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CONTENTS

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" The Wings of Victory " presented by K.G.V's. O. Bengal Group, R.I.E. and the " Sikh Clearing Mines " presented by the Royal Bombay Group, R.I.E.

Gifts Of plate From Indian And Pakistan Officers (2)

GIFTS FROM THE OFFICERS OF THE ROYAL INDIAN ENGINEERS AND OF THE ROYAL PAKISTAN ENGINEERS

Officers of the R.I.E. serving with the three famous " Sapper and Miner " Groups (Madras, Bengal and Bombay), and officers now of the R.P.E. formerly serving with those groups, have given to the officers of the Royal Engineers certain handsome pieces of silver. The inscriptions thereon commemorate the long association of R.E. Officers with the Sappers and Miners, which continue in India as three groups of the Royal Indian Engineers, and from two of which (Bengal and Bombay) the Royal Pakistan Engineers have been established.

The pieces are :—

(*a*) From Q.V.O. Madras Sappers and Miners
The Magdala Vase
The Madras S. & M. Cup
The Burmese Pagoda

(*b*) From K.G.V.O. Bengal Sappers and Miners
The Winged Victory

(*c*) From Royal Bombay Sappers and Miners
A new piece ; a very well modelled figure of a Sikh Sapper using a mine detector.

The Chief Royal Engineer has thanked the Commandants of the three R.I.E. Centres and the R.P.E. Centre for these generous tokens of good will, and has also conveyed appreciation to the Engineer-in-Chief, India, and to the Engineer-in-Chief, Pakistan.

The five pieces are at the R.E. Headquarters Mess, at Chatham, and are shown in the photographs opposite.

TRANSFER OF PLATE, ETC., FROM R.E. MESSES IN INDIA

In addition to the gifts of plate from the Sappers and Miners Messes of the Officers of the Royal Indian Engineers and the Royal Pakistan Engineers referred to above, a quantity of plate and other relics have been sent home from the R.E Officers' Messes at Quetta and Rawalpindi and from the R.E. W.O. and Sergeants Messes at Bangalore, Roorkee and Kirkee.

These items came from R.E. Messes as distinct from the Sappers and Miners' Messes, and were, therefore, considered to be R.E. property.

In consultation with the Chief Royal Engineer and the Corps Committee these items are now being distributed to various Messes in the U.K., and certain relics are being preserved in the Museum at Chatham.

SEVEN BRIDGES

By COLONEL L. R. E. FAYLE, D.S.O., O.B.E.

GENERAL

THE following is an attempt to outline the problems encountered and the lessons learned by an engineer formation—15 (Kent) G.H.Q. Tps. Engrs.—during the construction and maintenance of seven major floating bridges built during the campaign in N.W. Europe in 1944–5. Of these seven bridges, only one was a normal Bailey pontoon bridge, as in all other cases we had to deal with very great ranges in water level, and severe floods with their accompanying fast currents had to be allowed for: thus special problems were involved.

Before proceeding, it is best to mention that where the speed of a current is mentioned, it was measured accurately at the time. Many people estimate currents (which they have not measured) at quite double their actual speed: a river running at 5 knots (i.e., 8·45 ft./sec.) is a terrifying sight. Except in rapids, it is doubtful if any river anywhere in the world runs faster than 8 knots, while currents above 6 knots are extremely rare.

At Table I (pp. 285, 286) is a list of the seven bridges, giving some of the general particulars. The first was a normal 736-ft. Bailey pontoon bridge over the Seine and the next four were bridges across the Maas, 688 ft., 1,240 ft., 1,095 ft. and 1,243 ft. respectively: the first of these was semi-all-weather, and the remainder fully all-weather, and in each of them approach spans on fixed piers were necessary for crossing the flood plain. The sixth bridge was a 2,085 ft. all-weather bridge across the Rhine, and the last a Bailey barge bridge (456 ft.) across the Weser in tidal waters at Bremen. All of them were Class 40.

Table II (p. 287) gives some figures of times and labour; Plate I (at end of article) is a map showing locations, and drawings of the bridges are given at Plates II and III (also at end of article).

For all the bridges, a standard set-up was used, 583 Fd. Coy. being responsible for the near bank work, 584 Fd. Coy. for the centre portion, and 582 Fd. Coy. for the far bank work, the dividing line being fixed for each bridge according to the work involved. 297 Fd. Pk. Coy. was responsible for the checking and marshalling of bridging lorries, for welding and workshop tasks and for wearing surface and notice boards. H.Q. was responsible for design, gap measurement and general setting out, with C.R.E. as bridge commander. This method, which had been tried out in training at Goole, was found to work extremely well in practice.

SAUL BRIDGE, RIVER SEINE, VERNON, AUGUST, 1944

This was a straightforward task. About half of the formation had been involved in the assault crossing at Vernon which started on the evening of Friday, 25th August, operating stormboats, close support rafts and later a Class 40 raft. By Saturday night, 43 Div., R.E., had got a F.B.E. bridge across the river and by 8 p.m. on Sunday, 27th August, 7 Army Tps. Engrs. had completed the first Class 40 Bailey pontoon, and our rafting and stormboating ceased.

We knew we were to build a second Bailey pontoon bridge, for which we had already decided the site, but it was thought that the task would not be a rush job. However, at 11.30 p.m. on Sunday, 27th August, we received orders from C.E., 30 Corps, to build our bridge and open it by 1200 hrs. on Tuesday, 29th August. An "O" Group was immediately called and orders given, the troops to be on site by 0800 hrs. on Monday, 28th August, first lorries to arrive at 0900 hrs. 30 Corps Tps. were to build the approach road to the bridge under their own C.R.E., and a field company of 7 Army Tps. were to be lent to us to assist in off-loading, so as to allow some of our men who had just come off rafting to get some rest. We then turned in for the night, a course which was undoubtedly wise. In a bridging task lasting over twenty-four hours it is best to start fresh, in daylight: it results in earlier completion in the end.

Work started at 0800 hrs. with bulldozers ramping down the approaches, and at 0900 hrs. the bridging lorries, marshalled by 297 Fd. Pk. Coy. at Vernon railway station (which was connected by phone to the site and to C.E., 30 Corps), started to arrive. By noon the bankseat work was done and building commenced, while soon afterwards the troops who had been resting came on the job and we were able to release the company of 7 Army Tps. Meanwhile 30 Corps Tps. with a fleet of tippers were building some 200 yds. of approach road which was practically ready by nightfall. By dusk the near bank landing bay and end floating bay were in position, though not jacked down until about 2330 hrs.: rafts were brought into bridge with a motor boat and the whole bridge was linked up by 0100 hrs. on 29th August. One and a half hours later the far bank landing bay was jacked down and a small party remained on site until 0500 hrs., completing the ramps, when the bridge was complete bar wearing surface.

Over the wearing surface we had been remiss, as we had not thought of it until late on Monday night. However we found some timber—hardwood planks—and some thicker stuff which had to be ripped by the Field Park saws. The Field Park worked all night on preparation and by 0800 hrs. the wearing surface was being laid—a somewhat crude effort owing to lack of foresight by the C.R.E. However we were comfortably ready by 1200 hrs., Tuesday, 29th August, when the bridge was opened to traffic, on time, and later in the day much of the Guards Armoured Division crossed.

The only enemy interference during the work took place during the initial recce and survey when the site was periodically shot up with M.G. and mortar. By the time we started building, the site was absolutely quiet.

The lessons we learned from this bridge were:—

1. The three Field Company set-up as devised at Goole was almost ideal.
2. Wearing surface should be prepared in good time.

The bridge had gone so successfully that we were in danger of making under-estimates for time of construction in future work. But it was a straightforward bridge and current in the worst place did not exceed 1½ knots.

Kent Bridge, River Maas, Berg

Early in November we were on the Waal at Nijmegen, under 30 Corps, when the switch of the Corps to the Sittard area was ordered. This involved building bridges over the Maas, the Juliana Canal and a Belgian canal, all of which had to be done before the Corps arrived. There were to be two Maas bridges, one at Borgharen, to be built by 30 Corps Tps., and the second a few miles further north at Berg, which was to be our task. The recce was carried out by 30 Corps Tps., who were originally scheduled for both tasks.

The formation (less 584 Fd. Coy., which had been detached) arrived in the Berg area on the evening of 4th November, and C.R.E. got to the site at last light with company commanders and made a rough plan. The following morning at 0830 hrs. detailed recce was started, and at the same time bridging lorries started arriving and off-loading commenced. These lorries were ordered on the 30 Corps Tps. design, but this was changed consequent on a detailed recce. The site was a difficult one. On the west (Belgian) bank a road ran parallel to the river turning at the end to a flying ferry hard. The ferry hard on the east (Dutch) bank merged into a narrow village street bending sharply to the right, between houses. To allow for the possible rise of the river our bridge had to extend to these houses, so, to ease the bend, we placed the bridge somewhat obliquely to the current, coming straight off the bank on the west side, and running on fixed piers on the ferry hard on the east side. The last eastern approach span was skewed to ease the curve.

Double landing bays were desirable, but the bridge was required for 8th November, and the additional stores required were not readily available. We therefore compromised : on the east side we used double landing bays, the inshore one springing off a Bailey crib set on the hard. On the west side we used a single 110 ft. landing bay with provision for jacking up the end as required.

Intelligence on the water levels was not entirely accurate and our design was based on faulty premises. When we started the river was low—about 2 ft. above minimum level—and running at 2¾ knots.

As to the work, 583 Fd. Coy. took the west side and 582 the east side. All stores for the far bank were sent over in lorries on the existing flying ferry (Class 9): some of the later lorries turned out to be Class 12 and these had to be off-loaded on the near bank and their loads sent over as cargo. The ferrying work was slow and it was not until 1600 hrs. on 6th November, that all far bank stores were on site and the flying ferry—which was in the way of the bridge—could be dismantled. Pontoons had not started to arrive before 1400 hrs. on 6th November.

However by 0230 hrs. on 7th November, 1944, the Bailey crib on the east bank was complete and by 1200 hrs. the big 110-ft. east approach span on this crib was complete as was the western landing bay; the 6-pier and 4-pier rafts for the double landing bays were ready, as well as both floating bays. After a slow start we had got well under way and things looked rosy. The river had risen over the footing of our Bailey crib and was running at over 3 knots, but we had got the crib erected in time. Our troubles were now to begin.

The big snag was the inshore 110-ft. T-S landing bay on the east bank, running from Bailey crib to 6-pier raft. Since this had to be launched through the existing 100-ft. T-S approach span, we had to use separate girder method, launching as D-S. Work started at 1200 hrs. on 7th November and launching of the first girder commenced at 1600 hrs. The work went on all night, a wrong decision of the C.R.E., for it only tired the men and the work in the hours of darkness was very ineffective over this extremely tricky operation. One of the girders fell over once, there were other snags, and it was not until 1300 hrs. on 8th November that the girders were in place, while transoms and decking were not completed until 2100 hrs. We were now badly behind schedule and were being pressed to complete.

We started to build the two separate 60-ft. D-S girders for the east offshore landing bay, but closed down at 2100 hrs. as the river had risen still further and it was too hazardous to attempt launching single girders at night.

On 9th November work started at 0630 hrs. and not till 1230 hrs. had the separate girders of the 60 ft. east offshore landing bay been got into position. Meanwhile, earlier in the morning, the last floating bay had been brought into bridge. The method was interesting : we had built this bay upstream and the current—oblique to the line of bridge—was now running 4 knots. Our motor boats were rather unreliable, but we had some expert close support raft crews. We therefore fitted four propulsion units to the bay and brought it into bridge by manœuvring upstream till opposite the gap—then only 53 ft. or so for a 42-ft. bay—and then dropping gently down *with* the current, running the engines *against* the current to prevent the bay coming into bridge too fast. This worked perfectly.

By 1230 hrs. on 9th November we had been visited by the Army Commander, the Corps Commander and the Chief Engineer (Corps) all of whom were acutely interested in getting the bridge open as early as possible and the C.R.E. gave 1600 hrs. as the estimated time of completion. There was still much to be done, but by 1310 hrs. the west landing bay had been boomed out and jacked down and the bridge connected across, while twenty minutes later the 60-ft. east offshore landing bay had been decked. A 40-ft. D-S west approach span and ramp were being built; the 110-ft. T-S east inshore landing bay was being tripled up and the wearing surface was going in. Everyone was tired, but all, from C.R.E. to Sapper, realised that the bridge was late and felt it was a bad business after our success at Vernon: consequently the output of work in the last few hours was terrific: wearing surface, already cut and prepared by the Field Park, was following the decking closely—with N.C.O's. and officers helping to nail it down! By 1605 hrs. all the tasks were completed—practically simultaneously—and at 1610 hrs. the first traffic passed.

The formation (less 582 Fd. Coy.) were ordered away to 8 Corps the following night, but returned three days later to maintain the bridge and do other work in the locality. Traffic was still pouring across and the current and river rising. False bows and heavy anchors arrived and we added two additional tripartite piers to the western landing bay piers. The false bows were with us none too soon. In the 4¾-knot current, before the false bows were added, tanks passing forced the bows of the pontoons under water; this trouble, indeed, caused the loss of Borgharen bridge a few miles upstream, leaving Kent bridge for a time as the only British bridge over the Maas in this sector. Our morale, somewhat shaken over our miserable building time, rose at this thought, and we were determined to keep our bridge going. Heavy anchors were laid out with S.W.R. cables made fast to the bridge panels.

By 21st November the river had risen so high that the western landing bay had to be jacked up, as well as the eastern approach spans. This was done in pouring rain, most of the jacking being done under water, using pieces of timber as jacking platforms. These *would* keep slipping out and floating to the surface. A stout-hearted sergeant, dripping wet and very cold, had taken over the jacking. As the wooden jacking platform slipped from under the jack and plopped to the surface for the twentieth time he was heard to say, more in sorrow than in anger: "There's that —— piece of wood again!" The bridge was closed for 21½ hours on that occasion. On 25th November the water had risen further and the current was 5½ knots (see Photo No. 1); the Bailey crib was completely immersed with water over the junction links, the Eastern approach was under water a depth of 18 in. and some vehicles were stalling in the splash. The bridge was again closed for 6½ hours while 584 Fd. Coy., now back with us, added a 50-ft. D-S at the eastern end.

At 0600 hrs. on 27th November the river reached its peak, with the bridge still open to traffic. The river had risen over 13 ft. since building had commenced three weeks earlier, the western landing bay was running uphill, and water was pouring over the bottom chords of the eastern approach span with the Bailey crib well below the surface. But the bridge appeared safe and continued to take traffic. However, the west approach road, well under water, was disintegrating and the bridge was closed at 1200 hrs. to repair it. It remained closed to all except our own traffic for five days while these road repairs were completed. At the same time, some improvements were made on the bridge itself. By the time of reopening, the water was falling slowly.

The formation ceased maintenance of the bridge on 12th December. By that time it had taken 58,000 vehicles since opening on 9th November, taking 3,513 vehicles on the peak day.

During maintenance various types of icebreaking bows had been tried out: we favoured sheet-steel bow sheaths, conforming to the shape of the pontoon, with log fenders alongside the tripartite piers, and used these in all subsequent bridges.

The enemy F.D.L's. were some 2½ miles from the site when we started building. The only interference consisted of a few air burst shells on the evening of 6th November and a harmless bombing and machine-gun attack by friendly aircraft on the afternoon of 7th November.

We learned many lessons from the building and maintenance of this bridge:—

1. It is vital to know the water level at site with reference to the highest and lowest levels likely to be met if the bridge is to be properly designed.
2. Bailey cribs should only be used where no jacking up is ever likely to be necessary. Piers of steel Christchurch cribs are best if jacking may be required. Where jacking is needed wooden jacking platforms must be bolted down.
3. The launching of landing bays by single girder method is too slow and unreliable to be attempted. Some other method must be adopted.
4. An all-weather bridge with approach spans may take three times as long to build as a straightforward Bailey pontoon bridge of the same size.
5. Night work on tricky all-weather bridges is rarely of use. It only tires the men and the next day is spent in undoing the mistakes made at night.
6. Heavy anchors with S.W.R. cables with an adjusting tackle are vital for all-weather pontoon bridges.
7. False bows should be fitted in fast currents *before* the bridge is opened to traffic.

Quebec Bridge, River Maas, Ravenstein

The formation was ordered under command of 13 A.G.R.E. (under I Canadian Army) in the middle of December, 1944. Our tasks were the building of two major all-weather bridges across the Maas, the first at Ravenstein and the second at Mook. These were required for Operation "Veritable," already planned, though later postponed in consequence of the Ardennes battle. The bridge at Ravenstein was to be ready by 24th December, and the C.R.E. carried out the initial recce on 13th December, the formation arriving in the area on 14th December, ready to start work the following day.

