphasizing again that, in these days, when co-operating with guns, anything less than a 72-light lay-out is of little value; a single company of 24 lights is nearly hopeless; and a lay-out of 12 or 6 lights is quite useless."

And the Gunner: "This implies the use of a large number of lights; in fact, unless there is an adequate number and they can illuminate a sufficient area, it is better to rely for defence on other measures, such as black-outs and concealment."

The principle of concentration at the decisive time and place has long been taught in connection with land warfare. Surely the same holds good of Anti-Aircraft defence and available resources should be concentrated at the vital points?

Appendix.

Units despatched overseas by 1st Anti-Aircraft Battalion R.E.

Unit	*Served at*	*Created from*	*Officers*
Malta Reinforcements (12 lights)	Malta	Two sections of "A" Company.	Lieut. L. G. Robinson Lieut. D. N. Moore
"B" Company (12 lights)	Base Defences Mediterranean Fleet, Alexandria & Mersah Matruh	"B" Company	Major A. M. Cameron, M.C. Capt. J. E. L. James Lieut. R. Greenwood Lieut. R. T. L. Rogers Lieut. J. H. Gillington Lieut. G. C. S. Coode
Composite Searchlight Company (6 lights)	Base Defences Mediterranean Fleet Alexandria	H.Q. from "C" Company Section from Gibraltar	Capt. F. C. T. Noakes Lieut. J. S. Close
Aden Fortress Company (12 lights)	Aden	"D" Company	Capt. W. P. Rendell Lieut. R. T. Brain Lieut. J. A. Crawford
A.A. Section, Port Sudan Fortress Company (6 lights)	Port Sudan	"D" Company	Lieut. H. G. A. Elphinstone
"A" Company (12 lights)	Mersah Matruh and Palestine	Formed at Blackdown from H.Q. of original "A" Company and two recruit sections.	Major K. H. Lockhart (till 1/3/36) Capt. F. C. T. Noakes (from 26/7/36) Capt. F. K. Cran (present throughout. In Command 1/3/36 to 26/7/36) Lieut. C. R. Nicholls Lieut. J. G. Carr

MEMOIRS

BRIGADIER W. PORTER, C.B.E.

BILL PORTER'S sudden death, while on duty at the War Office, came as a great shock to his old friends in the Corps, especially to those in close touch with him. His death was almost certainly due to his own untiring devotion to work after an illness from which he had not really recovered. Throughout his career at school and in the Army, he had displayed the same energy at work and at play. A scholar and Captain of the XV at Tonbridge; a prize cadet, under-officer of his company, and in the XV at the "Shop"; a first in the Mays, and elected Captain of his college XV at Cambridge. He followed these with a Brevet Majority at the age of thirty-seven and a Brevet Lieutenant-Colonelcy at forty-one. Withal, he was as quiet, friendly, and unassuming to all whom he met, and with whom he worked, as on the first day he joined the "Shop."

He was the only child of W. A. Porter, Esq., C.I.E., I.C.S., of Hove, who, after retirement from the Civil Service in Burma, took a commission in the Royal Sussex Regiment on the outbreak of the last war, and fought at Neuve Chapelle as second-in-command of his battalion when over sixty.

Porter gained the King's Gold Medal on passing out of Woolwich, and was commissioned fourth in Hotine's batch in June, 1917. On the conclusion of a short war course at Chatham he was ordered, with the rest of his batch, except the Signallers, to join the Sappers and Miners in India, and was posted to Kirkee early in 1918. For some months he remained in the depot, learning the language and the customs of the Indian soldier, whose friendship and co-operation he quickly gained; he then joined a newly-formed field company and went with it to the frontier early in 1919, taking part in the campaign against Afghanistan in 1919 and in that of Waziristan in 1922. In addition to the frontier medal and two clasps he received a Mention in despatches. He rejoined at Kirkee early in 1923 as Adjutant of the 3rd Royal Bombay Sappers and Miners, but was ordered home soon after to take his post-war Supplementary Course.

After coming down from his year at Cambridge, he married in August, 1924, Mabel Kathleen, elder daughter of Mr. and Mrs. Clarke, of Hove, an old friend of his boyhood. They had two sons, one of whom is now a midshipman in the Navy. The Porters were a devoted family and it was always a pleasure to enjoy the quiet, kindly hospitality with which they entertained their friends. Bill's great delight was his yearly holiday with his family, much of which he spent in teaching his boys to swim, surf, and drive a car. His eldest boy's success in passing by direct entry into the Navy had given him intense pleasure.

After completing a supplementary course at Chatham, Porter was selected for the Adjutancy of the 44th (Home Counties) Divisional R.E., T.A.; while holding this appointment he was promoted to Captain and passed into the Staff College. A successful two years at Camberley, where he was a member of the hockey team, was followed by a year on works at Aldershot, while awaiting his first staff employment.

A grade III general staff appointment at the War Office in February, 1932 was the start of a long and highly successful series of staff appointments, broken only by two short spells of regimental employment, the first with the Searchlight Battalion in 1935, and the second as C.R.E. of a division in Home Forces in 1941. After the War Office appointment, his services were loaned to the R.A.F. for a year for air staff duties at Andover. He then returned to the War Office as a G.S.O.2 in the Training Directorate at a time of great activity in the re-organization, re-equipment, and training of the Army in face of the rising threat of outbreak of the present war.

His next appointment was the important post of Military Assistant Secretary to the Committee of Imperial Defence, which he held during the critical nine months before the outbreak of war, and during the first six months of its course. He was released early in 1940 to join the B.E.F. as Staff Officer to the Engineer-in-Chief. During the brief period of operations of the B.E.F. in Belgium in 1940 he displayed all his habitual energy and devotion to duty.

On his return to the U.K. he was immediately selected for appointment as G.S.O.1 of the Corps, which was to form the spearhead of a new B.E.F., but which, owing to the conditions in France, did not complete its landing. A brief return to the War Office was followed by an appointment at G.H.Q. Home Forces, and then one as C.R.E. of a division. Much to his regret he was not allowed to remain long in work which was particularly congenial to him, and for which he was admirably qualified by his quiet, unruffled, and effective manner of handling officers and men.

He was soon chosen for a special appointment in Cairo. This led to the Deputy Directorship of Plans, Middle East, and the rank of Brigadier; there he remained until early in 1943, gaining during this period his promotion to Colonel. He arrived at a time when the situation in the whole Middle East was critical, and the planning and organization, even for the defence of British interests in that theatre, were still incomplete. He remained until Egypt had been developed into the base from which a successful offensive had been launched; in its planning and organization he played a major part.

The accidental death of another Sapper brought him back early in 1943 to the War Office as Director of Plans. He was closely concerned with the work of the Quebec Conference, which he attended, and with the preparations for the Teheran Conference, on which he was working at the time of his death. Unfortunately he had not fully recovered from a bout of pneumonia which had attacked him in Cairo the previous year; the long hours and great strain in his last appointment undermined even his fine physique; he collapsed very suddenly at his work and died in a few hours.

His energy and devotion to duty had earned him a well merited O.B.E. in the Birthday Honours List of 1940, and a C.B.E. in February, 1943. Our sympathies go out to his relatives in their loss, which is a loss to the Corps, and the Army as a whole, by the death at so early an age of a man so full of promise and of the ability to shoulder the highest responsibilities. Well may it be said—"he died on active service."

E.I.C.J. writes:—"Bill Porter's chief characteristic was his resolute honesty of purpose. He was a man whose presence in times of difficulty and danger was a constant source of strength and encouragement to all around him. During the retreat to Dunkirk he was undaunted in the face of disaster. When Rommel stood at the gates of Egypt, those who worked with Porter testify to the high courage which he displayed, and the resolute spirit that he inspired. A tower of strength in adversity, he was at all times a true friend and loyal comrade. The Corps has suffered in this war the loss of many men of high achievement and rich promise. None is more grievous than this."