At the time of the recce the Maas at Ravenstein was about 600 ft. wide, with current running about 2½ to 3 knots and the water level falling slowly. A ferry hard at the site had been used for a low level Bailey pontoon Bridge (Yardley Bridge) at that time being completed by a formation of Royal Canadian Engineers. For the rest, the approaches on each side consisted of roads running parallel to the river along the floodbanks, which at that point were about 1,300 ft. apart. On the north side the flood plain had dried out, but on the south side it was mostly covered to a depth of 2 or 3 ft.

The site chosen was about 100 yds. downstream from the low level pontoon bridge. Fixed piers and approach spans were necessary on each side, with double landing bays (110 ft. and 90 ft. T-S) to take the 20 ft. possible variation in water level. To allow traffic to turn from the floodbank roads on to the bridge at each end the road had to be built out to meet the bridge in the form of a "bellmouth." This involved building a retaining wall or palisade of round timber, and filling the area contained with hard core. The rapid completion of these bellmouths depended on the availability of tippers. A sliding bay was to be incorporated in the floating portion to allow a cut to be made easily to pass river traffic through.

Since the floating portion of the bridge had to spring from fixed piers on either side of the river, accurate gap measurement was essential to allow the fixed piers to go up early. We therefore measured this by theodolite. A line of levels was also run out and we were able to give the heights with reference to the standard datum of Holland—N.A.P.—as a water level gauge giving the N.A.P. reading was in position close to the site. Intelligence had given the highest and lowest water levels to be expected, and thus we were able to go firm on a sound design at the outset—unlike our experience at Berg. In order to ensure that the pontoons would be afloat at lowest water level, soundings were taken, and the height of the fixed piers designed so that the bottom chords of the fixed spans should be above water at point of maximum deflection at highest possible water level.

As mentioned already, the north bank flood plain was exposed and dry, but the southern flood plain was still under water. Therefore for the south bank, our fixed piers, of Christchurch cribs 6 ft. × 2 ft. × 2 ft., were designed with big crib bases, in one case as much as 24 ft. × 12 ft., to distribute the load over the sodden ground, the whole pier resting on a mat of Chespale covered with one layer of Sommerfeld track, the latter screw-picketed down to the marshy ground, the area having previously been scraped roughly level under water, by men in gum boots (see Photo 2). For the north bank, no under-water work was necessary, and the south bank method being extravagant in cribs, we decided to place our piers—once again Christchurch cribs—on concrete bases. Each pier consisted of two towers of Christchurch cribs each 6 ft. × 6 ft. in plan, with cross bracing of light angle iron between the two towers. The bases were 7 ft. × 7 ft. × 6 in. thick, of concrete, 4 to 1 mix, using rapid hardening cement, reinforced by B.R.C. Underneath these slabs we drove in 5-ft. wooden pickets at 2-ft. centres before laying, as a kind of pile foundation.

We had been given ten days for the job, a very adequate time, except for the bellmouths, but as the bridging lorries would be arriving rather slowly—from 15th to 20th December—we could afford no snag, so we decided to adopt a new method of launching the double landing bays, rather than the tedious and tricky launching of single girders used with such unfortunate results at Berg. The method suggested by the C.R.E. was to build and launch the inshore landing bay first on to the 6-pier raft, type D, and then build and boom out the offshore landing bay from the deck of the pontoons of the 6-pier raft, building D-S, without decking, and with only two transoms at either end. A crane, moving on to the inshore landing bay, would pick up the inshore end of the offshore landing bay and lift it to the top of the crib piers mounted on the 6-pier raft, where it would be pinned in to the span junction posts already attached to the junction links. After this the remaining transoms were to be added, followed by stringers and decking, and the trusses tripled up. This method was actually used by 583 Fd. Coy. for the south bank and proved a great time saver over the single truss method.

However, O.C. 584 Fd. Coy. (Major W. P. Adams) asked permission to try his own method on the north bank. This was to build the inshore and offshore landing bays (less stringers and decking) together, complete with their span junction posts on two sets of rocking rollers. Initially the span junction posts were to be kept pinned top and bottom until they had reached a position between the two sets of rollers, with no tension or compression in the top pins, allowing them to be removed. Thereafter the double span was to be launched dog-legged : as the outer end of the offshore bay moved out and down, the end floating bay and 4-pier raft were to be floated under and pinned in. Then as building and launching proceeded, the 6-pier intermediate raft, type D, with its tier of cribs was to be floated beneath the span junction posts at the apex of the dog leg, and again pinned down. After that launching was to be completed as for an ordinary landing bay. The C.R.E. agreed to this method being tried out, though he was somewhat sceptical.

Work started on 15th December, with Pioneers helping the off-loading. The low-level Canadian bridge was a boon in getting lorries across to the north bank, but many lorry loads had to be carried thence by hand across 500 ft. of flood plain. On 17th December the fixed piers on the south bank started to go up and the big floating piers were being built, as well as the floating bays. On 20th December 584 Fd. Coy. had launched their double landing bays by their new method which had proved triumphantly successful. The south bank had been held up, for a check on gap measurement had shown that we were about 10 ft. out on our theodolite reading. This seemed inexplicable till we discovered that in measuring the base the wrong zero had been read on the tape. In the event it resulted in our having to move one of the south bank fixed piers about 10 ft. : this was less difficult than it might have been for the water level had fallen and the ground was now exposed.

Concreting the bases of the fixed piers on the north bank was slow but the bases were all completed by the evening of 20th December, and the following day the fixed piers on the bases started to go up, together with the north bank fixed spans, while on the south bank the inshore landing bay had gone up. On 22nd December the south bank offshore landing bay was launched and next day the rafts had been brought into bridge, wearing surface was going down, and tripling up the trusses on the south bank was well in hand.

By 1700 hrs. on 24th December the whole bridge, 1,240 ft. long, complete with wearing surface, had been completed, but was not open for traffic. The bellmouth approaches had not been finished : work on them had started on 20th December but tippers had been in short supply and by that time we had been told that, in any event, the bridge would not be needed before 31st December. The quantity of hardcore filling was enormous on the north bank, and though on the south side we had finished by 24th December, the former was not ready till 1700 hrs. on 28th December, when the bridge was opened to traffic.

When completed it was the longest Bailey in the world, but its record only stood till early in February, 1945, when 7 Army Tps. opened their 4,000-ft. pontoon bridge at Gennep.

It may be mentioned that on the pontoons we fitted false bows, steel bow sheaths for ice protection, and log side fenders for the floating piers : hatch covers were fitted to all Mark VI pontoons and a number of heavy anchors were provided.

Forty-three pontoon anchors, four heavy anchors and five shore lines were used. Downstream anchors proved rather inadequate in westerly gales and had to be increased.

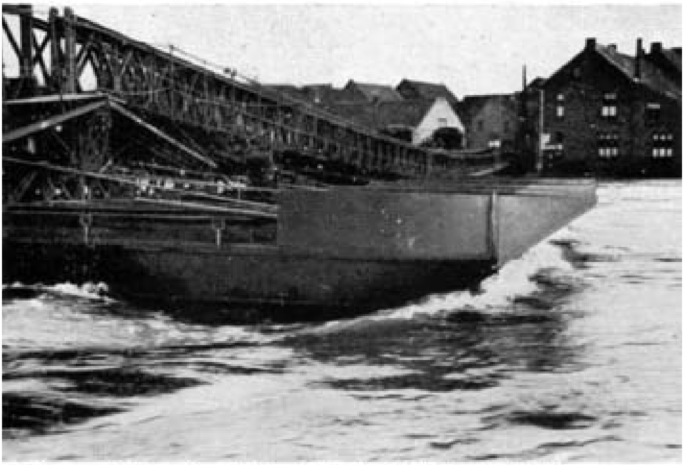


Photo 1.—Floods at Kent Bridge. Pier for double landing bay in 5½-knot current.

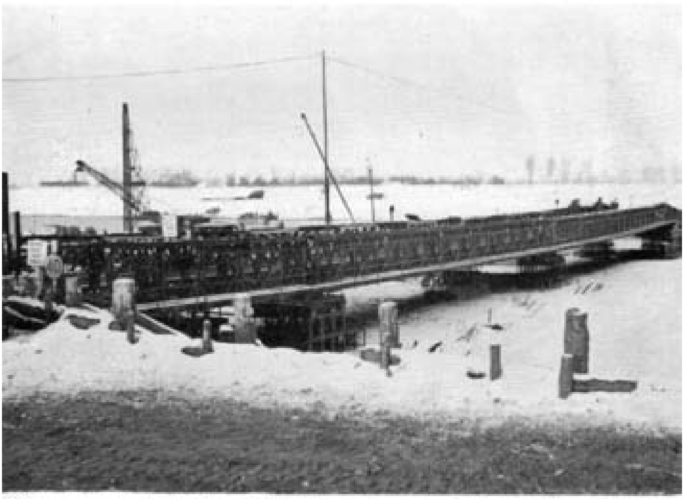


Photo 2.—Quebec Bridge, River Maas, Ravenstein. The southern approach spans showing the crib piers built on Chespale-Sommerfeld bases. The latter bases are under the snow.

Seven Bridges 1-2

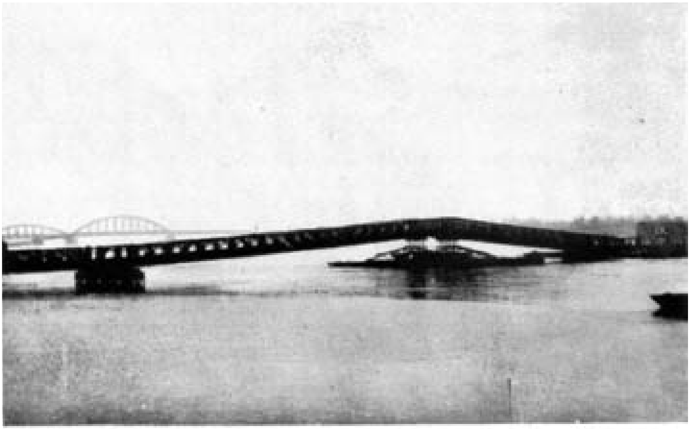


Photo 3.—Quebec Bridge. A double landing bay during floods.

Photo 4.—Ilex Bridge. Launching a double landing bay. Six-pier raft just showing in right foreground, ready to be floated in.

Seven Bridges 3-4

The bridge, in service, proved excellent. It withstood the cold, ice and low water of January, 1945, and remained in operation, giving no trouble, during the floods of February, when the low level bridge had to be dismantled and the river was 1,300 ft. wide and running 4 knots. (See Photo No. 3.) The fixed piers, including those built on Chespale-Sommerfeld track bases, withstood the current and scour without measurable movement. The bridge was used extensively for operation "Veritable."

The lessons we learned from this bridge were as follows:—

(*a*) Chespale-Sommerfeld mat foundations for fixed piers are satisfactory on marshy ground, but such piers are uneconomical in cribs and should only be used when the foundations are sodden or under water.

(*b*) Concrete foundations for fixed piers, to the design adopted, are excellent. To speed up work, concreting must be carefully organised. Aluminous cement is best as the load can be put on it within a few hours of setting.

(*c*) Accurate gap measurement by theodolite is desirable, but carelessness in its use is a menace.

(*d*) Initial information of water level on the spot enormously speeds the design of the bridge.

(*e*) For all-weather bridges secure downstream anchorage is essential; heavy anchors and 2-in. S.W.R. shore lines should be used.

(*f*) The 584 Fd. Coy. method of launching double landing bays is ideal and should always be adopted.

Ilex Bridge, River Maas, Mook

While Quebec Bridge was being finished, a preliminary reconnaissance of the Mook site was carried out by C.R.E. In general the site was similar to Ravenstein—high flood banks on each side and a wide flood plain, with a water gap at that time of about 500 ft. A low level Bailey pontoon bridge was already in service just upstream of the site selected while further downstream the Canadians were preparing to put a fixed Bailey over the piers of a demolished railway bridge.

The site was some 2½ miles from enemy F.D.L's. and was said to be overlooked—the natural approach along the west bank from the south was periodically shelled—consequently we had orders to limit our lorries at the site to eight per day. This we felt would mean at least a month to build the bridge, so we chose a site 4 miles downstream, at Overasselt, where the rafts could be built with impunity and towed upstream on completion.

As to design, we were told that the bridge must cater for a 26-ft. tidal variation. This would mean excessive gradient for the double landing bays assuming the variable slope span to be the usual 110 ft. Therefore we reluctantly decided that on each side of the water gap the last fixed pier should be a four-legged heavy trestle (E.B.E. type), which could be jacked up and down. On the west bank of the river the other fixed piers were to be steel Christchurch cribs—four tiers of cribs, capped—while on the east bank the ground was lower, so that we could use Bailey cribs (Double-Double).

Bellmouths as used at Quebec Bridge were again necessary to give an easy drive on to the bridge off the floodbank; to reduce the size of the western bellmouth a curve in the western approach spans was decided, each span being skewed 1 ft. in 20, a figure which allows of easy driving for vehicles crossing.

The foundations for the fixed piers, whether trestle, Christchurch crib, or Bailey crib, were to be of R.C. (*ciment fondu*), 6 in. thick, 5-ft. wooden pickets being driven beneath the concrete with their tops flush with the bottom of the excavation. The areas of the bases were as follows: for each trestle leg, 5 ft. × 5 ft.; for each Bailey crib pier, two slabs each 12 ft. × 4 ft.; for each Christchurch crib pier, two slabs each 7 ft. × 7 ft.

Completion of the bridge was required before the end of January, 1945.

Preliminary recce was done on 23rd December, and on 27th December the gap was measured (this time accurately!) by theodolite and the design of bridge completed.

On 29th December the centre pegs for each pier were put in and levels were taken, and on 31st December excavation for the fixed piers started. With the work beginning in earnest we were faced with difficulties of distance. It had been impossible to obtain accommodation for the formation near Mook and we had to remain near Ravenstein and travel to and from the site morning and evening—a total round distance of about thirty miles for most units.

On 3rd January, 1945, the first bridging lorries started to arrive. By that time the bellmouth timber palisades were being erected, and the next day concreting the pier foundations started. It was practically freezing but the concrete, made with aluminous cement which generates heat during mixing and setting, appeared to be quite good.

By 7th January there had been no enemy interference, so we arranged for twenty-four bridging lorries to arrive daily at the site instead of the usual eight, but the following day work was slowed down by heavy snow which fell throughout the day. These freezing conditions continued throughout the construction of the bridge except for a half-hearted thaw on 12th and 13th January. By the time that the snow started however, all the floating piers had been built at Overasselt. They were towed down to the site on 10th January, but on that day we were ordered not to launch landing bays owing to ice danger.

All the fixed piers—except the trestles—were built by 11th January, by which time the double landing bays were under construction, and next day the last of the bridging lorries was off-loaded. On 12th January 584 Fd. Coy. were ordered away from the formation, under Second Army, so the remainder of their task was given to 582 Fd. Coy. For this bridge, as usual, 583 Coy. had been doing the near (west) bank, 584 the centre, and 582 the far (east) bank.

On the evening of 14th January we received permission to launch landing bays, and the double bays were in position by 16th January, with their inshore ends on temporary cribs. We had, of course, used the 584 Coy. method of launching developed at Quebec Bridge. (See Photo No. 4.) Launching was not always easy as rollers froze and fires had to be lit under them to free them. Next day trestle erection started, but that evening orders were received to stop all work on water and not to complete the bridge. By this time we were beginning to be used to the sudden changes of plan, though somewhat irritated by them; it seemed that no one wanted us to finish our bridge—the real answer of course was that it was not wanted yet and its completion might make the enemy realize that a big attack was brewing, as indeed it was.

The net immediate effect was that we had to haul the landing bays 15 ft. inshore and so could not continue our work on the trestles; however, a gale gave us something to think about and dropped the eastern inshore landing bay off its packing. Then on the evening of 19th January we were told to go ahead again, but to break the neighbouring low level bridge before completing our own.

By 21st January the west bank trestle was up and the inshore landing bay was jacked up off its temporary pier into position. On the east bank the trestle did not fare so well. At 1430 hrs. on 21st January the whole devilish contrivance collapsed and though it was re-erected quickly we found some of the columns had been buckled, so it had to be dismantled and was not finally up, with landing bay in position, until 23rd January. Finally the last fixed span was put in, the sliding bay—the only floating bay apart from the landing bays—was brought into bridge, the last of the wearing surface laid, the bellmouths completed and the bridge opened for traffic at 1800 hrs., 24th January, 1947.

The whole bridge was 1,095 ft. long, and on its high fixed piers, with an easy grade down to the floating portion it looked very well indeed. We named it "Ilex Bridge" after the old R.E.Y.C. ocean racer, and added a small dedication board "To Ilex, R.E.Y.C.," with R.E.Y.C. burgee and racing flag and a sea horse (the insignia of the Royal Ocean Racing Club) above the usual name board.

In service the bridge fared well; it took a big volume of traffic during the early stages of operation "Veritable," when, with the river 1,100 ft. wide at the site and running 4½ knots, the low level bridge was unusable. Unfortunately our successors in the maintenance of the bridge omitted to jack the trestles up when the water rose and the result was a strange switchback effect.