P. St.B. S.

Brigadier William Porter CBE

Colonel Arthur H Bagnold CB CMG

COLONEL A. H. BAGNOLD, C.B., C.M.G., F.R.A.S., M.I.E.E.

ARTHUR HENRY BAGNOLD, the son of Major-General M. E. Bagnold, H.E.I.C., was born in 1854, and educated at Cheltenham and the R.M. Academy, Woolwich. He was commissioned in the Royal Engineers on 12th March, 1873 (later antedated to 12th December, 1872).

On leaving the S.M.E. in June, 1875, he was posted to the 18th Coy. at Aldershot, and in January, 1877, transferred to the C (Telegraph) Troop. Next year he was ordered to Cyprus, then in course of occupation by British Troops, returning home in 1880 to join the dismounted telegraphs units (22nd and 34th companies) employed under the Post Office. In 1881 he was sent out to South Africa, where the burghers of the former South African Republics had defeated a British force at Majuba Hill. He took out a section of Field Telegraphs to join the force under Sir Evelyn Wood, and laid 100 miles of telegraph line from Newcastle, in Natal, to Pretoria, but saw no fighting. He rejoined the dismounted telegraph units in England in 1882 but in August, 1884, he was again on active service, this time in Egypt, with the 4th Section Telegraph Battalion, which took part in Lord Wolseley's Nile Expedition of 1884-85. The main work of the section was the repair and maintenance of the Egyptian Telegraph line from Cairo to Merari, over 1,100 miles, all in very bad order. For his services in this campaign, Bagnold, who had been promoted Captain in September, 1884, received a Mention in despatches and the brevet of Major. He stayed on in Egypt until November, 1887; he then took over command of the section and was appointed Director of Telegraphs to the Frontier Field Force under Sir Frederick Stephenson. While in Egypt he was given the interesting job of recovering a colossal statue of Rameses, which weighed over 100 tons. With a few N.C.O's and men of his Telegraph Detachment, he raised the image from the sand, turned it over and left it lying face upwards on a secure foundation. On his return home in 1887 he spent 13 months on Engineer services, at Plymouth and Cardiff, and then joined the Electrical School at the S.M.E., where he was Instructor in Electricity from 1891 to 1896. During this period he was on the Council of the Institution of Electrical Engineers, which he had joined in 1877.

From 1896 he served at Devonport until his promotion to Lieut.-Colonel in May, 1899, when he was appointed C.R.E. Jamaica, where he spent three years, thus missing any chance of active service in South Africa. He was next C.R.E. Isle of Wight, until, in August, 1903, he was selected for the appointment of Superintendent of Building Works in charge of the Engineer Services at Woolwich Arsenal and other Ordnance buildings, with the rank of Colonel. He was retained in this employment till he reached the age for retirement in March, 1911, receiving the C.B. in 1907. On the outbreak of war in August, 1914, Bagnold was at once re-employed as Military Assistant to the Chief Superintendent of Ordnance Factories at Woolwich. In 1916 a demand arose for improvement in the systems of wireless telegraphy. For this purpose a special Signal Experimental Establishment was built on Woolwich Common and Bagnold was placed in charge, with the title of Chief Experimental Officer. He was not only a first class engineer but had a gift for invention and was a skilled worker with his hands, so he was an excellent selection for this job. The staff of the S.E.E. gradually grew to a total of 17 officers and 267 others. Under his care the systems for use in the field were much improved; he also evolved in a practical form a system of wireless communications with aeroplanes, which revolutionised warfare in the air. His valuable work was recognised by the grant of the C.M.G. in January, 1918.

After the war he retired to his home at Shooters Hill, interesting himself in current events and in various inventions and working in his well equipped workshop.

He died in December, 1943, in his ninetieth year.

J.E.E. writes:—

"No one served under Arthur Bagnold without being the better for it. He was not merely a great electrical scientist and one of the pioneers of the ever-improving military system of inter-communication: on every subject he was well informed and mere association with him was a liberal education. His great influence, however, was exerted by his example. Devotion to the work in hand was his watchword, without advertisement, without fear of failure, and without thought of reward."

Colonel Bagnold married in 1888 the daughter of Mr. W. H. Alger; she died in 1931. They had two children; their son Brigadier R. A. Bagnold, O.B.E., joined the R.E. in 1915 and transferred to the Royal Corps of Signals in 1920; he founded the Long Range Desert Patrol, has received the Gold Medal of the Royal Geographical Society for his explorations in the North African Desert, and he has just been elected a Fellow of the Royal Society; their daughter, who writes under her maiden name of Enid Bagnold, is the wife of Sir Roderick Jones, K.B.E., formerly of "Reuters."

W.B.B.

COLONEL J. H. COWAN, C.B.

JAMES HENRY COWAN, an outstanding rifle-shot and authority on rifle-ranges, was born on the 28th September, 1856, the son of William Cowan, Esq., LL.D., J.P. He was educated at Edinburgh Academy, Cheltenham, and the R.M.A., where he won his cap for Rugger, was R.U.O. and passed out top of his batch, winning the Sword of Honour and the Pollock Medal, passing first into the Royal Engineers in February, 1876. At the S.M.E. he won the Fowke Medal and, after going through the Submarine Mining Course, then mainly reserved for Pollock Medallists and eminent cricketers, joined the 33rd (S.M.) Coy., at Malta. In 1885, he returned and was posted to the office of the I.G.F. at the War Office, where he served continuously until 1887, first in the Submarine Mining and subsequently in the Fortifications Branch. He was promoted Captain in 1887 and Major in 1895.

Cowan served in the early part of the South African War and obtained a Mention in Despatches. In 1901 he was appointed C.R.E. Wei-Hai-Wei, but shortly after his arrival the Station was handed back to the Chinese, and in 1902, he was brought home to become a member of the Ordnance Committee.

In 1906-07 he was C.R.E. Chatham and, in 1908, on promotion to Colonel, he returned to the War Office as an A.D.F.W. and held that appointment until he retired under the age rule in 1913. Even then he was retained at the War Office to superintend the provision of rifle-ranges for the Territorial Army and continued in this work throughout the European War. In all, he arranged for the construction of 200 ranges in Great Britain, including ranges for the Royal Flying Corps; on not one of these ranges was there a casualty during the whole period of the war. He was awarded the C.B. in 1917.

In 1918 he finally retired and settled at Moffat.

Cowan's services in encouraging rifle shooting throughout the Army were outstanding. A fine shot himself—he won the Spencer Cup at Wimbledon while at Cheltenham, and from 1891 onwards he shot six times in the Scottish team for the Elcho Shield—in 1893 he was one of the founders of the Army Rifle Association. This was the beginning of serious rifle shooting in the Army, although the competition for the Army Championship had begun in 1887, and from that date until 1905 Cowan, except for the two years when he was serving in South Africa and China, always gained a high place and in 1893 he won the Gold Jewel. On thirteen occasions he shot for the Army Eight and was Captain from 1908 to 1911. He was a member of the British Rifle Team which represented this country at the Hague in 1899.

He shot for the Old Cheltonians in the Public Schools' Veterans' Trophy 41 times and led them to victory on ten occasions. The last of these was in 1925, when two fellow members of his team were Lieut.-Colonel (now Maj.-General) Philip Neame, V.C., and Major Sir Gerald Burrard, son of the late Sir Sidney Burrard, Surveyor-General of India.

His last appearance in this team was just before his 79th birthday, when he scored nine consecutive bulls but dropped to an inner with his last shot—this after his usual luncheon of two apples and a glass of milk—he was, it should be mentioned, a lifelong total abstainer. He maintained his interest in the Army Rifle Association to the end of his life and never failed to travel from Scotland to attend its annual meetings at the War Office until, after 1939, they fell into abeyance. He died on August 7th, 1943, a few weeks before his 87th birthday.