A snag was the sliding bay. We ran the wearing surface up to just short of the ramp over the sliding portion. Even so there was a bad hump which slowed traffic badly.

False bows, steel bow sheaths and log fenders were fitted, also well covers to Mark VI pontoons. In the snow and ice immediately following completion no damage was caused to the piers.

Twenty-four pontoon anchors, nine heavy anchors and eight shore lines were used to secure the bridge and proved adequate.

The complete lack of enemy interference throughout the construction of this bridge was remarkable, though extremely comforting to us. We left the bridge feeling that it was a good one, but the enforced slow tempo of construction had made the achievement fall rather flat for us, particularly as it was not till after we had left the site that traffic used it in any volume.

The lessons we learned were as follows:—

1. Avoid the use of heavy trestles wherever possible, and demand at least 10 per cent spare parts if you are obliged to use one.
2. Order the anchorage stores early: as it was we had to use cordage for many cables for which we should have preferred S.W.R.
3. If a sliding bay is incorporated in a bridge, wearing surface must be gradually thickened towards the ramp, so that it is a full 4 in. thick by the time ramp is reached: this avoids the bump which slows the traffic and causes congestion.
4. If there is sufficient time, if stores are available, and if the site is wide enough, triple landing bays, with the centre one almost horizontal, are preferable to double, to ease out the switchback effect when water level is high. This again should speed traffic.

Fulmar Bridge, River Maas, Venlo

During February, 1945, the formation was engaged on road work in 8 Corps area, while 6 and 7 Army Tps. followed the advance of 1 Cdn. Army by bridging the Maas at Gennep with two of the most remarkable bridges of the campaign. It was arranged that, as the advance continued, these formations should bridge at Well and Lottum while we were earmarked for a possible assault crossing near Venlo, or, more probably, to build an all-weather bridge at Venlo when the Americans, advancing from the south, should capture the town. We were to work direct under C.E. 8 Corps and we were given air photos and a section of the gap so as to be able to make a bid for the necessary stores. Accordingly a design of bridge was worked out and stores on this basis were earmarked at Corps.

C.E. 8 Corps laid down the following requirements :—

(*a*) Bridge to be all-weather, to cope with nearly 27 ft. variation of water level.

(*b*) As water gap at low water was comparatively small—only about 400 ft.—we were to build the bridge " high level " over the floating portion ; i.e., from the last fixed pier on each bank the usual type of inshore landing bay was to run to a 6-pier raft, type D, with two tiers of cribs, and the next spans, instead of running down to 4-pier rafts and end floating bays, would run to another 6-pier raft, type D, with two tiers of cribs, and so on. This would avoid awkward switchbacks at certain water levels.

We reluctantly decided on four-legged heavy trestles, as in Ilex Bridge, for the fixed piers nearest the water, to give the extra tidal variation called for, while the second requirement presented no known difficulty, though, as a high level floating bridge of this size had not been built before, snags could not be foreseen, so an estimate of seven days for construction was given.

On 1st March we were told that the Americans were likely to take Venlo that night and that we were to be on the site the following morning. That day our road task was handed over and a field engineer was sent to Blerick to liaise with the American unit holding that town, which lies on the west bank of the Maas opposite Venlo. The formation left their company locations near Helmond at 0500 hrs. on 2nd March, and by 0900 hrs. the C.R.E., company commanders and advanced parties were on the site and mine clearance parties started work on the west bank. Meanwhile the companies moved into billets in the rather shattered town of Blerick.

The enemy had gone from Venlo, and all we heard of him was a shell or two landing in the town early that morning. We found 8 Corps Tps. arriving on the site preparatory to building a Class 9 F.B.E. bridge just upstream. They looked as if they would get their job done that day, which meant that we should be able to get our far bank stores over by their bridge instead of rafting.

By 0930 hrs. west bank site was firm and the usual party with dumpy level and staff were taking levels, while F.E.2. was sent to Venlo to search for a water level gauge giving the existing water level so that we could tie our design to the maximum and minimum levels likely to be met. By 1100 hrs. east bank mine clearance started and half an hour later the east bank site was firm. We marked the centre line of the bridge and started to measure the gap by theodolite. Our F.E.2 returned at noon with details of the water level, having found a gauge in Venlo.

By 1630 hrs. all levels had been taken, the gap measured and results brought to C.R.E., and by 1700 hrs. the design of the bridge was firm and drawn out to scale in the bridge office on site. We had, after all, been able to dispense with trestles, for the site was not really suitable. So our fixed piers nearest the water were of Christchurch cribs arranged with jacking " steps " so that another tier of cribs could be added or removed at will. This allowed a 6-ft. variation in the height of the piers. When at full height, these piers brought the road level to the same height as that over the other fixed piers, but, as the water was fairly low at the time of building, we decided to build the " jackable " piers 4 ft. lower than their maximum height. On the west bank all the fixed piers were of Christchurch cribs to the usual pattern, but on the east bank heights worked out right for two D-D Bailey crib piers. Foundations for all these piers were R.C., similar to those used on Ilex Bridge.

There were no floodbanks at Blerick and Venlo, and on the west (Blerick side) the approach was via a rough road between houses on a slight down grade, from which the bridge sprang with piers increasing in height as the river proper was approached. On the east (Venlo side) the approach was peculiar. A broad road, mainly concrete, led to the first span (80 ft. D-S) which bore slightly left and uphill from the road, across a bomb crater on to the floor of a demolished factory. Then came a 40-ft. S-S span over irregularities in the floor, skewed to the right from the first span, then 100 ft. S-S Bailey causeway across the remainder of the floor, whence another span ran to the first of the Bailey crib piers on the flood plain. The rest was plain sailing on that bank.

For the floating portion we had 110-ft. T-S landing bays running out to 6-pier rafts, type D, with two tiers of cribs. There were four such rafts in all and the intermediate spans were all 80 ft. with deck level about 11 ft. 8 in. above the water.

So much for the design, and by 1900 hrs. on 2nd March all fixed piers were pegged out on the ground and levels marked, while a revised list of stores required had been sent to Corps.

Meanwhile on the same day mine clearance detection had revealed the site clear and at 1200 hrs. two Coles cranes were on site, and four close support raft lorries. The raft was then built as a reserve, but was not used as the F.B.E. bridge was opened in time to take all our far bank lorries. By 1400 hrs. companies were on site to help advanced parties, and bridging lorries started to arrive. By 1900 hrs., when we knocked off for the day, seventy-one lorries had been off-loaded. In this we were assisted by 14 Belgian Pioneer Coy., who remained with us for two or three days.

Next day (3rd March) over 100 more lorries were off-loaded, all but one of the concrete bases for fixed piers built, two 6-pier rafts were complete and we had launched the most easterly 80 ft. intermediate span on to it, from the west bank. Construction of 6-pier rafts had been accelerated, as 297 Fd. Pk. Coy. had made all the wooden packings and cappings for them long before our move to the site. Small parties worked on till midnight.

On 4th March fifty more lorries were off-loaded, and all fixed piers were built except the two "jackable" ones. Using our usual method of launching double landing bays we built the whole of the floating portion of the bridge (bar the east bank L.B.) on the west bank, floating the 6-pier rafts under the span junction posts as we boomed out. (See Photo No. 5.) A tail was built on the west bank landing bay and the whole boomed out about 40 ft. in excess. This allowed us to launch the eastern landing bay on to the easternmost 6-pier raft, connect up, boom back and remove the western tail. All this was done by 1630 hrs. The troops knocked off at 1900 hrs. but small parties again worked on till midnight, aided by artificial moonlight laid on at our request.

On 5th March the last bridging lorries were off-loaded, the "jackable" piers built and all but one of the fixed spans put in position. Meanwhile heavy anchors were being laid, and wearing surface was being cut in the Field Park workshops. The bridge was nearly complete, and on the east side we had concreted the approach to join in smoothly with the ramp.

On 6th March the last span was completed and cut stringers and decking added between spans: wearing surface was laid, foot-walks and handrails fixed, false bows and bow sheaths added to pontoons, and the anchoring scheme completed. We also scarified the western approach road and then laid and rolled a good tarmac carpet. At 1605 hrs., 4 days 2 hrs. after the arrival of the first bridging lorry, the bridge, 1,243 ft. long, was complete; the western approach was not completed until 1730 hrs., when the bridge was opened for traffic. The first vehicle (the C.R.E's. car) passed over at

45 m.p.h. without experiencing any bumps and we felt the bridge would take a high density rate of vehicles.

The anchoring scheme was far neater than for preceding bridges. Each 6-pier raft had exactly the same anchoring, except that the inshore piers had shore lines in addition. In all, sixteen pontoon anchors, twelve heavy anchors and four shore lines were used to secure the bridge, S.W.R. cables being used throughout.

We had been greatly assisted in the speed of building this bridge by the fact that 8 Corps Tps. had opened their F.B.E. bridge by the evening of 2nd March, but we had also crammed all the lessons learned by experience on the previous big bridges and all this enabled us to open the completed bridge in 4 days 8½ hrs. from first recce. We considered it our best bridge ; it was certainly trouble free and looked very well. It was named Fulmar bridge after *Ilex*'s predecessor in the R.E.Y.C.

The traffic carried by the bridge is interesting. It was used for both up and down traffic : in the first stages this was not heavy, averaging fifty-two vehicles per hour for the first seventy hours, but increasing to a peak of 4,990 vehicles, excluding motor cycles, in twenty-four hours, i.e., an average of 208 vehicles per hour, a remarkable figure in view of the fact that the traffic had to be stopped from time to time while the stream in the opposite direction was let through. In all, over 18,000 vehicles crossed in the first week. This included the tanks of at least two armoured brigades ; on the west bank, at the turn where our beautiful tarmac approach joined the main road, these destructive vehicles tore out ruts 18 in. deep. The concrete on the east side stood up perfectly.

The lessons we learned from this bridge were :—

1. Approximate design (and consequent ordering of stores for such a bridge) can be made from air photos and intelligence and greatly assists speed of construction.
2. A long bridge should be a " fast " bridge, with easy grades, to allow maximum speed and avoid bottleneck in traffic.
3. Approaches to important bridges, especially on bends, should be built of concrete, not tarmac.

Sparrow Bridge, River Rhine, Xanten

In February, 1945, long before the Venlo bridging operation, it became known that the formation was booked for the Rhine crossing at Xanten with 15 (Scottish) Division, under 11 A.G.R.E. Our tasks were the operation of stormboats and Class 9 rafts with one of the assaulting brigades, following up with the construction of a Class 40 all-weather bridge ; this latter would not be started until our rafting had ceased, i.e., after the completion of the first low level Bailey pontoon bridge in the sector.

As with Venlo, adequate intelligence and air photos were forthcoming, and a provisional site was fixed, as well as a design on which stores could be ordered before the event. Again, too, the Field Park were able to prepare cappings for piers and rafts and other small accessories, long before the event.

After the Venlo operation, the formation was busy with rehearsals and preparations for the assault phase of the crossing until the actual assault, and our future bridge rather faded in importance in our minds.

The assault crossing of the Rhine at Xanten took place at 0200 hrs. on 24th March, 1945, and by 0230 hrs. our stormboats were operating, followed at 0630 hrs. by the rafts. It was not until Sunday, 25th March, that the C.R.E. was sufficiently free to visit the proposed site of the new bridge : however a recce on that day fixed the line by 1100 hrs., when water levels were noted (a tide gauge was on the site, mercifully) and some levels taken.

On 26th March rafting and stormboating ceased at 1200 hrs. and companies concentrated and rested before the new task. We had been unlucky in losing two company commanders wounded in a recce before the assault—Major Keeble of 582 Fd. Coy. and Major Barton of 583 Fd. Coy., but the former was only slightly damaged and rejoined us to our delight on this day. Throughout the day, gap measurement and levelling was done, the design of the bridge fixed, the centre pegs for piers set out, and the required bridging lorries ordered, in a daily programme. Our estimate for time of completion was ten days.

The design of the bridge had to cater for a 20-ft. range of water level, which at the time of building stood at about 4 ft. above lowest level for the design, rising very slowly. We decided to build the bridge with temporary approaches for first opening, following up with extensions and permanent approaches to be opened later.

On the west bank the approach road ran to the river bank about 100 yds. downstream of our site and then turned right along the edge of the water past a wharf, to the site of the bridge. This road along the bank, though at the time some 14 ft. above the river, would be flooded at highest water, apart from giving an awkward run on to the bridge ; so we used this as our temporary approach, and decided to put in, later, some 300 ft. of Bailey, at a skew to the main bridge, cutting the corner across a field, to join on to the main approach road at a point where it would not be flooded, and to act as the permanent approach. As to the main bridge, there was only one 60-ft. approach span on the west side, on to a crib pier, whence the triple landing bays—110 ft., 90 ft. and 90 ft.—sprang. We decided on triple landing bays to ease the switchback effect at high water and generally to improve the grades. For the main floating portion 32-ft. bays were decided on, as giving best buoyancy for an all-weather bridge, and a sliding bay was to be incorporated. Again on the east bank there were to be triple landing bays running from a high crib pier on the end of a groyne and from this pier one 90-ft. and five 80-ft. spans on crib piers built on the groyne ran to the flood bank. From here our temporary approach road of hard core, to be made through an orchard, wound to the left, joining on to a main road after 100 yds. or so ; this would be below water at highest flood level, so the permanent scheme allowed for an additional 80-ft. span which extended the bridge to a higher floodbank along which we decided to build 200 yds. of concrete approach to join on to the main road to Bislich at a safe level above floods.

On 27th March, the companies moved early to their new locations and small parties were started on mine clearance by 1000 hrs. Only a few schumines were encountered. At 1400 hrs. the first bridging lorries arrived and with the companies all on the job we started on the off-loading of stores, track laying for raft building sites, and excavation for fixed piers. At 1800 hrs. the men were knocked off after off-loading forty-three bridging lorries.

On 28th March with 53 Coy. Pioneer Corps assisting, 123 lorries were off-loaded, excavation and concreting for bases of piers continued, one landing bay was started and some of the floating piers constructed.

Next day about one hundred more lorries were off-loaded, building of fixed and floating piers continued and launching of the eastern offshore landing bay was done.

On 30th March all remaining bases for piers were concreted, all the landing bays except one span were launched, some fixed piers were completed, and some floating bays built. It should be mentioned that we launched our landing bays from falsework piers of steel cribs, built between the final piers and the water. During the launching of one of the landing bays the young officer in charge of the operation omitted to put on his preventer in good time so that the whole thing collapsed on to one of the 6-pier rafts. This lamentable performance was witnessed by our friends and rivals 7 Army Tps. who were maintaining their tactical low level Class 40 bridge (the first British Class 40 over the Rhine) 200 yds. downstream of our site. Their generous comments to me on this "piece of bad luck," as they termed it, perhaps softened the blow, but the culprit then acted with commendable resource and all was shipshape again within 1½ hours. On this day we heard that 6 Army Tps. had opened the first all-weather Rhine bridge at Rees; they had had two days start on us, but their time was very good and we did not hope to equal it: in fairness to ourselves, however, it should be mentioned that their approach spans were much shorter.

On 31st March the last landing bay was completed and both inshore landing bays were jacked up on to their final fixed piers, a 4-ft. lift on the west bank and no less than 8½ ft. on the east, accomplished at the rate of 1 ft. per hour. All floating bays were completed and a few were rafted into bridge. The western approach span was put in and on the east bank 400 ft. of D-S and 90 ft. of T-S was built and launched, undecked, as a continuous span, for the eastern approach. This was done by one platoon and a winch lorry.

Next day the east approach spans were divided up, fitted with end posts, jacked down and partly decked. On the west the temporary approach road was being made, while early in the day—by 1140 hrs.—the rest of the rafts were brought into bridge and connected up. This last was a remarkable operation, performed almost entirely by a Mark II tug with a crew of two, the skipper being one L/Sgt. Price who in peace-time had been skipper of a tug on the Thames. The rafts had been built upstream. Picking each up in tow behind her the tug would move out into the stream and then turn at full speed downstream towards the gap, going, with the current, 9 knots over the ground. Just short of the bridge, the tug would turn at full helm, the raft spinning behind her to come to a full stop exactly alongside the next floating bay and to be pinned in instantly by the waiting party. Within a second or two the tow rope would be cast off and the tug would dash off upstream for another load. The whole performance was a perfect exhibition of seamanlike judgment: Sergt. Price has, I believe, returned to the Thames, and no doubt is handling big ships with equal skill.

It should be mentioned that while the rafts were being brought into bridge another party was laying out the pontoon anchors. Wearing surface started to go down this day.

On 2nd April the finishing touches were put to the bridge with its temporary approaches. Steel bow protectors and false bows were fitted to all pontoons and hatch covers added to the Mark VI type. The temporary approach roads were completed, but on the west side the immediate approach to the bridge would form the final roadway, so finishing was done in *ciment fondu* concrete. The whole job was complete by 1800 hrs. but opening was withheld till the next day to allow the concrete to harden.

On Tuesday, 3rd April, at 1000 hrs. the bridge, named Sparrow Bridge, was opened for traffic. It was, as completed with temporary approaches, 1,713 ft. long excluding ramps, and weighed over 700 tons. The bridge had been completed in 6 days 3 hours from time of arrival of first lorry, and opened for traffic 8 days 21 hours after first recce. (See Photos No. 6 and 7.)

Although the bridge was taking traffic, the extensions were still to be done and heavy anchors laid out. The full anchoring scheme was completed by 7th April by a small party, and on the same day at 0800 hours the new western approaches, including 289 ft. of Bailey across the field already mentioned, were opened to traffic. The eastern concrete road, 14 ft. wide,

Photo 5.—Fulmar Bridge—booming out.

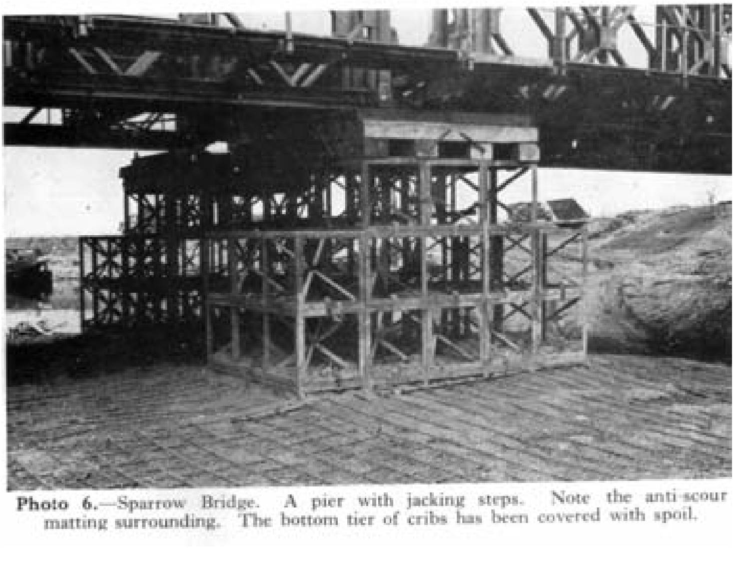


Photo 6.—Sparrow Bridge. A pier with jacking steps. Note the anti-scour matting surrounding. The bottom tier of cribs has been covered with spoil.

Photo 7.—Sparrow Bridge, River Rhine, Xanten. View from west bank, downstream side.

Photo 8.—Bristol Bridge. Wooden stability framework on the small barges.

took longer, again with a small party, but these two were opened for traffic at 0020 hrs. on 17th April. The bridge, as finished, consisted of 2,085 ft. of Bailey in two portions, 289 ft. and 1,796 ft. and concrete approaches totalling 654 ft., a grand total of over half a mile.

The anchoring scheme was on the lines of that used for Fulmar Bridge, but as the low water gap was over 1,000 ft. the quantity of stores was much greater. No less than fifty-seven pontoon anchors, forty heavy anchors and four shore lines were used.

In service the bridge took a great volume of traffic. It was used entirely for up traffic. Up to 1200 hrs. on 17th April, a fortnight and two hours after opening, it had taken 41,467 vehicles (excluding motor cycles), including 880 loads of Class 30 and over: the heaviest traffic for one hour actually recorded was 371 vehicles, and the heaviest for any one day, 4,343. Speed of traffic was undoubtedly assisted by good approaches, and it is thought that the eastern concrete approach must have paid a dividend later, though we were not there to see its continued use. The sliding bay, with its double storey construction, was inclined to slow heavy loads such as transporters carrying dozers, whose blades were apt to catch in the upper panels, but these were comparatively few and far between. The graded wearing surface on this bay to overcome the "hump" of the slide worked perfectly (a lesson we had learned from Ilex Bridge) and could be taken at really high speed without inconvenience.

We really learned no new lessons from this bridge but found the value of earlier lessons learned on previous tasks.

Bristol Bridge, River Weser, Bremen

Instead of going to the Elbe for the crossing with 8 Corps as we had expected, the formation came under 30 Corps who were advancing on Bremen. While undertaking various tasks in the Corps area we were given the future task of building a Class 40 bridge across the river in Bremen as soon as the city should be captured.

On 25th April a field engineer from the formation was sent to join one of the assaulting brigades to report on the state of the existing bridges, which were known, by air photos, to have been destroyed, and on the morning of 25th April the C.R.E. accompanied C.E. 30 Corps in an attempt to see the possible sites: the only result was to get rather mixed up with the battle, but by noon the city was mainly in our hands and a second recce was carried out in the afternoon by the C.R.E, this time in company with C.R.E. 30 Corps Tps. By now our task had become the building of a barge bridge while 30 Corps Tps. were to build a normal Bailey pontoon bridge. The result of this recce was to find a good site which would do for either bridge, rather above the city centre, and a difficult site in the city centre, suitable only for the barge bridge.

Detailed design was worked out, but meanwhile the plan was changed. The ordinary B.P.B. was not to be built, but a barge bridge—using half-prepared German barges on the site—was to be built at the good upstream site by 3 Inf. Div., R.E.

On 28th April, 3 Div. R.E., were on the site and had started preparation of barges, building bankseats, and measuring the gap, when at 1300 hrs. the division was ordered to join another corps and the task of the bridge was given to 15 (Kent) G.H.Q. Tps. The C.R.E. was on the site at 1400 hrs. while the companies moved in to Bremen. 3 Div. handed over and left the site at 1700 hrs. and 584 Fd. Coy.—the first of the formation to move into Bremen—continued with the off-loading of lorries and preparation of barges.

The site was a good one. On the south-west bank a gravel road about 18 ft.

wide ran to the water's edge, some 5 ft. above normal high water, while on the far (north-east) bank another gravel road bore left from the bank seat, rising by a gentle grade to the level of the main street into which it joined. An alternative straight run off on a steep grade was available for tanks. It was clear that the Germans had prepared this site for an emergency barge bridge.

As to barges, there were four on site—two large ones about 130 ft. long by nearly 30 ft. beam and two smaller ones 108 ft. × 19 ft. The larger barges were estimated to have a displacement of 250 tons and a useful buoyancy to 2 ft. freeboard of 385 tons. For the smaller barges, displacement was 112 tons and useful buoyancy 158 tons. One of the large barges was already nearly decked over but the other was unprepared. Both the smaller barges were practically ready to take a crib pier amidships. To save time we decided to design the bridge on a three-barge basis and dispense with the large unprepared one.

The normal tidal variation here was about 12 ft. so the bridge was designed so as to have landing bays level at half tide. This would allow of greater latitude in water level and easier gradients under normal conditions. The gap was about 450 ft. between bankseats, so design allowed for a 130-ft. D-D landing bay on S.W. side, two 100-ft. T-S intermediate bays and a 120-ft. D-D landing bay to N.E. bank. In order to use the barges in the order they already lay (they were moored to the N.E. bank) we decided to use the small barges for the shoremost piers and the prepared big barge for the middle one. Two piers of Christchurch cribs, 4 ft. high, capped with timber, would bring the level of the small barges up to that of the big one.

The design was unconventional but simple. On the pier cappings of the small barges and on the deck of the large one were to be placed junction link bearings to which were fixed junction links and the span junction posts taking the ends of the spans. The big barge would be stable under these conditions but not the small barges, so a timber framework was built up on the latter which would bear against the bottom chords of the spans if the barge lay over at all. The barges in fact lay over to a slight list as soon as the load was put on, and the timber framework came into play and remained pressed up against the bottom chords of the landing bays at all states of the tide. The overturning moment was very small and the timber not unduly stressed. (See Photo No. 8.)

On 29th April all companies came on the site at 0800 hrs., about twenty-five bridging lorries were off-loaded, bankseats were completed, as was the preparation of the barges, and some of the spans were partly built.

On 30th April launching began: our method was dictated by the site and the position of the barges. The S.W. bank landing bay was straightfoward, but the centre spans the special difficulty. We therefore got all stores for the centre spans on to the large barge in the middle and boomed out on to the offshore small barge to which the span junction posts, links and bearings were attached. Keeping rollers on the centre barge we boomed out both centre spans together with centre span junction posts pinned top and bottom until there was 170 ft. of T-S construction—undecked—spanning the gap between the barges—giving a startling sag. Then the last 30 ft. was built on at the tail, back to the inshore barge and pinned down to it. The next stage was, keeping the two outer barges stationery, to boom the big barge sideways across the river (with the rocking rollers on deck keeping under the bottom chords) until it was in the correct position, a job done partly by shore lines and partly by two small bridging tugs pushing. The rollers on the centre barge were then jacked out, launching links and top pins removed from centre span junction posts and the whole jacked down on to links and link bearings.

After this the N.E. landing bay was boomed out to join with the inshore barge, and having a tail, was over-boomed to allow the S.W. landing bay to be launched on to the barge nearest it, before booming back to remove the tail.

There were many stoppages in the construction of this bridge, not owing to snags in construction, but to the fact that stores for the N.E. bank—i.e., the bulk of the lorries—had been routed over a bridge ten miles further upstream where there was great traffice congestion: thus we had insufficient stores on site to complete the landing bays until 0800 hrs. on 1st May, and a further wait was then imposed by the tide from 1200 to 1600 hrs. as it was impossible to launch at all states of the tide without complete redesign of roller set-up.

However the bridge was across and all connected by 1730 hrs. on 1st May and the tail had been removed and all jacked down and decked before 2330 hrs. During the night the double storey for the S.W. landing bay was completed, ramps—consisting of 5 ft. of sliding stringer bay—were put in at each end and wearing surface was completed. The bridge was opened for traffic at 0400 hrs. on 2nd May, four hours before our original E.T.C., but all foot-walks had not been completed nor final anchoring done before 1230 hrs. on the same day.

Anchors totalled six, all heavy type, with four shore lines in addition. The winches and bollards on the barges were useful in this scheme. Current was sluggish, 1½ knots in the ebb and ¾ knot in the flood.

The bridge took plenty of traffic, including many civilian vehicles when the local population came to life. The Americans took over the area and with it the maintenance of the bridge. On many occasions they put Class 70 loads (Shermans on transporters) over this 456-ft. Class 40 bridge, and did not seem to damage it. The design was strongly criticised by higher technical authority in view of the alleged instability of the barges—a criticism which the designer tried to refute in rather acrimonious correspondence; his best justification is that the bridge remained in service until November or December, 1945, when it was removed on the score of redundancy having given no trouble throughout its life, in spite of having been grossly overloaded on frequent occasions.

If we learned any lessons from this bridge we were not particularly interested, for the war in Europe ended six days after its completion.

Conclusion

In any other war, for one engineer formation to build seven bridges with an average length of 1,077 ft. in an eleven-months campaign would have been staggering. In this war it was almost commonplace. For example 7 Army Tps. built the first tactical Class 40 British Baileys over the Seine, Rhine and Elbe, as well as the Gennep Bridge (the longest operational bridge ever built), the 1,000-ft. Well Bridge and the Class 70 Bailey at Venlo. 6 Army Tps. bridged the Seine, the Maas (three times) and Rhine; 8 G.H.Q. Tps., 8, 12 and 30 Corps Tps. and some of the R.C.E. formations all have 1,000-ft. bridges to their credit and many others nearly as long. It would be interesting, before memories fail, if some of these would place their stories of big bridges on record, and if this crude account will stimulate them to do so it will have been worth while.

Our task, difficult no doubt at another time and place, was made simple by the time available for training before the campaign, the ready availability of equipment, the first class work done by R.A.S.C. bridge and other companies, the amazing versatility of the Bailey bridge, and last but not least by the cheerful hard work put in by the Sappers and N.C.Os. of the formation.

TABLE I. GENERAL

Bridge	River	Place	Water level range for which de-signed	Worst gradient in bridge in worst condition	Wet gap for designed water level range	Total Length		Weight including piers, pontoons, anchors and founds. Excluding approaches and spares
						Excl. ramps	Incl. ramps	
			ft. in.		ft.	ft.	ft.	tons
Saul ..	Seine	Vernon	6 10	1 in 10·0	650–710	736	766	268
Kent .. (as opened)	Maas	Berg	12 8	1 in 9·2	390–600 (oblique)	626	636	251
Kent .. (as extended)	Maas	Berg	13 11	1 in 9·2	390–680 (oblique)	688	708	281
Quebec	Maas	Ravenstein	20 0	1 in 9·2	440–1,290	1,210	1,240	526
Ilex ..	Maas	Mook	25 9	1 in 7·9	370–1,150	1,095	1,095	490
Fulmar	Maas	Venlo	26 10	1 in 8·6	320–980	1,243	1,273	480
Sparrow (as opened)	Rhine	Xanten	16 9	1 in 10·0	1,030–1,670	1,713	1,743	760
Sparrow (as extended)	Rhine	Xanten	20 0	1 in 10·0	1,030–1,810	2,085	2,085	880
Bristol ..	Weser	Bremen	12 0	1 in 16·7	360–450	456	466	630 (177 tons plus barges)

PARTICULARS OF BRIDGES

Detail of Spans			Lorry loads for construction (including 33 per cent spare pontoons, 10 per cent spare panels and cribs excluding concreting materials)
Home Bank Approaches	Floating Portion	Far Bank Approaches	
ft. One 10 ramp	ft. in. Two 110 6 T-S landing bays Two 31 6 S-S end floating bays Ten 42 0 S-S floating bays One 32 0 S-S floating bay Total 736 0	ft. One 20 ramp	108
One 10 ramp One 40 D-S Total 42 excluding ramp	One 110 6 T-S landing bay One 41 6 S-S end floating bay Two 42 0 S-S floating bays One 31 6 S-S end floating bay One 60 6 D-S offshore landing bay One 111 0 T-S inshore landing bay Total 441 0	One 111 T-S One 30 S-S Total 143	96
One 50 D-S Total 52	As above Total 441 0	One 111 T-S One 30 D-S One 50 D-S One 20 ramp Total 195 excluding ramps	108
One 30 D-S One 70 D-S One 90 D-S Total 198	Two 111 0 T-S inshore landing bays Two 91 6 T-S offshore landing bays Two 31 6 S-S end floating bays Two 42 0 S-S floating bays One 44 0 D-D sliding bay Total 596 0	Five 80 D-S One 30 D-S Total 446	213
One 60 D-S Three 70 D-S Total 284	Two 111 0 T-S inshore landing bays Two 91 6 T-S offshore landing bays Two 31 6 S-S end floating bays One 42 0 D-D sliding bay Total 510 0	One 71 D-S Two 72 D-S One 81 D-S Total 301	191
One 10 ramp Four 81 D-S Total 330 excluding ramp	Two 111 0 T-S inshore landing bays Two 82 0 D-S intermediate bays (T-S end) One 82 0 D-S Intermediate Bay Total 468 0	Two 81 D-S One 52 D-S One 100 S-S causeway One 40 S-S causeway One 80 D-S One 20 ramp Total 445 excluding ramp	202
One 60 D-S Total 63	Two 111 0 T-S inshore landing bays Two 92 0 T-S intermediate landing bays Two 91 6 T-S offshore landing bays Two 31 6 S-S end floating bays Fourteen 32 0 S-S floating bays One 42 0 D-D Sliding bay Total 1,142 6	Five 80 D-S One 90 T-S One 30 ramp Total 508 excluding ramp	331
Two 80 D-S Two 60 D-S Total 289 approach bridge One 60 D-S Grand total 352	As above	Six 80 D-S One 90 T-S Total 591	368
One 5 sliding stringer ramp	One 131 0 D-D landing bay (T-S end) One 121 0 D-D landing bay (T-S end) Two 102 0 T-S intermediate bays Total 456 0	One 5 sliding stringer ramp	67

TABLE II. DETAILS OF TIME AND LABOUR

Bridge	Length ft.	Weight tons	Time from 1st recce to: 1st working parties on site days hrs.	Arrival of 1st bridging lorry days hrs.	Completion of bridge days hrs.	Bridge open to traffic days hrs.	Time from arrival of 1st bridging lorry to: Completion of bridge days hrs.	Bridge open to traffic days hrs.	Man-hours excluding approaches and bellmouths	Man-hours-ton	Average man-hours-day
Saul	736	268	1 22	1 23	3 2	3 2	1 3	1 3	4,625	17·3	4,109
Kent (as opened) ..	626	251	0 14½	0 14½	4 22	4 22	4 7½	4 7½	9,170	36·5	2,128
Quebec	1,240	526	1 22	1 22	11 5	15 5	9 7	13 7	17,046	32·4	1,835
Ilex	1,095	490	7 22	10 22	32 7	32 7	21 9	21 9	12,857	26·2	568
Fulmar	1,213	480	Nil	0 5	4 7	4 8½	4 2	4 3½	12,207	25·4	2,815
Sparrow (as opened) ..	1,713	760	1 23	2 3	8 6	8 22	6 3	6 19	17,928	23·6	2,850
Sparrow (as extended)	2,085	880	1 23	2 3	22 12½	22 12½	20 9½	20 9½	10,150	10·2*	86*
Bristol	456	650 (including barges) 177 (excluding barges)	2 0**	1 19	5 11	5 11	3 16	3 16	7,705	11·8 (including barges) 43·5 (excluding barges	2,227

* For the extensions only.
** 3 Div. R.E. on site 5 hours earlier for offloading.