"G.B." writes :—"He was always wonderfully fit and active, and when nearing eighty thought nothing of cycling 50 miles a day. Deeply religious, ever thoughtful for others and unostentatiously kind and generous, his character was as charming in its simplicity as it was grand in its honesty."

He married, in 1880, Alice, daughter of the late General De Butts, then C.R.E. Chatham, who survives him, and had three sons, of whom one died in early youth and the two others went into the Royal Artillery, and three daughters, two of whom predeceased him.

H.M.F.

COLONEL S. L. CRA'STER, C.B., C.I.E.

SHAFTO LONGFIELD CRA'STER, the name is an abbreviation of Craucesterre (the land of the Raven) was born in July, 1862, the son of Major-General George Ayton Cra'ster, Royal (Bengal) Engineers. He was educated at the United Services College, Westward Ho!, and the Royal Military Academy, and was commissioned in the R.E. on 22nd February, 1882; after 2½ years at the S.M.E. he elected for Indian Service. There he joined the brilliant group of Engineer officers who were constructing the Sind-Pishin railway on the North-West frontier. In 1888 he joined the Military Works Department and constructed Defence Works at Bombay and Sukkur, then reverted to railway work and from 1894, until he left the regimental list in 1911, he was employed on railway construction at a number of stations, including three new branch lines on the frontier. This period of 17 years was broken by three tours of active service. In 1897-98 he went as a Field Engineer to the Tirah campaign, being mentioned in despatches and receiving the medal and two clasps. In 1901-02 he was with the Force in N. China, as Deputy Director of the British controlled railway from Tientsin to Shanhaikuan and received the thanks of the Chinese Government. From 1902 to 1904 there was a troublesome campaign in progress in Somaliland to suppress the Mahdi, and in 1903 Cra'ster was offered the job of making a survey for a line of railway, from Berbera to the town of Harar, occupied by the Abyssinians. He received the medal and clasp, a Mention in despatches and a letter of thanks from the Foreign Office.

In 1911 Cra'ster was promoted Substantive Colonel, and in 1912 was made Engineer-in-Chief, first to the Eastern Bengal Railway at Calcutta and then to the N.W. Railway at Lahore. In 1915 and 1916 he was President of the Punjab Engineering Congress, and finished in 1916-17 as Agent to the N.W. Railway. This saw the end of his Indian service, and he was given the C.I.E. Soon after returning home he was appointed Chief Mechanical Engineer (F.W.8) in the D.F.W's office. This branch was responsible for the purchase and inspection of all non-vocabulary engineer stores and machinery. The demands for these were enormous, and the branch had grown from a Staff Captain's charge to a large organization in Adastral House. Cra'ster took over this organization, as if he had done such work all his life, and expanded it to 49 officers and 143 other ranks, with 74 travelling inspectors. He had the additional duty of supplying the Americans with engineer stores. He remained in charge until he retired in July, 1919, and was given the C.B. in 1918. Cra'ster was an outstanding example of the best type of Sapper officer; with a sound knowledge of general engineering, he made himself a master in his selected work of railway survey and construction. He contributed materially to the literature of railways. He delighted in outdoor recreation and in India he successfully took up big game shooting.

He died on 21st December, 1943, in his 82nd year.

Cra'ster married in 1888 the daughter of Mr. Charles King, of Hampstead, who survives him. They had two daughters, the eldest is the widow of Lieut.-Colonel C. H. W. Owen, C.M.G. (late R.A.) and the younger the wife of Brigadier M. E. Mascall, D.S.O., O.B.E., also late R.A.

W.B.B.

BOOK REVIEWS

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

WORLD IN TRANCE

By Leopold Schwarzschild

(Hamish Hamilton, Ltd. Price 12s. 6d.)

"The Years Between"

We are in no doubt that in 1918-1939 we lost the Armistice terms, the Peace Treaty and the Peace, and that the League of Nations proved a fiasco. How all this came about is, however, somewhat obscure. Vaguely we know that the French could not get their way and that the U.S.A., for the first time in history, let their President down. Few of us have had time even to glance at more than one or two of the dozens of authoritative books on the subject. There is now, however, no need to do more than read *World in Trance.* Herr Leopold Schwarzschild is a publicist, born in the Rhineland, but had the wisdom to leave Germany in 1933. Basing himself on the best authorities, he has told the whole story in dramatic manner in the small compass of 280 pages. The book is well worth reading as a clue not only to the years between, but also to German mentality, mendacity, and pertinacity. Here are some of the outstanding features.

President Wilson, once a college President, an idealist, who knew nothing about Europe, set himself with his "14 Points," "5 Particulars" and "4 Ends," first, to bring about a peace which would maintain the Balance of Power; secondly, to turn Germany into a democracy; and thirdly, to establish peace on earth by means of a League of Nations. To achieve his purposes he opened a correspondence with the German Government without consulting the "Associated" Powers (he disclaimed France and Britain as Allies).

The Germans tumbled quickly to the situation and saw a way to dividing their enemies. To please Wilson, the Kaiser was packed off and a pseudo-democratic Government set up (it was not intended to last). Wilson's first struggle with his associates was over the Armistice terms. Those drafted by France and Britain—and the American C.-in-C.—were too severe for him: if Germany were made too weak, he could not succeed in coercing the Allies to his views. As early as September, 1918, Colonel House, his agent and confidant, who was in France, told him "as the Allies succeed, your influence will 'diminish.'" Thus it happened that House, speaking for the President, threatened to make a separate peace and go out of the war, unless the Allies accepted Wilson's dicta—and Germany got easy Armistice terms, not intending to abide even by these.

The first overt act, to test what the Allies would stand, was the scuttling of the German fleet. This was no loss to Germany as the vessels were to be handed over. No punishment, no sanctions followed, and she saw that she could presume further.

A long struggle over the Peace Terms ensued. Wilson again whittled them down severely: for Germany lost little territory—and not the Ruhr, as she expected and the French wished. She gave no security that she would pay Reparation, except what was afforded by an occupation of the Rhineland, limited to 15 years. She was not made militarily impotent. But as Wilson had not got entirely his own way he refused to ratify the Treaty, when the other Powers did so in January, 1920. He had obtained the acceptance of the League of Nations, but made it impotent; for he had declined to endow it with coercive powers. "All his lifetime the President had a violent aversion for everything that even remotely suggested force and compulsion."

Germany did not neglect her opportunities, and by this time the Great General Staff and the German Officer Corps were again in power. They exhibited the Bolshevic bogie to frighten the Allies into permitting them to retain a large army. To quell rioting (induced by fear that the Republic would be abrogated) they sent a large force into the Demilitarized Zone, though permission to do so had been refused by the Allies. But no sanction was imposed, except that France occupied Frankfort—and was compelled to come out by Britain's pressure; for by that time Britain, fearing that France might again become Napoleonic, was beginning to "treat the French as if they were Germans, and the Germans as though they were English" (said by the British Ambassador in Paris). In Berlin a pro-German British Ambassador was installed, who was soon to be known to the Fatherland as the "Lord Protektor."

The Allies had listed 900 "war criminals" (including the Kaiser); it was against Germany's "honour" to hand them over; her Supreme Court would deal with them. It tried 12 (of low rank), of whom six were acquitted and six sentenced to trifling periods of imprisonment and these, it is believed, were not served. The whole business was a farce and a calculated mockery.

Thus reassured that impudence would be tolerated, the whole official hierarchy of Germany set about to resist, with success, the reduction of the Army and the destruction of armament and of the armament factories; and Germany was never disarmed.

The payment of Reparation and delivery of goods in kind next began to fail; the Reparation Commission declared Germany a defaulter and France and Belgium, with an Italian token detachment, against the counsels of Britain, occupied the Ruhr. America thereupon withdrew her contingent; but in under nine months Germany capitulated. Monsieur Poincaré understood his Germans better than any other European or American statesman.