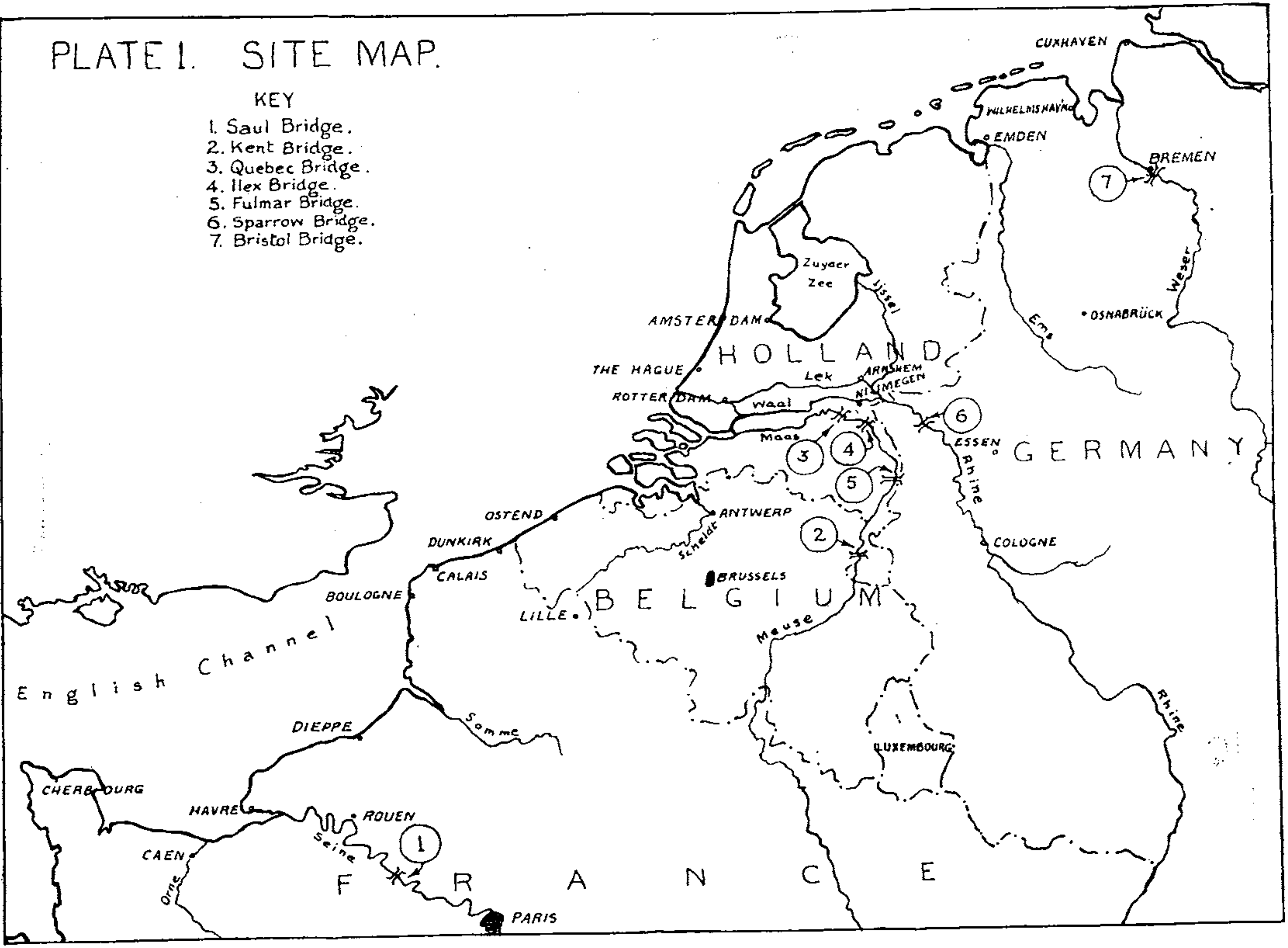
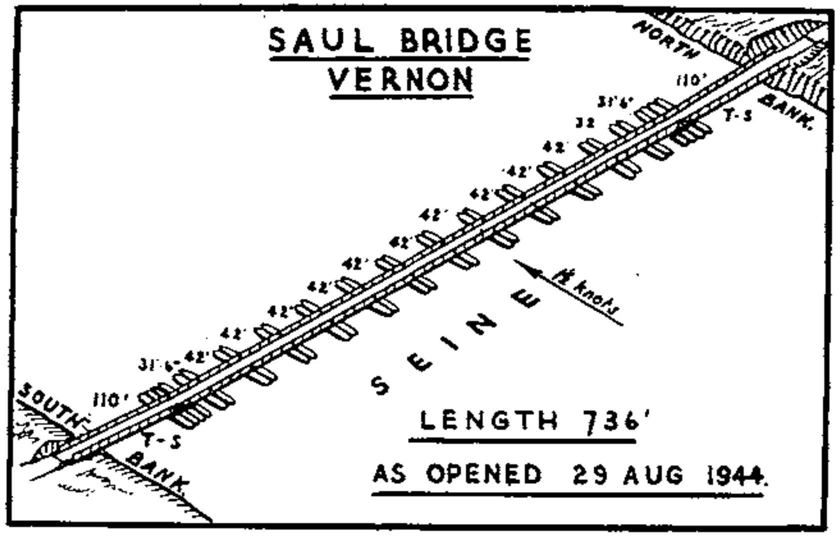
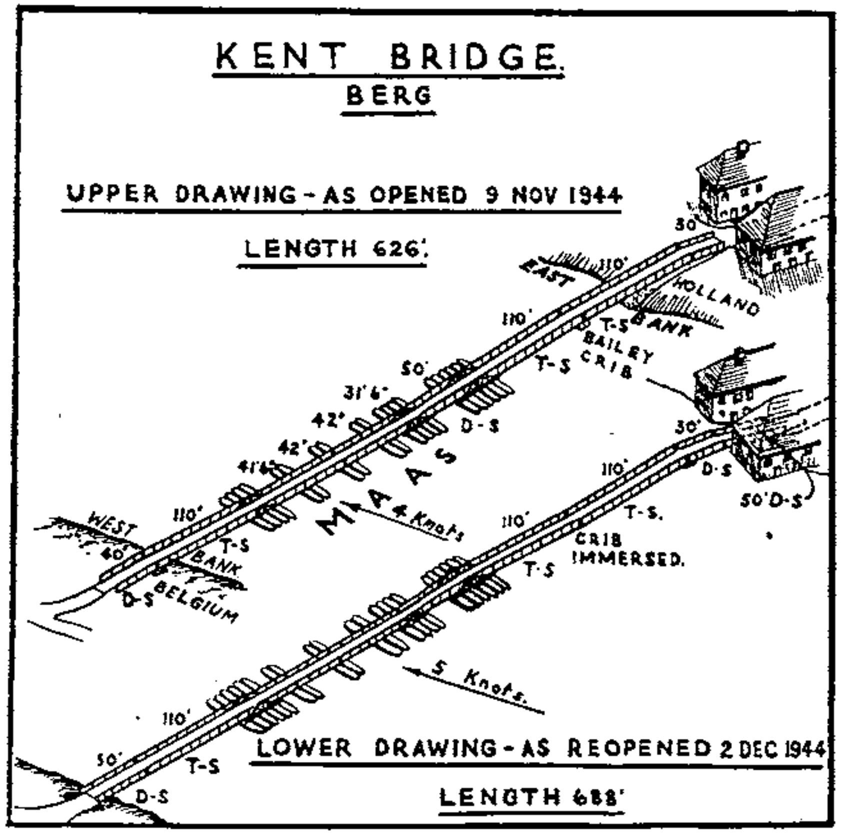


PLATE I. SITE MAP.
KEY
1. Saul Bridge.
2. Kent Bridge.
3. Quebec Bridge.
4. Ilex Bridge.
5. Fulmar Bridge.
6. Sparrow Bridge.
7. Bristol Bridge.
CUXHAVEN
WILHELMSHAVN
EMDEN
BREMEN
Zuyder Zee
Ijssel
Weser
Ems
OSNABRÜCK
AMSTERDAM
HOLLAND
THE HAGUE
Lek
ARNHEM
NIJMEGEN
ROTTERDAM
Waal
Maas
ESSEN
GERMANY
Rhine
OSTEND
ANTWERP
DUNKIRK
Scheldt
COLOGNE
CALAIS
BRUSSELS
BOULOGNE
BELGIUM
LILLE
Meuse
English Channel
LUXEMBOURG
DIEPPE
Somme
CHERBOURG
HAVRE
ROUEN
Seine
CAEN
Orne
FRANCE
PARIS


SAUL BRIDGE
VERNON
LENGTH 736'
AS OPENED 29 AUG 1944.
SEINE
1½ knots
NORTH BANK
SOUTH BANK
T-S
110'
31'6"
42'
32


KENT BRIDGE.
BERG
UPPER DRAWING - AS OPENED 9 NOV 1944
LENGTH 626'.
LOWER DRAWING - AS REOPENED 2 DEC 1944
LENGTH 688'
MAAS
4 Knots
5 Knots.
EAST BANK
WEST BANK
HOLLAND
BELGIUM
BAILEY CRIB
CRIB IMMERSED.
T-S
D-S
110'
50'
31'6"
42'
41'6"
40'
30'
50' D-S

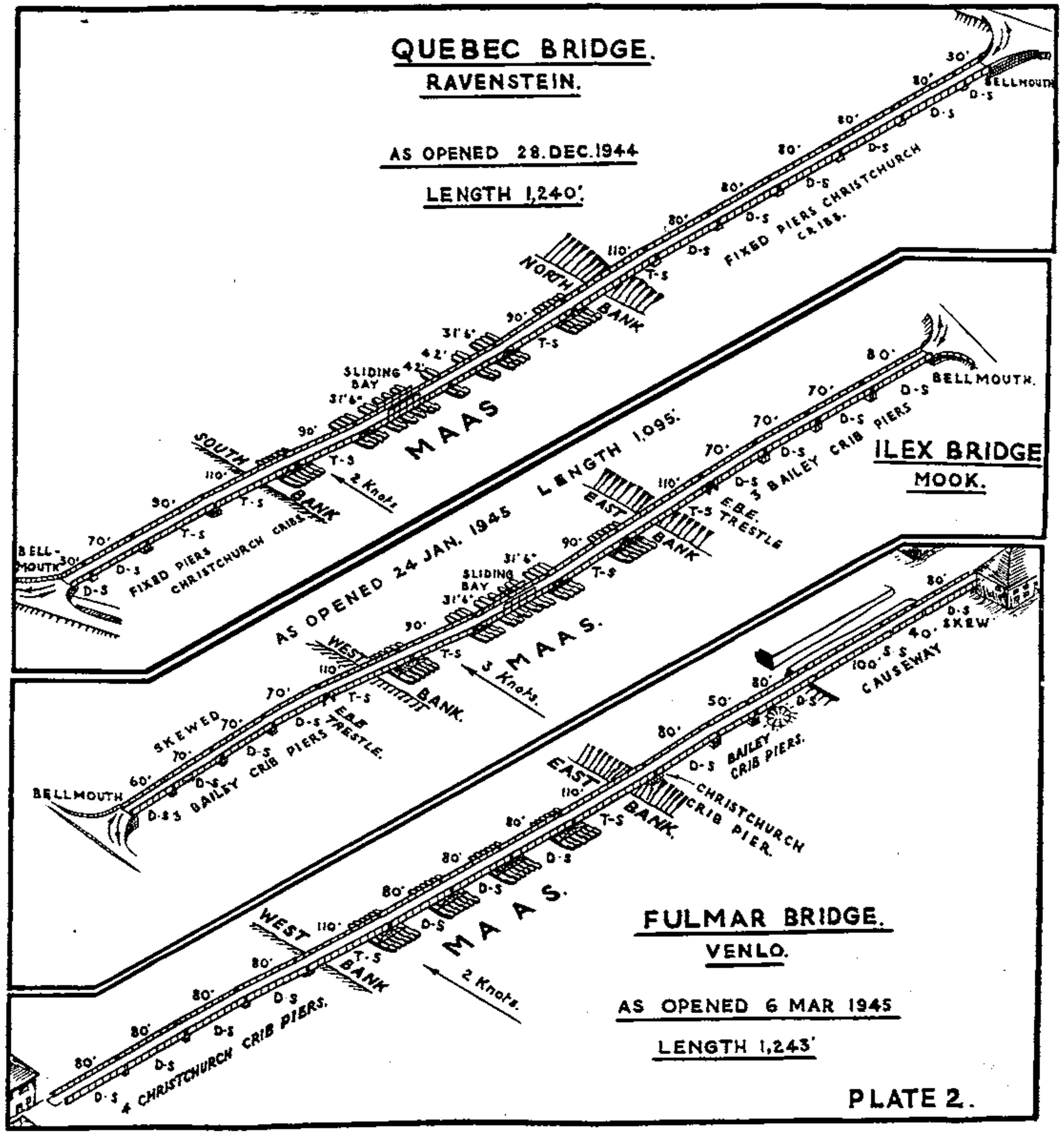

QUEBEC BRIDGE.
RAVENSTEIN.
AS OPENED 28.DEC.1944
LENGTH 1,240'.
MAAS
2 Knots
NORTH BANK
SOUTH BANK
SLIDING BAY
BELLMOUTH
BELL-MOUTH
FIXED PIERS CHRISTCHURCH CRIBS.
ILEX BRIDGE
MOOK.
AS OPENED 24 JAN. 1945 LENGTH 1,095'.
MAAS.
3 Knots.
EAST BANK
WEST BANK
SLIDING BAY
BELLMOUTH.
SKEWED
E.B.E. TRESTLE
3 BAILEY CRIB PIERS
BAILEY CRIB PIERS
FULMAR BRIDGE.
VENLO.
AS OPENED 6 MAR 1945
LENGTH 1,243'
MAAS.
2 Knots.
EAST BANK
WEST BANK
CHRISTCHURCH CRIB PIER.
BAILEY CRIB PIERS.
CHRISTCHURCH CRIB PIERS.
CAUSEWAY
SKEW
T-S
D-S
110'
100'
90'
80'
70'
60'
50'
40'
30'
31'6"
42'

PLATE 2.

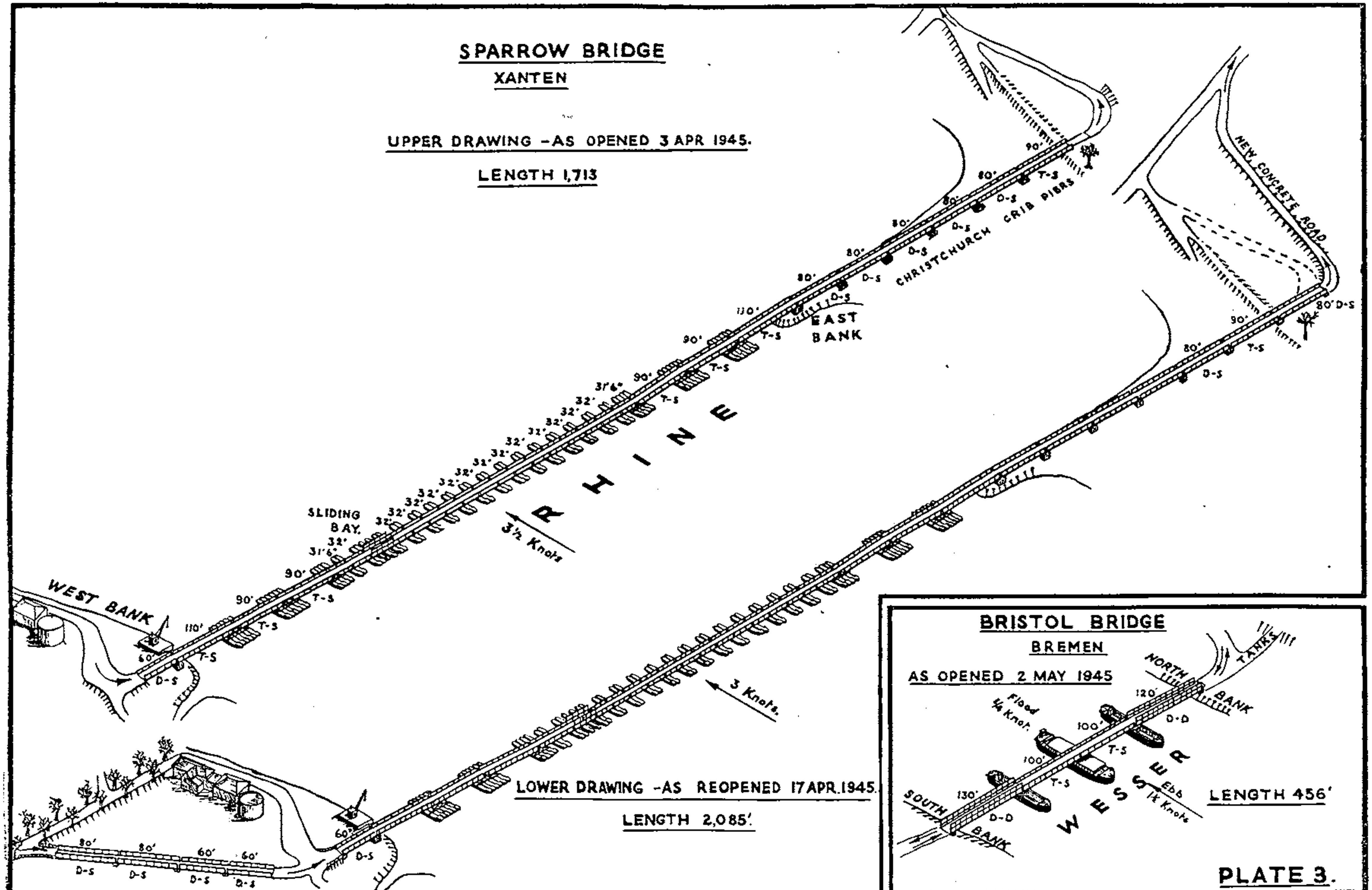

SPARROW BRIDGE
XANTEN
UPPER DRAWING - AS OPENED 3 APR 1945.
LENGTH 1,713
LOWER DRAWING - AS REOPENED 17 APR. 1945.
LENGTH 2,085'
RHINE
3½ Knots
3 Knots.
WEST BANK
EAST BANK
SLIDING BAY.
CHRISTCHURCH CRIB PIERS
NEW CONCRETE ROAD
BRISTOL BRIDGE
BREMEN
AS OPENED 2 MAY 1945
LENGTH 456'
WESER
NORTH BANK
SOUTH BANK
TANKS
Flood ¼ Knot.
Ebb 1½ Knots

PLATE 3.