Some other means had to be found to avoid payment, so Germany set about ruining her currency. "The German Government's failure to take measures against the fall of the mark was determined by its intention to sabotage the reparations payments." Dr. Helfferich, one of the foremost financial experts of the world, said to a bank director who insisted that a remedy against the fall of the mark must be found, "You are a baby. The remedy is there. But as long as we are not rid of reparations, we shall see that it is not applied." All Germany's troubles were ascribed by her to the "*Diktat*" of Versailles. So she had to be helped. The Dawes' Plan, the Young Plan, etc., "the nonsense of economic experts," cut down the total of what Germany had agreed to pay; and money was lent her to make the reduced payments.

The Allies were still occupying the Rhineland, and the Commissions of Control were still trying to pry into German activities in training troops and hoarding armaments; they had to go, so Stresemann with British approval invented "appeasement," sanctified at Locarno and by the Kellogg Pact. Germany was admitted as an equal to the League of Nations, and in spite of her flagrant violations of the Peace terms control was brought to an end, and the Allied troops in the Rhineland were withdrawn by June, 1930 (the British in December, 1929) before the 15 years were up.

Clamouring for "disarmament" (of other nations) Germany set about rearming at high speed, spending hundreds of millions on arms, though too poor to pay reparation. On 16th March, 1936, Hitler proclaimed the reintroduction of conscription and the repudiation of the military clauses of the Peace Treaty. Most of us know the rest only too well.

J.E.E.

ORDEAL BY BATTLE

By Cyril Falls

(Methuen & Co. Price 6s. od. 184 pp.)

Dedicated to kindly Taskmasters. J. E. E. etc.

This valuable contribution to the study of the Art of War is a book which will appeal specially to military students ; yet it is written with such freedom from pedantry and abstruseness that it may be read with pleasure and profit by all sorts and conditions of educated men.

Its first chapter shows how the forms of War have varied throughout the centuries, and how, having reverted to " Total War," we are to-day just where we were in the Stone Age. What a reflection on our vaunted civilization ! What a confession of the failure of mankind to implement the teachings of religion ! In this connection, the penultimate page of the book supplies an apt quotation :—" *The final and determining causes of war are to be sought and found in moral weakness, moral obliquity. There are many forms of insurance against war, but the most powerful is virtue, in nations as well as in individuals.*"

The theory of War is dealt with in two short chapters with such a wealth of illustration that they should prove attractive to the veriest tyro. Indeed these, and other chapters whose titles may sound to him most formidable, are just those most easy of digestion by the general reader. The author does not claim to have made an exhaustive study of what he terms " High Policy in War " " *a vast subject . . . which deserves full and instructed treatment* " ; but he has opened the door upon it, and relies upon others to assume the task, " *as they undoubtedly will.*"

If it be true that Strategy is " *to a very large extent a matter of shrewdness and common sense,*" and if " *the uninstructed and the romantically minded are bewitched by the splendour of Strategy, which indeed covers almost all that kindles the imagination of the ordinary man in the conduct of war,*" then therein perhaps lies the reason why Captain Falls' chapter on " The Realm of Strategy " demands far less expert knowledge in the reader than the two succeeding chapters on " Tactics " ; for tactics, the art of fighting, can only be understood by those who have learnt it in the practical schools of training and experience. The author shows how correctly the Germans discovered and applied the tactical lessons of the first world war. He then proceeds to detail all the tactical developments of the past 25 years, dealing with this subject almost weapon by weapon. " *In the tank, the Germans sought surprise, fire-power, shock, and invulnerability and they called in the bomber to support it.*" He describes the functions of the various tactical formations in the attack, *e.g.* the armoured division, with the motor-borne forces on its very heels, and the engineer-arm. He considers that the present trend of tactics is bringing artillery back to its own, but that the palmiest days of heavy artillery have gone by except in Siege Warfare. " The Tactics of Defence " present a far more difficult problem. In total warfare " *it demands a new attitude on the part of the commanders and the troops alike. . . . Yet in one important respect there is no change. To-day, as in the past, the commander who is committed to the defence, should have as his object the infliction of a sharp defeat upon the enemy.*" This is a chapter to be read with close application by every serious soldier.

The following chapter on " Logistics," is in some respects, the most important in the book, and the most likely to command attention outside the fighting services. The essential features of supply by water, rail, road, and air are analysed and illustrated, notably by some statistics derived from a comparatively recent article in *The R.E. Journal.** It is the author's aim in this chapter to aid its reader " *to comprehend that the business side of war is as important as the fighting side.*"

Capt. Falls concludes with chapters on " War at Sea " and " War in the Air " which all soldiers will find interesting and informative, and a chapter on " Leadership of the Nation in War " which we strongly recommend to all statesmen.

T.F.

* *The R.E. Journal*, December, 1942 and September, 1943.—" Q " in the East African Campaign. By Brig. A. C. Duff.

ENGINEER FIELD MANUAL FM 5-6 "OPERATIONS OF ENGINEER UNITS"

(Published by the United States War Department)

This is one of a series (FM 5) covering the activities of the U.S. Corps of Engineers. The Field Manual series are generally non-technical: technical subjects being dealt with in the TM series, in which the Engineer "basic" number is the same, i.e., 5.

FM 5-6 is therefore a non-technical manual dealing with the tactical handling of Engineer Units in the field. It includes matter which, in the British Army, has been spread over a number of different publications: F.S.R., E.T., M.T.Ps, R.E- and F.S.-P.Bs, and Standing Orders for Div. R.E., but which has here been collected into one compact little book.

Chapter I contains a general survey of the duties of Engineers, on the lines of the Engineer paras in F.S.R. Chapters II and III are mainly devoted to Engineer Appreciations ("Estimates of the Situation"), and the organization of Engineer Reconnaissance, the procedure being on very much the same lines as our own. Chapter IV is devoted entirely to minor tactics. Throughout the Manual the impression given is that the employment of Engineers as Infantry is visualised to a far greater degree than is the case in the British Army. Chapter IV covers all forms of tactical operation—attack, defence, security—at rest and on the march—tank hunting, outposts and patrols, passage of obstacles, etc., considered purely from the infantry angle. Similarly, in the succeeding Chapter on River Crossings, much space is allotted to the tactical organization of the operation—distribution of troops to craft, forming up, etc., and only in the latter part of the Chapter is the Engineer aspect of the problem discussed. Chapter VI deals, again from a general, as opposed to an engineer, angle with operations in cold climates, in jungle, desert, and mountainous country, and contains a mass of useful information on such subjects as care of men and transport, hygiene, bivouacs, and so on. Other noteworthy features in the Manual are the Chapters on Movement, by road and by rail; on traffic organization and control, and on the supply of Engineer stores, the latter being a notable gap in our own Service Manuals. The final Chapter gives short résumés of the organization and duties of each type of Engineer Unit in the Army, under the headings "General," "Considerations Affecting Employment," and "General Employment."

A.C.S.

AN ACCOUNT OF SOME RECENT EXCAVATIONS AT SEBA, BRITISH GUIANA

By J. E. L. Carter

(Reprint from *American Antiquity*, 12 pp. pamphlet)

Seba, some 100 miles up the Demarara River, has recently been reported as a prehistoric site, and Captain Carter, who was stationed in Trinidad, in a 36-hour visit to the site, was fortunate in discovering a cache of pottery fragments and small stone implements of considerable interest. The shards, of which 9 vessels of various shapes have been reconstructed, were found in an area roughly elliptical, measuring some 4 ft. by 7 ft., and under them, lying side by side, were the largest of the stone implements, two sharp pointed cones described as hammerstones. No human remains were found. Captain Carter considers that the burial of these objects was ceremonial and suggests that it is an attempt at homœopathic magic; the hammerstones representing a man and his wife, while a smaller one found near by represented the desired child. Similar ceremonies amongst the Macusis of British Guiana are recorded by Frazer. This pamphlet gives a full and fully illustrated account of the find and discusses its implications.

F.E.G.S.

MAGAZINES

THE GEOGRAPHICAL JOURNAL

November-December, 1943

A paper by Sir Aurel Stein has a melancholy interest in having been received after the death of that distinguished archæologist and explorer. It deals with the route followed by Alexander on his famous retreat from India through Gedrosia, when his army suffered terrible privations and losses. Sir Aurel, having explored the country with his characteristic thoroughness, adduces good reasons for supposing that Alexander's route was not along the sea coast, as has hitherto been generally accepted, but that it followed a more northerly direction, and the line of the present main caravan route to eastern Makran. Some striking photographs are included.

Professor Patrick Abercrombie deals with some of the many problems that have had to be faced in planning for the future London. Some kind of balance must be struck between the various claims of traffic, housing, occupations, communities, open spaces, and public services.

W. B. Kennedy Shaw writes an interesting account of some problems of desert navigation, as experienced by the Long Range Desert Group. The chief points of interest are the use of the Bagnold sun-compass, and the adoption of the R.A.F. methods of rapid calculation.

A pamphlet, published by the U.S. Dept. of Agriculture, on soil erosion shows that under natural conditions the rate of normal soil erosion is balanced by the rate of soil formation ; but that when man clears away the covering of vegetation, the normal processes of erosion by wind, rain, etc., are accelerated to such a degree that soil formation can no longer keep up with them. The results, often serious, sometimes calamitous, are seen to-day in many parts of the U.S., and they have their lesson for us in Britain in view of the policy of ploughing up all available land.

E.M.J.

EMPIRE SURVEY REVIEW

January, 1944.—Brigadier Winterbotham contributes an article on "Surveys and History" which is not only extremely interesting, but serves to illustrate the remarkable erudition of the author. He points out the enormous value of properly kept histories of all operations and activities, even those which at the time may appear unimportant ; and makes the excellent suggestion that a chronological record of all happenings should be kept in every Survey Department, which would form a good basis for such a history. Having dealt with the history of mapping, he makes some interesting remarks on the mapping of history.

L. P. Lee, of the Lands and Survey Department, Wellington, N.Z., has an informative article on "The Nomenclature and Classification of Map Projections," in which he tabulates projections under two sets of headings ; in vertical columns according to their properties of representation, and in horizontal groups according to the pattern formed by the meridians and parallels ; a form of tabulation which appears to be new. He discusses in detail various questions of nomenclature.

There is a clearly written account by F. H. Peters, Surveyor-General of Dominion Lands, Canada, of the methods of land surveying and land tenure in the Dominion. While all methods in use appear to have for their object the division of land into rectangular plots, for the purposes of townships and sections, the systems in six Provinces vary to some extent, while in the remaining three the Dominion Lands System of Survey is in use uniformly. In this the basic unit of sub-division is the township, which is six miles square, and which is divided into sections approximately one mile square. The approximation is due to the fact that the north and south dividing lines are true meridians.

E.M.J.

THE ENGINEERING JOURNAL

(Published monthly by the Engineering Institute of Canada)

November, 1943.—The first article, by Mr. J. T. Bain, deals with the "Development of Post-War Aircraft," and is based on two convictions :—

(i) The basic aeroplane of to-day will not undergo any revolutionary change, in structure or size, for some considerable time after the war.

(ii) New methods of aircraft operation are needed to achieve the necessary standards of safety and regularity.

The war has not on the balance given a great impetus to aeroplane development, although many items, whose growth has been forced under war conditions, could be adapted for furthering peace-time operation : on the other hand, the development of several new transport aircraft was stopped at the commencement of hostilities. The writer foreshadows the control of aircraft from the ground, to an extent that will restrict the use of the control column and rudder bar to emergencies only, and landing will be completely controlled from the ground stations. The final standard might reach that of the "Elder brother," the "Underground," which handles an astronomical number of passengers daily in perfect safety by a complete system of automatic controls.

Other features in this issue consist of the addresses—now given in full—delivered at the joint meeting of the American Society of Mechanical Engineers and The Engineering Institute of Canada at Toronto on October 1st. These were reviewed in *The R.E. Journal* for March, 1944.

December, 1943.—This number has on the cover, an excellent picture of the fastest aeroplane in the world—The Mosquito—and the first article, by Mr. R. B. McIntyre, of de Havillands Aircraft, deals with the design and details of this outstanding craft. The whole basic structure is made of wood, the company having had long experience of such designs ; other reasons in favour of wood are :—It is "buckle free," quick and easy to repair, it enables a fresh labour group to be employed, and a new material supply tapped.

The Mosquito's best performance is at an altitude of 22,000 ft., when its twin Rolls-Royce engines with two-speed superchargers reach 1,120 b.h.p. each. "All out" speed figures cannot be quoted, but Downsview to Dorval (nr. Montreal) in 55 minutes is almost a cruising performance.

An article on the St. Lawrence River Control and Remedial Dams, discloses that the Beauharnois Power canal, utilising the 82 ft. of head available in the Soulanges section, takes 82,000 cusecs from the river, practically the same as that used by the Canadian and American Power Companies at Niagara.

"Synthetic Rubber" : The United States, for their manufacturing programme, have installed boiler plant of a capacity of 13,000,000 lbs. of steam per hour. This could not have been achieved under the present steel supply situation, had not a somewhat lower factor of safety for welded steel drums and seamless tubes been sanctioned.

January, 1944.—Charles Stanton's article : "The Post-War Possibilities of Air Transport," written in conjunction with the railroads of Canada and the U.S.A., deals with this question from a novel view point. As the result of their studies, they have determined the optimum distance for air travel as approximately 180 miles, measured in terms of rail transport. As the distance of air travel increases over the optimum, the number of passengers declines roughly in inverse ratio to the distance raised to the power of 3/2. Also the number of passenger miles, declines roughly in inverse ratio to the square root of the distance—for journeys under 150 miles air travel scarcely exists, but the mass market is the shorter distance travel market ; it seems essential therefore that air transport, to cope with this, should be intensively developed. This will probably involve planes specifically designed for short range operation, with small pay loads. As regards this market the helicopter is capable of revolutionizing aviation, but it may take many years to obtain such machines.

Apart from aircraft and air transport, the remainder of this number is given over to thoughtful articles on "Post-War Planning" and "Benefit Plans for Workers."

H.M.F.

JOURNAL OF THE UNITED SERVICE INSTITUTION OF INDIA
October, 1943

Oh to be in India, Now the Monsoon's Here! Relates the life of a party of Indian soldiers in an English village and is amusingly told.

The Background of the Japanese Army. The subject is considered under the headings of the personal, historical and religious backgrounds. The last is the most important, as the Japs consider themselves to be descended from the gods, and therefore superior to the rest of the world. This factor is reinforced by the other two. But their education is so uniform as to constitute a weakness, in that individuality ceases.

Frontier Warfare in Retrospect and Prospect. In this excellent article it is only possible to take exception to one item, namely that during 1914-18, we were let off lightly on the Frontier. Actually, there was fighting on the Chitral road, a big Mohmand show—two considerable campaigns in Waziristan—and an expedition against the Marris; most of these were worthy of battle honours. Otherwise one is entirely in agreement with the author. Frontier warfare, as he pictures it, will be shorn of baggage trains and perimeter camps. Instead, highly trained paratroops and commandos will work over hostile country, with air-borne supplies. Political difficulties are touched on, but wisely left for discussion between civil and military chiefs.

A Prisoner of War in Italy. Gives a good account of the experiences of an officer in a camp in the south of that country. The Red Cross comes in for deserved praise.

India's Longest March. 2,730 miles in 28 days, 4 of them rest days, was done by the 2nd Bn., 4th Bombay Grenadiers, from Karachi to Madras via Lahore and Poona. The Bn. was nearly new to M.T. and the march began in April, so it is all the more creditable that hardly a vehicle fell out.

The Old School Tie. While allowing that the public school system admits of improvement, this is a slashing criticism of the ill-informed idiots who are using the phrase as a slogan.