THE USE OF BAILEY BRIDGE GIRDERS IN OPEN EXCAVATION AT BUCKINGHAM PALACE

By R. P. Haines, A.M.I.C.E., A.M.I.Struct.E.
(E.-in-C's. Dept., War Office)

AN unusual adaptation of the Bailey Bridge equipment was employed in the excavation operation carried out by the Ministry of Works at Buckingham Palace.

The sheet piling to be used in this excavation was the largest section available, but was considered insufficiently strong to retain the soil by cantilever action, and some means of holding the pile caps horizontally was deemed imperative. Orthodox methods of strutting from within the rectangular-shaped excavation were not favoured on account of the considerable quantities of timber involved and the difficult supply position. Additionally the employment of this method would have provided obstruction to the free removal of the soil.

A " ring " girder consisting of four mutually supported girders laid horizontally, one to each side, round the outer lip of the excavation was thought to provide the best answer and Bailey Bridge trusses appeared to be eminently suitable for this purpose.

Prediction of the amount of relief to be afforded the pile caps could not be determined with any certainty, but an arrangement of four girders of double-single construction, each taking their end support from the ends of the adjacent girders through connecting posts, was thought to be adequate. The use of the connecting posts at the corner junctions allowed free rotation at these points to accommodate changes of slope due to the deflection of the girders when under load.

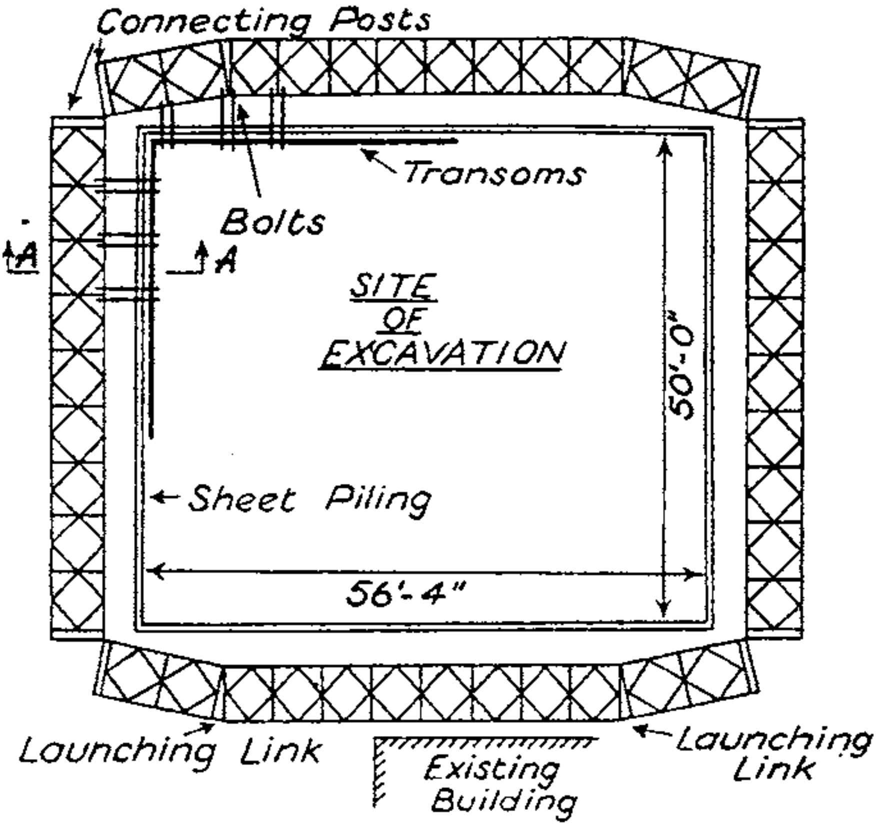
The use of straight girders on the longer side of the excavation would have left little clearance from the pile caps and no allowance for irregularity in their alignment. Launching links were therefore introduced into the top boom, and these served to strengthen the girders by inducing a large reverse bending moment from the supported reactions of the short girders, in addition to providing the extra clearance required.

The pile caps were connected to the girders by long bolts, which were fixed to short lengths of angle iron housed in the normal transom seatings of the panels and threaded through the piling and connected to walings of B.B. transoms running along the inner face of the piles.

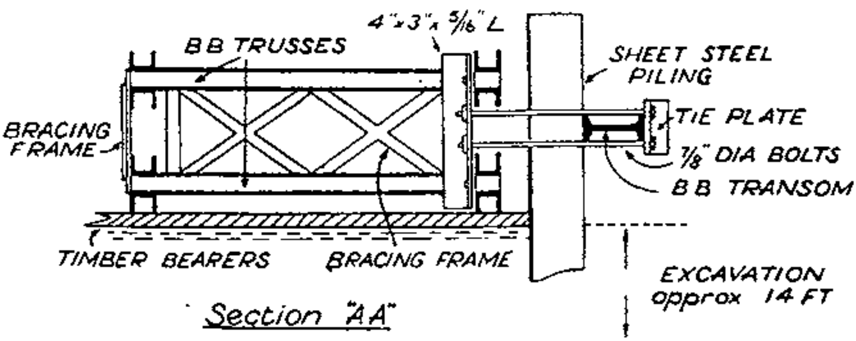
In the operation the piles were first driven, and then a temporary timber stage was laid level and horizontal on the earth round the outside of the piles. The girders were then erected on the stage and the load applied to them by tightening the bolts of opposing girders until a predetermined deflection was registered. The excavation of the soil was then commenced.

The photograph shows the clean appearance of the finished excavation.

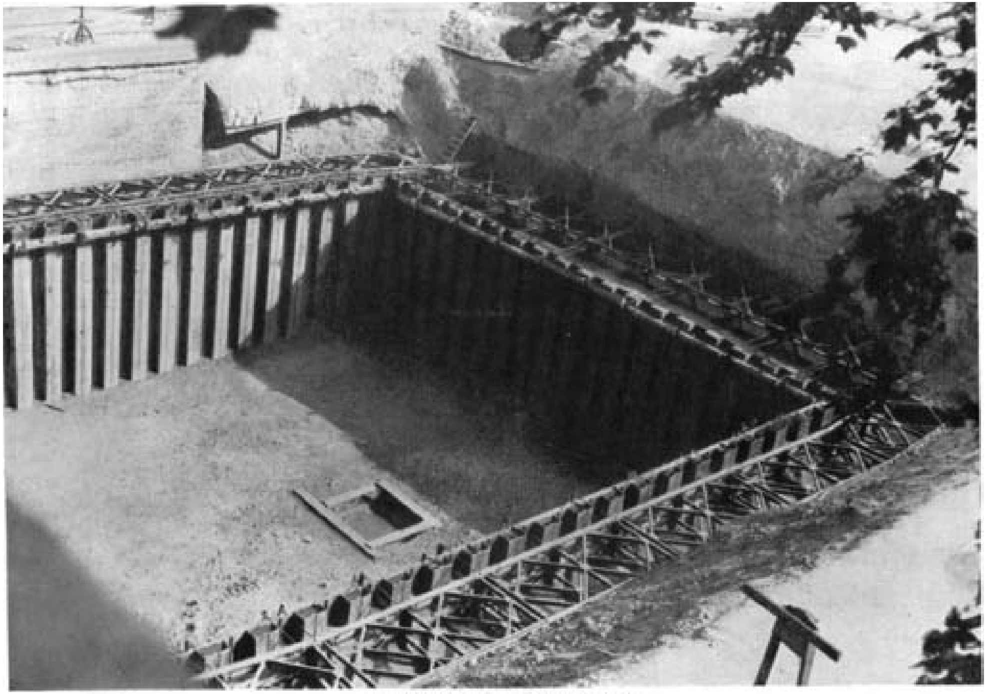
The method proved markedly superior to the more orthodox shoring and strutting on this particular job, both in economy of material and in the time spent in erection. In addition, the unobstructed site was invaluable in allowing speedy and uninterrupted removal of the soil in the actual excavation operation.



PLAN



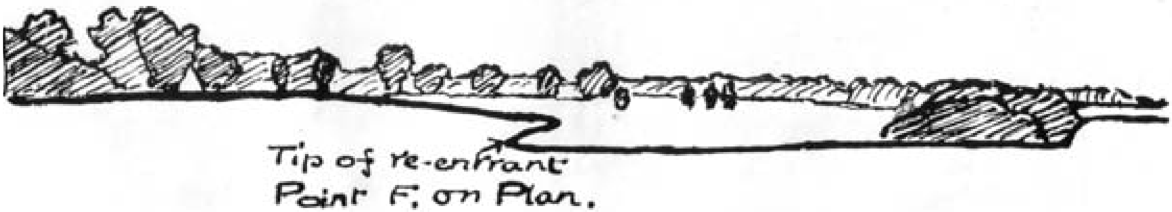
Section "AA"



Bailey bridge panels in excavation.

Bailey Bridge Girders at buckingham palace

Castillon Re-entrant.



The French Camp At Castillon

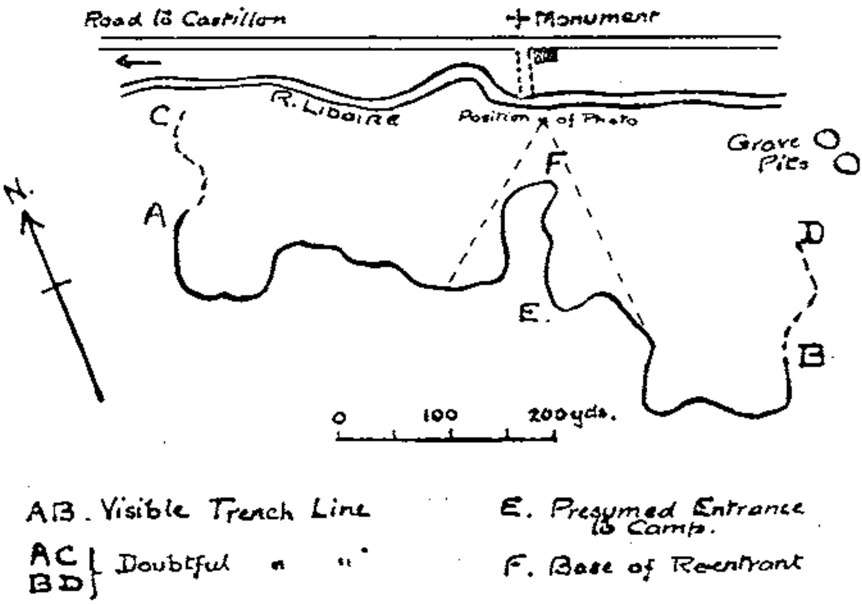
THE FRENCH CAMP AT CASTILLON

By Lieut.-Col. A. H. Burne, D.S.O., late R.A.

On 17th July, 1453, was fought a battle that, historians are agreed, marked one of the turning points in our history. Had John Talbot, Earl of Shrewsbury, won the battle of Castillon, history might have been changed. The Gascons, on whose behalf we were fighting, were devoted to the English crown, and there seemed every probability that the connexion between the two countries would continue indefinitely. It is therefore a matter of some interest, historical and military, to discover the cause of this disastrous defeat. I recently paid a visit to the scene of the battle and came away with one problem unsolved. In the hopes that a Sapper may be found to throw some light on it I have written this article. The battle is indeed one of peculiar interest to Gunners and Sappers alike.

* * * * *

The "brain" of the French Army was one Jean Bureau (who incidentally had opened his military career serving with the English artillery). It was he who had so improved the French artillery that the English castles in Normandy had fallen to his guns like so many ninepins. His normal procedure was, not to open lines of circumvallation straight away, but first to construct an entrenched camp out of range of the town's guns, into which the besiegers could withdraw if a relieving army should approach. This procedure he adopted at Castillon. One mile to the east of the town is a strip of flat meadow-land, 600 yds. wide, bounded on the south by the River Dordogne, 100 yds. wide, and on the north by the River Lidoire, a mere trickle in July, but running beneath steep banks 10 ft. high. Bureau constructed his camp with the River Lidoire as its northern boundary, with a width of about 200 yds.



In the sixteenth century the trace of this camp was distinctly visible, and in 1862 a local archaeologist, M. Drouyn, found that it was still possible to map it, and he did so with the aid of two engineer friends. The resulting plan he included in his immense compilation *La Guyenne Militaire.* (There is a copy in the British Museum.) Noticing that it was drawn to a very large scale, and not put out by his conjecture that the trenches would have completely disappeared in twenty-five years time, I made a copy of the plan and took it out with me on a recent visit. By pacing carefully from the river bank I was able to reach the spot where the trench should first appear. With suppressed excitement I approached this spot, when, to my great delight, I saw not only that the trench line was perceptible but that it had been used as a field boundary, and as the hay had just been cut on the near, but not on the far side, the trench stood out plain to behold. Plan in hand I was able to trace it out almost the whole length as shown on the plan. I sat down and said "Eureka!"

If the reader will now turn to my copy of this plan he will see what a peculiar trace it has. But before examining it in detail we must have a little more history.

Bureau employed 700 pioneers on the task, from 13th July to the 16th July, 1453, working day and night. A rhymed chronicle of the time* relates :—

Car avoit sept cens manouvriers,
Qui faisoient fosses par compas,

which seems to indicate that Bureau traced out the work with great care and precision. Moreover, praise has since been lavished on him for his skill in this work. Certainly it proved effective. Portions of the trench were strengthened with tree-trunks and palisades, and the whole was lined with a force of about 300 cannons. It was the point-blank fire of these cannons that repelled the first attack. After that the fighting seems to have taken place principally on the parapet and in the ditch. No appreciable penetration was made by the English troops.

* * * * *

And now at last I come to my problem. *What is the explanation of the extraordinary shape of the camp?* Was it purposeful design on the part of Bureau or was it merely fortuitous—each sector working according to its own ideas? In particular, what is the explanation of the central part marked EF? M. Drouyn suggests that E marks the entrance to the camp on the south side (a northern entrance being provided by a bridge over the Lidoire). If this be correct, one would expect to find the base of the re-entrant (F) levelled to allow of vehicles passing. But there is no indication of such levelling ; on the contrary the ditch is better defined here than elsewhere, and from its peculiar shape at this point it could not possibly be a modern field ditch. The answer may be that there was a bridge at F.

The very indented nature of the trace may of course be accounted for by (*a*) the necessity of providing room for such a large number of guns (I calculate there was one gun per 5 yds.), and (*b*) the desirability of providing cross fire for them. But on these points I crave the expert opinion of a Sapper. Is the trace exceptional, or was it normal for the period? What form did Bureau's camps take in Normandy? Was there a barrier or gateway at E? M. Drouyn suggests that there was.

I should add that the ditch at present varies in depth between 1 and 2½ ft. ; there is no sign of a parapet ; and there is, of course, no indication as to the original width of the ditch. In Drouyn's time the ditch was up to 3 ft. deep.