F.C.M.

THE INDIAN FORESTER
October, 1943

Aerial Photography. Has been used in British Honduras for the preparation of a map of the coastal pine areas, which were then divided into arbitrary classes by examination of stereos, the office work being later checked on the ground.

November, 1943

What is Forestry? A lecture given by Sir Herbert Howard, Inspector-General of Forests. He takes his text from a question made by a fellow traveller to whom he remarked that he was a forester, and was going to the Black Forest, "Oh, are they going to cut it down?" Thereupon he dilates on the extraordinary ignorance of the general public on the subject. Briefly, the purpose of the forester is to balance nature's annual increment by judicious felling, and to protect trees from insects, animals, man, and fire. There are minor, but often valuable, by-products such as rubber and resin to be cultivated. A forester must know a good deal about a whole range of subjects—political economy, mineralogy, geology, survey, engineering, botany, and law, among others.

Programmes. Discusses forestry on the assumption that a good amount of state planning will be necessary in post-war years. It is a thoughtful article, and perhaps the most interesting part is the insistence on the right of forest dwellers to have a say in the matter. More national parks are a desideratum.

Soil Erosion Control. This in Behar, where gully erosion and sheet erosion are rife, is done by closing or at least restricting grazing, and by contour trenching. The trenches are about 2 ft. by 1 ft., the vertical interval is not stated, but presumably varies with the situation.

F.C.M.

AN COSANTÒIR

(Journal of the Eire Army — mainly intended for Junior Leaders)

December, 1943.—Starts with a long article on an ambush of a party of Black and Tans during the trouble. It rubs in the old lesson of the Indian Frontier—when living in hostile country your movements must never become a matter of regular routine to an extent that will allow the enemy to prepare a carefully thought-out ambush. An article on the Consolidation of the Offensive from the Soviet War News gives some interesting examples of Russian practices. Then follows an original article on the psychological aspects of Observation Training, of real interest to the Intelligence Officer of a Unit—both for training his men and himself.

An American Infantryman, in a good article, stresses the special difficulties of trying to utilise ground features for cover, when on a bare coral atoll.

January, 1944.—The number opens with an admirable article on the instruction of N.C.O's and men in Elementary Map Reading. The writer points out—and I think the criticism applies equally to our text books—that the Manual is written largely for the man who has had education up to say matriculation standard. His four " lessons " are designed to deal with the man who may have forgotten most of whatever mathematics he learnt at his primary school. The subject is dealt with in a masterly way, even though it does not go beyond the elementary stages.

" Tips on the Bull Market " (from America) refers not to Wall Street but to the Rifle Range and is useful to all interested in the training of recruits ; it is based on the teaching of an American Colonel whose motto was " When the rifle is shot badly, check the ' nut ' behind the butt-plate."

An article on motor cyclists demonstrates their value as a Mounted Infantry Commando Force. It is claimed that they have been most successful raiding behind enemy lines, dealing with the landing of parachutists before the latter could assemble and organize, and supporting tanks pouring forward to exploit a break-through.

" War is like this " from America gives a glimpse of Jungle Warfare in the early days of New Guinea. The only cheering note in this description, of the ghastly conditions prevailing, is the confirmation that the white man seems to stand up to them better than the Jap.

February, 1944.—Contains Part I of a highly practical article by Major J. Costello on Leadership ; it is well worth studying by senior and junior officers. The importance of selecting good leaders for most non-commissioned and commissioned appointments (other than a few special administrative ones) is stressed, and hints are given as to how to look for and select the best.

" Battle Team Work," by Commandant J. Murray, is a plea for the training of a Brigade Group, containing all Arms and Services, so that they will function in practice as a " Team." Each man must not merely know his own job well but must also know enough of the other man's to understand what he can and cannot do—to know how each can help the other. Most training in the British Army tends to keep the different Arms and Services apart ; no one would train a football side by training the forwards, half-backs, and backs separately, and then expect them to give their best in a match. Similarly on such lines it would not be possible to make an individual Infantryman, Sapper, Gunner, R.A.S.C., etc., realize that they are part of a team and not a number of individuals.

The Book Review this month is by " Blackberry "—Charles Graves. It is strongly recommended to all who have anything to do with the training of N.C.O's and potential Officers.

D.R.ff-M.

THE MILITARY ENGINEER

(Published by the Society of American Engineers)

November, 1943

Classification of Military Bridges and Bridge Loads. By Lieut.-Colonel W. Whipple.

The manual for calculating and classifying the strength of bridges, and their safe loading, is now in many respects obsolete. Most of the hasty calculations in it are based on the H-system of highway loadings. The H-system rates capacity in terms of a two-axle truck with 80 per cent of the weight on the rear axle, a type unlike most military loads. It is assumed that division loads will not exceed H-10 loadings, and that corps and army bridges will be designed on either H-15 or H-20 loadings, depending on the span.

It has been found in practice that the rules laid down are very inaccurate when applied to short spans and vehicles with several axles, erring on the side of safety. A new system is, therefore, now under consideration, in which the principle of concentrated load equivalent is applied directly to the classification of both bridges and vehicles. New bridges would be designed for a concentrated load of, say, 8 tons, instead of for a given type of vehicle. The bridge would then be marked with the rating and the span. Each vehicle would also be given a rating in terms of concentrated load equivalent for various spans. Shear would be taken into account by suitable assumptions based on average axle loadings.

The new system would be very accurate for fixed bridges, but less so for floating bridges. Each bridge would be marked with the weight-class of the heaviest vehicle it would carry with safety. Supplementary tables would show what excess loading is permissible, if vehicles proceed with caution, i.e. at slow speed in the centre of the roadway.

In combined operations, with the British army, vehicles of one army may have to cross bridges rated by the other. The British methods of classification are relatively complicated, but the classification of standard bridges is almost the same. For practical purposes, the systems might be made interchangeable if 10 per cent be added to the rating of British vehicles when crossing American bridges.

High-Altitude Rockets for Meteorological Research. By W. Ley and W. Schaefer.

The exploration of the upper air has hitherto been carried out by sounding balloons carrying a set of recording instruments. A sounding balloon never lasts for more than one ascent. It ascends until it bursts, the instruments being lowered to the ground by means of a parachute. It is moreover very expensive.

The writers have carried out a good deal of research work on utilizing rockets for the same purpose. The experiments they have made permit a preliminary design of a meteorological rocket, which consists of a light motor in the head, a tubular tank for liquid oxygen and a tubular fuel (alcohol) tank in the central portion, and a space for instruments and for a parachute in the tail. Calculations show that such a rocket should reach the same height as that attained by sounding balloons. The record height reached by the latter is 117,750 feet.

December, 1943

Combat Engineers in Jungle Operations. By Lieut.-Colonel G. F. Dixon.

This article, illustrated by clear photographs, describes some of the work carried out by a Divisional Engineer Battalion in the operations against the Japanese at Guadalcanal and New Georgia Island in the Solomons. The Engineers' primary job was to build up supply routes behind the advancing troops who were endeavouring to encircle the Japanese forces.

The roads were hurriedly constructed bull-dozed trails, located, as far as possible, along ridge lines, in order to simplify drainage. Bridge construction was varied, native timber being used almost entirely. Some of the bridges had timber trestles ; a few were of pile construction, in which petrol drums, welded together, were used. The drum piles were driven into the soft river bottom by air hammers and then filled with ballast. All culverts were welded petrol drums.

New Georgia, being less rugged but jungle covered, presented problems slightly different from those at Guadalcanal. Roadmaking remained the major job to be tackled. Coral rock, the only material available for road surfacing, proved unsatisfactory owing to the heavy traffic and exceptional rainfall. The only alternative was the construction of corduroy roads, which were resorted to extensively.