* *Les Vigilles de Charles VII*, by Martial D'Auvergne, written about twenty years after the battle, and not necessarily correct.

ADVERTISING THE CORPS

By " CHILIARCH "

MY desire to keep my identity secret is not dictated by any lack of faith in what I have written. My object is to promote fair and unbiased thought and discussion, unclouded by any personal feelings the reader may have about the writer. I have so often heard people say " Oh, I seldom read anything so-and-so writes, and I always take it with a grain of salt. He so obviously has a personal axe to grind." A man is not necessarily wrong because his thoughts are based on his personal experiences, even when he is being critical of others, but if the writer remains anonymous it is easier to read what he has to say with an unbiased mind.

In 1945, shortly after the close of hostilities in Europe, a very distinguished and successful Commander said to me " I can never over-estimate the debt I owe to the Sappers, who never once failed me. The trouble about you people is that you don't advertise yourselves enough."

Three years later I met this same Commander again and, without any prompting, he made precisely the same remark to me again.

Now when a very senior, distinguished, and successful Commander, who avows himself to be a great admirer of the Sappers, makes an unsolicited remark such as this on two occasions separated by three years, I think it is safe to come to two conclusions—firstly, that he was right in 1945, and secondly, that nothing whatever has been done to correct the fault.

My reply to the criticism was that, so far as Regimental Sappers, officers or men, were concerned, the first part of his remark was positive proof that the criticism could not fairly be levelled at them. I cannot think of a better advertisement for the Corps than to have it said of its individual members and units that a responsible Commander owed them a debt he could never over-estimate.

So it seems to me that the real meaning of the criticism is that the Corps has signally failed to derive any benefit from the wonderful advertisement written for it, throughout the late war, by its Regimental officers, men and units.

I have spent three years thinking over the criticism, and if it has the meaning which I have suggested I am convinced that it is a fair one.

If the statement itself is accepted as being true in substance, it is then necessary to decide whether its truth has any material significance for the Corps. Here, of course, I have the advantage that I know the Commander who made it. Among his many and great qualities is the very relevant one that he does not make purposeless remarks. Even if, by a process of independent observation and thought, I did not thoroughly agree with him, the fact that he made the remark would be sufficient to convince me that the Corps was being inactive in some way which was operating to its disadvantage.

What is the purpose of legitimate advertisement, with the accent on the word legitimate?

The purpose, surely, is the mutual benefit of the community and the advertiser. If the makers of the Rolls Royce car were to announce that, as a result of their conviction that they produced the highest quality car in the world, they were reducing the price rather than that anyone should be without one, no one would believe them. It would be very generally agreed that the quality of the car must have deteriorated. Conversely, if the same firm were to announce that, rather than reduce the quality, they found themselves compelled to increase the price, very few people would question or take offence at the statement.

As I interpret the criticism of the Corps, therefore, it means that we are either accepting less from the community than is reasonable for the quality of service we render, well knowing that we cannot afford to do so, or that we are not asking for more in respect of the same quality of service given in increasingly difficult circumstances, or even that we are voicing our requirement but failing to produce the abundant available evidence that it has been well and truly earned and that it is vital to the maintenance of the quality of our service.

I do not think it is necessary to consider the second alternative. There seems to me to be ample evidence that the Corps is suffering from the effects of the first alternative and that if the reason is not that given in the first alternative it is certainly that quoted in the third. Moreover my own observations suggest that the process has been going on for some time, and that the position in which the Corps finds itself today is the result of a cumulative lack of profitable and essential advertisement. This seems to have bred and fostered an idea that, after all, even the Corps does not rate the achievements of its Regimental soldiers very highly and that, after the manner of irresponsible schoolboys, we know we have been enjoying a status in the past which would be certain to disappear as soon as we were "found out." Possibly the Corps felt that its own well-being was of secondary importance to that of the Army as a whole. Possibly, before this last war, the Corps was not prepared to argue in support of its beliefs in a changing world where the substantiation of those beliefs was the achievements of the past and forecasts of the problems of the future. But the war of 1939–45, as seen and experienced by every soldier in the field, not only vindicated those beliefs but actually enhanced them. The legitimacy of the special status of the Corps was no longer a matter of opinion, but a matter of fact, plain for all to see.

I have spent the greater part of my service, and certainly the greater part of my more responsible service, with Regimental troops, and I am convinced that there is now an appreciable gulf between the status of the Corps and the reputation of the Corps in the Army, two terms which should, in fact, be a mirror image of each other. I doubt if the reputation of the Corps has ever been higher. There is a most impressive amount of goodwill towards the Sappers in the Army at the present time, and yet it seems to me that the official status of the Corps is lower than it has ever been within the memory of any living Sapper.

If, at the least, the lost ground is to be recovered, it seems reasonable to try to assess the ground that has been lost and, if possible, to deduce the reasons. I have tried to assemble these under separate headings, although I am sure, in my own mind, that there are many overlaps.

Self-satisfaction

Kipling said of the Sappers "We are the men who do something all round." I see no point in being mock-modest about this. If the statement is true—and it is true—it also means that we do these things very adequately. We do not merely "have a shot at them."

Now, in any normal walk of life, the man who does a number of things well enjoys an advantage over the man who does fewer things well. This advantage can take many forms. He may be better off financially, or his opinion may be treated with greater respect when he is asked to say, within the range of his subjects, what is and what is not possible. He is accepted as a man with a broad and responsible outlook, less likely than others to over-emphasize one subject at the expense of another. His point of view will be appreciated if he says that his ability to deal with a number of subjects does not mean that he is the proper person to deal with all those subjects at one and the same time without assistance. He will, in fact, enjoy a higher status than the man who is more limited in outlook, whether by virtue of his nature or by virtue of his circumstances.

This is almost an economic law, and the circumstances of Army life do not invalidate it, even if they do not permit it to have its natural effects. I suggest that there is no justification for failure to give effect to this law in the Army. When I have discussed this point with senior Sapper officers, above the rank of Lieut.-Colonel, I have frequently found their attitude to be that the Sapper, of necessity, enjoys a status above his rank and that it is all quite satisfactory, being a matter of " tradition " and " personality." To me this attitude has always spelled one of three things, if not a combination of all three. Either the problem has not been considered in relation to the facts, or the speaker is being self-satisfied (" rank for rank, we Sappers expect to have more demanded of us than officers of other arms, and we prefer it that way ") or he is adopting a " dog-in-the-manger " attitude (" I never had it so why should anyone else ? ")

It is noticeable that I have seldom heard this opinion expressed by any officer of Regimental rank. Moreover the arguments about " tradition " and " personality " do not, in my opinion, hold water. By tradition, the U.S. Army has not, in the past, had any officer above the rank of four-star General. This did not prevent them from instituting the rank of five-star General in order to give General Eisenhower the requisite status viz-a-viz Field-Marshal Montgomery. If the late war proved anything, it certainly proved the value of personality, which became as important a factor in the advancement of a Commander as his military genius. If, therefore, personality is so important in a Sapper officer as a factor affecting his relations with the Senior Commander under whom he serves, this is a very solid argument for his tenure of a higher rank than his Regimental opposite number in the other arms. The need for personality arises from the fact that the Sapper has to convince a Commander of all arms that he fully appreciates the position from the point of view of all arms, and that he is right. I do not know of any other arm whose officers, of equivalent rank, are ever placed in this position, with the possible exception of the Royal Corps of Signals.

Self-satisfaction on the part of the Corps has had other boomerang effects which have hurt no one so much as the Corps itself.

It was accepted, in theory at least, before the last war that the provision of bridging equipment on wheels at the right place and the right time for handing over to the Sapper units concerned was the responsibility of the " Q " Staff on the detailed demand of the Engineers. I never remember this as working smoothly in pre-war exercises because, whenever the " Q " Staff failed to produce the goods, or looked like doing so, the Sappers would step in and put matters right themselves. Nothing was ever said about the failure. The general attitude was that the Sappers knew what was wanted and, being gentlemen, would of course always step in and restore the situation when someone else had messed it up. The result has been that, generally speaking, no " Q " Staff has ever handled the problem satisfactorily, or in the manner prescribed by the training manuals, and the Sappers have been saddled with it ever since. This would not have mattered if the Corps had frankly said "Why not leave the matter to us and give us the necessary increase in staffs." In the event, the result of the Corps' self-satisfaction was the overloading of the Chief Engineer and, far worse, the R.E. units on the ground.

Even now I doubt if the " Q " Staff realizes the extent to which their job was done for them by the Sappers. If a bridge is built it is reasonable to suppose that a Formation Commander does not inquire whether everyone concerned played his part in the building of it. An Infantry Brigade Commander would certainly hear about a failure on the part of the R.A.S.C. to supply one of his battalions with ammunition long before it came to the point of the battalion fetching it for itself. If our Regimental officers are to be expected to do other people's work as well as their own, or at least to be capable of doing so, then they are, in my opinion, qualified to hold a higher rank or to enjoy some other increase in status.

The Status of the C.R.E.

I could, of course, have started much higher than the C.R.E., I could have produced arguments, quite conclusive to myself, that the Engineer-in-Chief should be a Lieut.-General with or without, but preferably with, a seat on the Army Council. I could produce aruments to show that the Chief Engineer of an Army should be a Major-General and that the Commander of an Engineer Group should be a Brigadier.

I have concentrated on the C.R.E. for two reasons. Firstly, he is the highest ranking officer in the Sappers who deals intimately and in detail with the officers, N.C.O's. and men who actually do the work, and secondly, because the whole of the reputation of the Corps, so far as the Army is concerned, depends upon the manner in which these Regimental units do their work.

I will take this last point first.

I have the greatest admiration for the Sapper brains (my own was *not* one of them) which planned and provided for the Sapper work carried out in all the campaigns of the war. But I do not consider that the reputation of the Corps in the late war is based on their labours, however great they may have been, any more than the reputation of the many units of British Infantry engaged in the campaigns can be said to be based on the remarkable strategical and tactical conceptions of Field-Marshals Wavell, Alexander and Montgomery.

In the late war, as in all other wars in which they have been engaged, the reputation of the Sappers was entirely in the hands of its Regimental officers, warrant officers, N.C.O's. and men. The units which built the Rhine bridges will be remembered by the Army long after the Army has forgotten that the Corps had anything to do with the conception, design and construction of the Mulberry harbour.

As I see it, therefore, the responsibility of those who represent the Corps in the more ethereal strata of the Army is to do everything in their power, at all times, to appreciate and ease the problems of the Regimental Sapper of all ranks.

It has always been my experience that, provided the interests of the Regimental officer are jealously safeguarded by his superiors, it is hardly necessary for anyone above Regimental rank to worry about the interests and the well-being of the warrant officers, N.C.O's. and men. Using the word " officer " to describe all that is meant by an officer, and not merely someone who has to be used as an officer, I am sure that, so long as he has no avoidable personal problems, he will always devote his full attention to the well-being of his men. In passing, I would like to recommend this idea to some of the present-day " specialists " in Army welfare.

If, therefore, the C.R.E. is fairly and adequately dealt by, everything else will automatically find its proper level.

I do not think anyone who has been close enough to troops and units to notice these things will disagree that the status of the C.R.E. is not what it was.

I will go further and say that the whole status of the Lieut.-Colonel, throughout the Army, has suffered a decline and that nowhere is that decline more serious or less justifiable than in the case of the C.R.E.

I have recently read, with great interest, Field-Marshal Earl Wavell's book *The Good Soldier*. I cannot hope to do better than to quote his conception of the Regimental Commanding Officer. He says " I always regard the battalion commander as the gamekeeper, who rears the birds, trains the beaters, breaks the dogs, and kills off the vermin ; the Brigadier may be taken to represent the host ; while divisional commanders, or better, represent the guns who come out in the autumn, shoot—or miss—the birds, and criticize the sport. The gamekeeper is the man who really knows the difficulties and possibilities *and I have consulted several of them* ; but no one is responsible for any heresies I may utter, except myself."

The italicizing of the above words is my own. I merely wished to draw attention to the fact that Brigadier Wavell, as he was then, saw fit to consult several Infantry Battalion Commanders in spite of the fact that there can have been very few soldiers and trainers of recent times so little in need of advice on the subject as himself. Is the Corps, whose senior officers tend to drift much further away from Regimental life than Earl Wavell has ever done, quite so good about soliciting the opinion of its Commanding Officers ?

If Earl Wavell's statement is, or was, a heresy I am only too pleased to be a heretic in such distinguished company. Is this a fair description of the status of the present-day Battalion Commander ? Whether it is or not, is it a fair description of the status of the present-day C.R.E. ? Because what Earl Wavell has to say about the Battalion Commander is equally applicable to the C.R.E. In my opinion it is even more applicable because, as things stand at present, there is virtually no Sapper who stands in so close a relation to the C.R.E. as that of the Brigade Commander to one of his Battalion Commanders. One thing at a time, however. The first question was " is this a fair description of the present-day status of the Battalion Commander and the C.R.E. ? "

I think the answer is " No " in respect of the Battalion Commander and I am sure that it is " No " in respect of the C.R.E.

So far as the Battalion Commander is concerned the change may be, to some extent, inevitable and deliberate. It appears to have been decided that battalion commanders will, in the future, be appreciably younger than they were in the past in order to ensure that those selected for higher rank shall gain experience early and reach such rank while they are still comparatively young. Relatively, therefore, they will be inexperienced as compared with their pre-war forerunners of whom Earl Wavell wrote. I have even heard it said that it is for this reason their Brigade Commanders must be Infantry soldiers, with an intimate knowledge of their arm. But the same is not true of the C.R.E. The outlets for the Sapper, and particularly the Regimental Sapper, will be fewer than in the past. Consequently, unless he is going to retire at an unreasonably early age, it seems that the age and length of service of the average C.R.E. will be relatively much the same as before the war, and almost certainly greater than the average obtaining among Infantry Battalion Commanders. Whatever may be thought right and proper in the case of the Battalion Commander, there can be no justification for failure to restore the old status of the C.R.E. Whether or not the rank of the Sapper was a vital factor in deciding his status before the war, there is no doubt that it is a vital factor now. During the war all appointments, whether new or of time-honoured standing, were graded by rank, sometimes with the most unfortunate results. The one appointment which altered not at all so far as rank was concerned and less than any other so far as seniority and length of service was concerned, was that of the C.R.E. It was relatively far easier for a Sapper Captain to become a temporary full Colonel in a staff appointment or in the Ministry of Supply than to become a temporary Lieut.-Colonel and C.R.E. of a Formation. The fact that the Sapper who remained a Regimental Commander in the field may, in the long run, have been doing better for the Army, the Corps and himself, is not the relevant point. The relevant point is that the honourable rank of Lieut.-Colonel became heavily devalued, and to a generation of Formation Commanders who knew little of the Sapper tradition and who were not "educated" to the handling and treatment of Sappers, there was something more than a tendency for the Sapper Lieut.-Colonel to be considered as being in no way different from any other Lieut.-Colonel, regardless of his age, seniority, or experience. The tendency remains to this day, more than three years after the end of the war and I doubt, myself, whether the mere process of time will ever correct it. Quick promotion to high rank will, in future, be a prize within the reach of the keen Infantry or R.A.C. officer, and of the Sapper who decides to desert the Corps for the Staff. I attach no offensive meaning to the use of the word "desert." I mean merely that the prize will not be within the reach of the keen, efficient, honest-to-God Regimental Sapper, whose whole working life will be, and must be, lived in service to the Corps. I feel very strongly that a very serious injury will be done to the interests of the Corps unless the status of the C.R.E. is greatly improved. In any circumstances that I can foresee, I can see no other way to improve his status than to increase his rank to that of full Colonel. I realize that this will mean reconsideration of all Engineer ranks above C.R.E., but that is as it should be. I mentioned earlier in this article that very cogent reasons exist for the upgrading of senior Engineer ranks on their own merits, quite apart from the consequential effect upon them of an upgrading of the rank of the C.R.E.

It is perhaps worth mentioning that the majority of my Gunner friends whom I have known as Divisional Cs. R.A. have frequently told me of their inability to understand why the C.R.E. has always remained a Lieut.-Colonel. They do not understand, any more than I do, why the number and size of the units commanded by the C.R.E. should be the ruling factor rather than the nature and extent of his responsibilities. I cannot understand, myself, why the A.D.M.S. of a division should be a full Colonel if the C.R.E. is to remain a Lieut.-Colonel. I do not resent the fact that the A.D.M.S. holds this rank. "More power to their elbow" is my reaction, and maybe the R.A.M.C. can drop us a hint as to how they managed to pull it off. I know all the arguments about early specialist training and higher age on date of first commission, but they do not affect the point at issue. An officer is supposed, nowadays, to hold the appointment and the rank for which his knowledge, experience, and qualifications fit him. It is quite immaterial how and when he acquired these qualities. A good Engineer officer receives no special consideration because he took the trouble to become a qualified engineer before joining the Army. He is not, for that reason, promoted to full Colonel when he is appointed to be a C.R.E. The only acceptable criterion is whether or not, when he becomes a C.R.E., he is expected to have a degree of knowledge and experience which covers a wider and a more difficult field than is expected of the general run of Commanding Officers in the Army. To my mind the answer is a most emphatic affirmative.