Among the lessons learned in these operations were (1) the necessity for heavy angle-dozers, (2) the importance of keeping construction immediately behind the front line as the advance progresses, (3) the value of an engineer survey party, (4) emphasis must be placed on the training of equipment operators and other technicians.

Peripatetic Pipe Line.—At the height of the Tunisian campaign sixty per cent of the dead-weight moved to the front consisted of petrol and oil. In the first twelve months of the present war, the United States shipped overseas more than eighty times the amount of petroleum and petroleum products that were shipped in the first twelve months of World War I.

In order to reduce the vast expenditure of petrol and oil, necessary for the conduct of a campaign, a portable pipe-line has been introduced, operated by Engineer Petroleum Distribution Companies. There is a training centre for these companies at Camp Claiborne, Louisiana.

The pipe-line is extremely portable: one mile weighs 13 tons, including pumping stations. Twenty-foot sections of the spiral-welded pipe weigh less than 100 lbs. apiece. An army lorry and crew can carry and handle 1,000 feet of the line. Having unusually flexible joints, the pipe sections can be laid on the top of any ground accessible to the lorries.

The saving in fuel by the use of the pipe-line system is even more remarkable than the saving in time. On the Burma Road, tank lorries delivering petrol burnt up more than half their fuel in making the trip alone, whereas pumping stations on a pipe-line need no more than 5 per cent of the fuel to keep up the flow.

January, 1944

Combat Engineers in North Africa. Part I. The Capture of Fort Lyautey. By Lieut.-Colonel F. A. Henney.

The writer was a member of the Western Task Force whose mission was to land at three points in French Morocco. The sub-task force, to which he was attached, was ordered to land near Fort Lyautey in darkness early on November 8th, 1942. The special River Party, of which he was in command, had to remove the navigation obstacle in the Sebou River, which was indicated by four barges spaced evenly across the river. The first attempt failed owing to enemy fire. A second and successful attempt was made on the night of the 9th, and the cable net, which was composed of cables of one-inch diameter, was cut. The following day the Kasba—a fort that commanded the river mouth—was captured, and an armistice with the French was signed on November 11th.

Life in a Combat Engineer Battalion. Part I. In Action.

In this instalment, 1st-Lieut. K. F. Curtis, of the U.S. Marine Corps, relates his experiences in Guadalcanal. When the Americans first landed on the island, they were greatly handicapped by a shortage of tools and building materials. They were able to supplement the latter by stocks of planks and bags of cement left behind by the Japanese. All kinds of machinery were found: e.g., rock crushers, concrete mixers, etc., as well as a number of lorries undamaged by the American bombardment.

A.S.H.

INFANTRY JOURNAL

November—December, 1944

(Published by the U.S. Infantry Association)

(*November*, 1943.)—*Achtung! Minen!* The writer relates his own and others' experiences in connection with German mines in the North African theatre of war. Do not ignore any warning sign, such as *Achtung! Minen!* (Attention! Mines!), and do not fire your rifle nor throw stones in any area where a warning notice exists. By so doing you may disturb delicate mines and booby-trap mechanisms so that they will be harder to detect and neutralize later. There is also an ever present danger of "sympathetic detonation."

The writer lost his right hand by picking up a German "egg" grenade that he saw lying on the ground, with its pin apparently in. It had not occurred to him that a fine piano wire might lead from the other end of the grenade to a stake sunk into the ground directly underneath, so that when he picked up the grenade a pull on the wire would set it off.

Our men have learnt that the Germans not only display the greatest ingenuity in devising means for catching men off their guard, but they also think ahead and try to anticipate how they might act in every circumstance. Their methods are never cut-and-dried. They never do the same thing day in and day out, but go in for variety to catch us unprepared.

Soldier! Look at the Ground. By Colonel E. R. Dupuy.

All through military history it is amazing how commanders actually holding ground have shown a lack of terrain knowledge. The writer quotes instances from the present war. In New Georgia an American Marine detachment marched through jungle, that the Japanese believed to be impassable, and isolated the garrison at Munda. The Japanese commander paid for his false confidence.

In the Tunisian campaign, when Rommel was still clinging to the Mareth line, fending off Patton's thin-spread II Corps along the mountain ranges to the west, the Axis forces thought their position impregnable against the attacking 1st Division, who had no cover. American patrols, however, found a chain of connecting valleys and crevasses to the north, and, after an all-night march, a battalion succeeded in taking the enemy in the rear, opening the pass, and taking 1,400 prisoners.

Further instances are taken from history. In 217 B.C. Hannibal surprised the Roman consul Flaminius by crossing marshes believed impassable and won the battle of Lake Trasimene. In 1759 General Wolfe surprised the French force under Montcalm by scaling the Heights of Abraham from the St. Lawrence. On two occasions during the Mexican war of 1847 Scott succeeded in circumventing the Mexican forces and gaining signal victories.

(*December*, 1943.)—*Nazi Defence of a Pass.* By Captain W. B. Larson.

The writer describes some of the methods adopted by the Germans in Tunisia and Sicily in defending positions against American attacks.

In holding a pass the Germans always defend the highest ground. Here they place their observation posts, and dig them in so thoroughly that mortar and artillery fire cannot knock them out. The O.P's are located, not on the hill tops, but carefully camouflaged to one side of them.

The Germans' favourite defence is that of a saddle. They avoid the forward slopes and place their infantry and automatic weapons on the reverse slopes. All approaches and dead ground, that could provide cover to the attackers, are liberally sprinkled with barbed wire, booby-traps, and S-mines. Automatic weapons are dug in on the reverse slopes of the knobs of the saddle, firing through the saddle and providing a cross fire to cover the forward slopes on the opposite sides. Riflemen are dug in to give all-round protection to the machine-guns and cover the very tops of the knobs. Anyone coming over the top makes a perfect silhouette target.

Ersatz Compass. This is a description of an "emergency home-made compass." Magnetize an ordinary double-edged razor blade, marking the north pole with an "N," you can then float the blade in a cup-full of water and so obtain the direction of the magnetic north.

A.S.H.

REVUE MILITAIRE SUISSE

September, 1943.—*Réflexions sur la Campagne de France.* By Major E. Bauer. The Swiss critic continues his examination of the disastrous campaign in France, and goes into more detail about the weakness of the divisions allotted to the Northern Army Group. He examines in particular the composition of the Second and Ninth Armies. Not only had they too few divisions for their wide fronts, but their divisions were insufficiently equipped with the necessary weapons to meet a German attack. Reserve divisions of Type A and Type B were not fitted to be opposed to " panzer " divisions. General Corap's Ninth Army had serious gaps in its frontage, through which Rommel, commanding the 7th Panzer Division, hastened to force his tanks. The two Cavalry divisions, which covered Corap's Army, were unable to do anything to delay the Germans on the right bank of the Meuse, and the nearest reserves for the Ninth Army were ; the 1st North African division about Villers-Cottérêts and the 43rd Division about Chatillon-sur-Marne ; neither of them was motorised. The 1st Armoured Division was thrown in between Phillippeville and Charelcroi on the 14th May, but it ran short of petrol, and was engulfed by the 5th and 7th Panzer divisions of von Hoth.

Corap, whose name has been frequently mentioned in connection with the disaster on the Meuse, seems to have been innocent of the charges commonly made. There is much to be learnt yet about this unfortunate campaign.

Commentaires sur la guerre actuelle.

The 8th September, 1943, seems likely to be the " black day " of the German Army, as the 8th August, 1918, was in the earlier war.

Although the Italian performance fell far below the Axis hopes and boasts, the Italian collapse hit the Germans hard. For three years Italy had tied down large Allied forces in the Mediterranean, which would have been very valuable in the Far East. She had also closed the Mediterranean to our convoys, forcing us to use the long route round the Cape. The removal of Italy, as one of the principal Axis partners, threw a heavy strain on the German Army, and may have contributed largely to the subsequent failure on the Russian front.

According to German reports, about 500,000 Italians were disarmed and only some thirty battalions of the Fascist militia went over to the Germans.

The situation on the Russian front has changed so much of late that it makes the commentary of September, 1943, out of date. Already the Germans were everywhere on the defensive. Their line became ever longer as a result of their withdrawals ; the stubborn holding on to the Don, then the Donetz, then the Dnieper, gave shape to a dangerously large salient, but it indicates the importance which Hitler attaches to the Ukraine.

The commentator admits the German embarrassments, but holds that they have the situation well in hand.

October, 1943.—*L'Art de la guerre de Napoleon à nos jours.* By Colonel Lecomte.

Some reflections based on reading the American book *If War Comes*, published in 1937. Obviously, Jomini and Clausewitz needed up-to-date revision, and the development of air power alone demands that our ideas of war and strategy shall be overhauled. But Colonel Lecomte still reminds us that the opening phrase of most books on strategy is " War is an art which is based on immutable principles." Jomini and Clausewitz based their works chiefly on the wars of Frederick and Napoleon, because these were the most fruitful in illustration. They would have been glad to have the history of the wars of 1870-1918 to draw upon as well.

There were Napoleonic lines in the shape of the campaigns of 1914, both on the Eastern and Western fronts ; but the thunderbolt campaigns of 1939-1941 have been altogether different. Tanks, aircraft, submarines, and total mobilization have almost revolutionized the art of war. We may stick to the old-fashioned principles, but we must word them differently.

As Colonel Lecomte says " He who would write to-day a treatise on the Art of War cannot throw overboard the theories of the XIXth century ; he must, however, adapt them to the circumstances of the times. And possibly his effort may prove useless, for some new progress in the industry of war may overtake him before his book is out of the press."

But we need not throw away our Jomini or our Clausewitz.

Commentaires sur la guerre actuelle

The beginning of the winter brought no cessation of the Russian operations. The thrusts against the Dnieper line went on in full vigour in October; and the Russian strategy of launching successive offensives, now here, now there, without giving the enemy time to regroup his reserves, had begun in earnest. Such important results would ensure from the forcing of the bridgeheads on the Dnieper that the Germans were likely to offer a very strong resistance.

The Russians seldom waste time in attacking big towns street by street, ruin by ruin; they prefer to go round, and pinch them out.

At the end of September, the Germans gave out that they were about to shorten their line, and that the big towns, then being claimed by the Russians, were only abandoned as part of this plan. The total line then held amounted to about 2,000 kilometres. A line formed on the Bug, to the Dnieper south of Kieff, along the Beresina and the Dwina to Riga, which is often spoken of as the only real line to which the Germans could fall back, would be some 600 kilometres shorter. This would economise some 60 divisions but in the process of withdrawal the front might become even longer than 2,000 km., and the losses incurred might overbalance the saving effected by a shortened line. This is indeed what is happening.

The campaign in Italy does not receive much comment, operations had been slowed down by the powerful German defences now consolidated.

November, 1943. La Bataille pour Nice

An account, from French sources, of the operations of the troops of the "fortified sector of the Alpes-Maritimes" from June 11th to 25th, 1940, during the brief campaign between Italy and France, before the latter's total collapse. The French troops were heavily outnumbered, but they relied on their excellent artillery. The Italians put in five divisions, with three more about to engage when the Armistice ended the fighting. They were unable to reach Nice, but they occupied Mentone and Fontan.

The disparity in losses, as given in this article, is remarkable; the Italians are said to have had from 4,000 to 5,000 killed or wounded, as against French losses of 8 killed (4 of these by accident) 35 wounded and 33 missing.

Commentaires sur la guerre actuelle

The Swiss were getting anxious about the growing state of anarchy on their borders. The underground organizations of resistance against Germany had given rise to a disruption of authority on the surface. Each faction, almost each individual, was pleasing itself. This was evidently having repercussions in Switzerland, whose isolated position in the midst of all the disrupted countries is extremely delicate. Opposition to an invader, nevertheless, will be perfectly intelligible to the Swiss.

The clash, after the war, between collaborationists and patriots will be bitter.

The Russian campaign was showing no sign of abating with the arrival of winter. The remarkable rhythm already apparent in the successive offensives of the four big Ukrainian Army Groups was being developed. The two wings of the great battle being waged between Kieff and the Black Sea were in action. The Germans were producing no big scale counter-offensive. Their desperate resistance in certain sectors was at the expense of dangerous weakening in others, a sure sign of inadequacy of the mighty Wehrmacht's reserves. The Germans have often claimed the encirclement and liquidation of entire Russian Armies; it now seems that the Russians were on the way to some certainties in that direction. But nowhere had there been any indication of a breaking-up in morale among the German troops.

W.H.K.

CORRESPONDENCE

THE PROTECTION AND DEMOLITION OF OIL INSTALLATIONS

R.E. Mess, Gibraltar Barracks,
Aldershot, 9th March, 1944.

The Editor, *The Royal Engineers Journal*,

SIR,

In reply to Lieut.-Colonel Britten's letter in the September, 1943, *R.E. Journal*.

It was intended to use depth charges for the destruction of oil storage tanks in the Middle East. The following formulæ were used :—

(i) For storage tanks surrounded with splinterproof walls of brick, etc.

$C = 3/5 \sqrt[3]{T^2}$ Where T = Tonnage of Tank contents.
C = charge in lbs.

(ii) For storage tanks with no splinterproof protection.

$C = 1/5 \sqrt[3]{T^2}$

The size of depth charges required are tabulated below. A minimum charge of 25 lbs. Any available explosive could be used.

Tonnage	*Walled Tanks*	*Ordinary Tanks*
12,000	314 lbs.	105 lbs.
10,000	280 lbs.	94 lbs.
5,000	176 lbs.	59 lbs.
2,000	96 lbs.	32 lbs.
1,000	60 lbs.	25 lbs. (20 lbs.)
500	38 lbs.	25 lbs. (13 lbs.)

Depth charges were made up into containers weighing about 50 lbs. They were to be suspended in the liquid so that 2/3 of the liquid covered the charge, to be detonated electrically or by F.I.D. Oil quickly penetrates the covering material of primacord and cordtex, so these fuzes are not suitable. The charges were never tested in practice.

A certain keen young officer, who was very " depth charge minded " fired a No. 27 detonator in his bath when half full. (Presumably he evacuated it before carrying out the test). A piece about 3 in. square was blown out of the bottom of the cast iron bath. This method is, however, not recommended as a means for demonstrating the effect of explosives fired under water.

Yours faithfully, A. E. L. CROSTHWAIT, *Major, R.E.*

LIEUT.-COLONEL HENRY STURGEON, ROYAL STAFF CORPS

To the Editor, *The Royal Engineers Journal*.

SIR,

It is rather surprising that *Sturgeon, Wellington's bridge builder*, who was killed in France on 19th March, 1814, had no British Honour. Fletcher, the C.R.E., was a Baronet and K.C.H. when he was killed at San Sebastian, but Sturgeon apparently had no Honour. So it was with considerable interest that I accidentally came across the following Notice in the *London Gazette* of February 5, 1814 :—

" His Royal Highness the Prince Regent hath been pleased, in the name and on behalf of His Majesty, to give and grant unto . . . . . and Henry Sturgeon, Esq. Lieut.-Colonel in the Army, and Major in the Royal Staff Corps, His Majesty's royal licence and permission, that they may accept and wear the insignia of Honorary Knight Commanders of the Royal Military Order of the Tower and Sword, with which his Royal Highness the Prince Regent of Portugal has honoured them." Another Royal Staff Corps officer, the Hon. R. L. Dundas, also received the Honour.

It is just possible that Sturgeon knew of his Honour and saw the *Gazette* before his death. Officers of that time holding foreign knighthoods used the title Sir without having a British knighthood, and it is gratifying to think of this great Military Engineer as *Sir* Henry Sturgeon.

Yours faithfully, F. E. G. SKEY,
Colonel.