THE ATTITUDE OF THE FORMATION COMMANDER TO HIS SAPPER

Sapper officers who were in a position to observe such matters before the late war (and among them were many junior officers who were the senior officers of the late war) will agree, I think, that a disagreement between a Formation Commander and his Senior Sapper was a very rare thing. I am not suggesting that either " ate out of the other's hand," nor that their points of view were always the same. But, as one who was himself in a position of observation, I am most definitely suggesting that, when there was a difference, the Sapper's arguments were listened to with the greatest courtesy, and with unquestioning faith in the Sapper's sincerity, by the Formation Commander. I know of one exception, it is true, but since the Formation Commander in question was at loggerheads with all arms and all ranks I think he may be disregarded.

Now whatever part these pre-war Formation Commanders may have played during the war there is no doubt that the foundation work of the Army which persevered from the shock of Dunkirk to victory on Lüneburg Heath was done by them. They were sincere and able men who were most assiduous in their study of the characteristics of all the arms with which they had to deal. If tactical and technical interests were found to clash, the Sapper was not baldly instructed to overcome the technical difficulties (flattering, but not very helpful) nor to stop bellyaching about them (neither flattering nor helpful). Higher opinions were sought and, if necessary, the matter was made the subject of study and trial. The Formation Commander did not consider he had lost in dignity or displayed culpable ignorance in producing a situation where he and his Sapper disagreed. What, after all, is the object of training if it is not that everyone concerned shall learn something and that diverse parts shall be made to fit ? It is a very easy matter to order that a square peg shall be made to fit exactly and smoothly into a round hole without altering the shape of either, but even with mirrors it cannot be done.

My own experience, and the experiences of other Sappers as recounted to me, have convinced me that this courteous attention to the problems of the Sapper was noticeable only by its absence in altogether too many cases during the war. Sapper problems became increasingly complex, and even Sapper officers themselves had more and more technicalities to learn with less and less time in which to do so. It was natural that there should be less certainty in the Sapper's mind about the smoothness with which his particular peg fitted into the pattern. What is not so easily explained, or perhaps I should say not so easily justified, is the ease with which certain Commanders either decided that there was no problem at all or that it was a very simple matter for the whole of the necessary adjustment to be made by the Sapper. And yet it must be explained, if the old balance is to be regained, and I propose to be so bold, or so rash, as to attempt to do so.

I am leaving out of consideration the possibility of basic ignorance, feeble-mindedness, or wilful lack of co-operative spirit on the part of the Sapper, because I am convinced that any of them were and are extremely rare. It is a very easy accusation to level and, like Section 40 of the Army Act, a charge which is generally levelled when nothing else can be made to fit.

I have, therefore, arranged my " explanation " under the following heads :—

- (*a*) Basic ignorance of Commanders.
- (*b*) Failure or unwillingness to realize the extent of their ignorance.
- (*c*) Failure on the part of someone to " nail " this ignorance, when it became apparent, as the root cause of the trouble.
- (*d*) Failure on the part of someone to implant in Commanders the right kind of Sapper-mindedness as a substitute for the wrong kind.
- (*e*) A faulty psychology of Command.

(*a*) I propose to cite only a few instances of this basic ignorance:—

(i) The Commander who insisted that all Field Company G1098 equipment should be held on charge by the Regimental Quartermaster at the C.R.E's. H.Q. The atmosphere was cleared in the military sense, but clouded in the psychological sense, when the C.R.E. pointed out that there was no such animal because Field Companies had very deliberately been made self-accounting units in order that they might the more efficiently perform their essential service to the Army.

(ii) Having negotiated this hurdle, the C.R.E. was told that, in any case, there was no justification for permitting platoons to hold their own G1098 equipment. The C.R.E. explained that for the kind of work for which G1098 equipment was most normally used, it was far more usual for the Field Company to be working in platoons on separated sites than as a Field Company on one site. It was quite clear, however, that, to use an expression so often seen in military publications to the dismay of those concerned, the Divisional R.E. were, in the eyes of the Commander, a " Battalion or equivalent Unit."

(iii) The Commander who stated that he could see no point in Sappers doing anything in the way of bridging exercises once they had done a Bridging Camp, as they should, by then, be fully trained.

In opposition to this was the view of the Commander who stated that a Bridging Camp was a pure waste of time and that all Sappers should do all bridging exercises as set schemes on unknown sites.

The C.R.E's. view that the Bridging Camp and the bridging exercise had their counterpart in the Classification Range and the Field Firing Range was dismissed by both as being " an obviously attractive simile, but unacceptable," for some reason not specified.

(*b*) By " failure to realize extent of ignorance " I mean a failure to realize how many things there are that need to be known. It is very difficult to make some people realize that the Sapper usually finds himself combating nature as well as enemy action and that nature can be the worse opponent of the two. The average Englishman, for instance, is not nearly as quick as the average Canadian to realize the power of water and the effect of that power on bridging operations. The Englishman is not " educated up to " big rivers and their foibles. Because the Sapper exists to deal with certain aspects of war there is a tendency, among certain people, to think of him in much the same way as one might think of the modern professional golfer ; as a man who has a particular club for every possible contingency and whose responsibility is merely to pull out the proper club and swing it in the proper way.

Unwillingness to admit ignorance is far more embarrassing to the Sapper, because the ignorance becomes incurable.

A certain Divisional Commander paid a surprise visit to one of his Field Companies which had just received a new Commander. The latter, who knew his job and had already mapped out a training plan in his mind, regaled the Divisional Commander for some twenty minutes with his proposed plan and his reasons. That evening the Divisional Commander sent for his C.R.E., told him of his visit, and added that he had a poor opinion of the new Field Company Commander. The reason, the C.R.E. was informed, was *not* that the Field Company Commander knew nothing about the training of Sappers ; whether the Field Company Commander had or had not talked sense was never touched upon. Offence was taken because the Divisional

Commander had assumed that the Field Company Commander was deliberately telling him something he did not know. Only a man who did *not* know and who (although the Field Company Commander did not realize it), was being made to realize how much he did not know, could possibly have reacted in such a way. In modern parlance, he was a man with an acute inferiority complex about Sappers, and I can think of no more awkward situation for a Sapper than to serve under such a Commander.

(*c*) Failure to "nail" such ignorance is a much more ticklish matter, I admit, than is the problem of making it known in the right quarter. The C.R.E. concerned can make it known to his own technical superior, but is it equally obvious what action the latter then takes?

One thing seems quite clear to me; it is quite useless telling the C.R.E. that it is his job to educate his Divisional Commander. Education, from the very derivation of the word, implies as big an effort on the part of the student as is demanded of the teacher, and presupposes a willingness to admit initial ignorance. A C.R.E. can "teach" his Divisional Commander only to the extent that each can be, at one and the same time, both teacher and student, each gaining something and giving something from the particular matter under discussion. But a Commander whose ignorance is fundamental is likely to be just the very man who cannot be taught by a subordinate, more especially since this type of man is almost always hyper-sensitive about his rank and the extent to which it marks him out as the mental superior of those of lower rank. This is the kind of situation where the Corps, by which I mean the non-Regimental higher strata of the Corps, must, in my opinion, step in and take some positive action for the sake of its own Regimental officers and men, the Corps, and in fact the Army as a whole.

(*d*) By "the right kind of Sapper-mindedness" I mean the frame of mind which sees a Sapper problem in its correct proportions within the problem as a whole.

I do not believe that the old conception of fighting arms and ancillary arms is true any longer except in a very broad sense. It is probably quite true that no war will ever be won without infantry, but I find it difficult to believe that any future war can be fought at all, let alone won, without all of what are known as the ancillary arms.

Is not the real truth the fact that modern war is rather like football? The ball goes from player to player each of whom, while he has the ball, is the man who really matters. All the other players must position themselves to distract attention from the player in possession, to back him up, and to be ready to take immediate advantage of anything he may achieve.

I remember one Corps Commander saying, during the preparations for D-day in 1944, that the invasion was a Sapper operation. The initial object, he said, was to get a sufficient force in over the beaches to cover the landing and subsequent work of very large numbers of Sappers, whose job it would be to make possible the landing of a vastly greater follow-up force. Therefore the operations must be so conducted that the Sappers could start and complete their work with the least possible delay or interference. That is what I mean by "proper Sapper-mindedness." The opposite, which may still be met with, is the attitude which takes the Sapper part of the programme for granted. This is not intended as a compliment, nor can it be accepted as such, because it tends to leave the Sapper with no margin at all for the unforeseen. It tends to suggest, and to expect, a mechanical exactitude about the start, progress, and conclusion of Sapper work which is at no time justifiable. All battles tend to be fought in phases nowadays and although timings may be given to them these timings are accepted as being governed by the unknown "x," where "x" is the enemy reaction. The same is true of Sapper work, and particularly of large-scale Sapper work. I can remember a certain Formation's operation order in the early days in Normandy in which the Formation intention was stated to be the capture of "A" with exploitation to "B." In actual fact "A" was not captured until ten days or so later and no British troops were anywhere near "B" until several weeks later. There were excellent reasons, I have no doubt, both for the order and for the failure to achieve it, and so far as I know neither was ever questioned. I do not suggest that anything really vast in the way of latitude in time is required by the Sappers. Generally speaking the Corps can pride itself on having delivered the goods reasonably punctually, but I sometimes wonder whether it is not too often assumed that this only goes to show how simple and readily calculable it all is.

(*e*) Psychology of Command is a very big subject and I only wish to touch on one small aspect of it.

I cannot help thinking that Field-Marshal Viscount Montgomery's technique of command, in common with many other things the Field Marshal has said and done, has been, so to speak, taken out of its context by too many people with unfortunate results.

For anyone in the Field-Marshal's position it is obvious that he had to have a staff which suited him and worked to a pattern of his own. Anything else could not have failed to distract his mind from the many problems with which it was engaged.

On the other hand it is abundantly clear that he made a very careful study of his subordinate Commanders, even if he did select them himself. He knew their characteristics thoroughly, and the best way to deal with each of them. Some would-be imitators of the Field-Marshal seem to have forgotten this. As I see it, every Commander is as much responsible for studying his subordinate Commanders as are the latter for studying their superior Commander. In fact I would say that he is more responsible, because he is, or should be, wiser, more experienced, more skilled in handling human nature, and possessed of a broader outlook. Presumably that is why he is a superior Commander.

If this is so, then a disagreement between a Commander and a C.R.E. whose attainments are known and vouched for by his technical superior is surely an indictment of the Commander rather than of the C.R.E. It is surely his business to accept his C.R.E. as he is, and to employ such methods as will get the best out of him. I may be wrong, but my impression is that the responsibility for the establishment and maintenance of good relations was placed fairly and squarely upon the C.R.E. alone.

Personally, when D-Day arrived, I was very lucky. I could not have asked for a better Divisional Commander, but I hasten to add that he was one of the old school in all respects. It is not for me to suggest all that the Corps should do to put things right. My object has been to show how and where the shoe tends to pinch, and to suggest that the Regimental officers and men of the Corps have earned the right to be equipped with shoes which do not pinch. But I would like to make one or two suggestions.

Umpiring

It is the duty of R.E. umpires to put their finger on R.E. mistakes. But it is also their duty to seek out the origins of these mistakes with a very keen nose in order to ascertain, beyond any doubt, whether they were born in the R.E. nursery or whether their parents were, in fact, the "G" or "Q"

Staffs or even the Formation Commander himself. If the latter, the R.E. umpires must say so with no uncertain voice. I know of one case where this was done by a strong-minded senior R.E. umpire with most salutary effect. I also know of other cases where it was equally necessary but was not done.

Corps History

We are, I think, much too fond of publicizing the things that have had their origins in the Corps and are now no longer our responsibility. We would do better to concentrate on the work that the Sapper has always done and still does, with the accent on the manner in which the work has increased in scope and complexity.

It would be considered extremely tactless to remind the great American nation that they had their origin in the British American Colonies. I do not think we improve our relations with the R.A.F., the Signals, and the Tanks by reminding them that they had their origins in our Corps. They have their own traditions now, which probably owe very little to the original source.

It should be sufficient to record the fact that we had a great deal to do with the development of the work now performed by the Royal Corps of Signals which accounts for our very close liaison with that Corps, and that our Corps had a great deal to do with the development of military aviation. If we are going to mention tanks we should, I think, admit that individual Sappers were the principal actors in the design and development of the tank rather than the Corps as a whole. By the same token we take justifiable pride in the achievements of the Corps with the Bailey bridge, but are inclined to gloss over the fact that it was designed by a civilian.

Corps Loyalty

In the past the Corps has been the career selection of a very large number of men of outstanding all-round ability. Many have distinguished themselves over a very wide field, in appointments which have no particular connexion with the work of the Sappers. Whether, in fact, they owe any of their success to the fact that they were Sappers is a very debatable point. When we talk about some Sapper who has received a very important appointment as "having achieved something that is rare among Sappers," are we not, in fact, paying him the compliment of saying that he has done what he has done in spite of being a Sapper? We may greatly admire the individual and we may bask in his reflected glory, but can we, as a Corps, pat ourselves on the back for having owned him in the days before he discovered that other activities were more up his street than being a Sapper? As a Corps, surely we should take far greater pride in the achievements of those who have made their names as military engineers in the field. Nevertheless, a Sapper who leaves the realm of Sapper work for other fields will normally subscribe to the adage that once a man has been a Sapper he is always a Sapper. I suggest that, when and if these words occur to him, he should repeat them as a reminder to himself rather than as a statement of fact. There are many ways of remaining a Sapper after giving up active participation in Sapper work, and not all of them are good ways.

The ex-Sapper who insists on all possible occasions that the points raised by the working Sapper require most earnest consideration, and who is able to appreciate those points, is a good Sapper whatever job he may be doing. On the other hand the ex-Sapper who produces his own solution to an Engineer problem and backs it, either in place of or in the face of the solution of a C.R.E. or a Chief Engineer, is a snake in the grass and a viper in the bosom, who does nothing but harm to the Corps.

Command and Representation

It is an unfortunate fact that, once they have risen above the rank of Major, very few Sapper officers are directly under the command of a senior officer who is still within the Sapper orbit. The best they can hope for is a Sapper as their "technical superior." This is right and proper where the Sapper units concerned are, by design, an integral part of a force of all arms such as a division. It was wrong in the case of a Corps, where it was clearly impossible for the Corps Commander to deal direct with the C.R.E. Corps Troops, and the latter was left with, virtually, no superior Commander. This very obvious anomaly has been put right in the only possible way, by making the Chief Engineer of the Corps a C.C.R.E. The Gunners must often have wondered why so many years passed before this solution was arrived at.

Since it has been arrived at, I cannot understand why the position is now so readily accepted that R.E. units which have no lower-formation function should be placed under the command of a lower formation Commander merely because he has to administer them. Whatever the reasons may be, the psychological results of this facile solution are unfortunate and the long-term result may be even more unfortunate. The Chief Engineer is not required to exercise guidance and control as a soldier, from which it is but a step for other arms to assume that he is not the type of man who is considered capable of doing so. From this situation it is but a step to the appointing of a Chief Engineer who, by virtue of his specialist experience and employment, is not even qualified to exercise such guidance and control.

It is a bad thing for the Corps, in my opinion, if in a large W.O's. and Sergeants' mess one does not meet Regimental W.O's. and N.C.O's. who reminisce about their Chief Engineer when he was a Regimental Subaltern, Captain, Major and Lieut.-Colonel. I would add that, after those of their own officers, the Chief Engineer's face and voice should be the best known in any R.E. unit.

I fully appreciate that administrative responsibility of a Formation Commander for a unit must imply a certain amount of control, but I am equally sure that there is a middle-path solution which would harm no one and, at the same time, be of the greatest advantage to the Corps as a whole. Aldershot in pre-war days seemed to have the answer, and to have established the principle, and I would very much like to see it revived everywhere to the fullest extent possible consistent with local circumstances.

It should not be forgotten that, even if a Chief Engineer is to be only the technical superior of a Sapper Unit Commander, he must know all about that Unit Commander's problems and responsibilities, both as a Sapper and as a soldier. Nothing is more disheartening for a Sapper Unit Commander than the knowledge, or even the suspicion, that his Chief Engineer knows nothing of his administrative and disciplinary problems and handicaps.

Even from the technical standpoint, it is a big handicap for the Commander of a Field Engineer Regiment or R.E. Training Unit to find that his technical superior is an officer whose whole experience, or the majority of whose later experience to date, has been in the realm of "Works." I may be voicing a heresy, but in my opinion any really good Regimental Sapper officer can master the intricacies of works procedure, given an adequate technical staff, whereas it is probably superfluous to remark that ability to deal with such intricacies is by no means the principal or the most exacting requirement in the specification for a good Sapper Commander. Has it escaped the notice of the Corps that the Army refers to R.E. units as "The Sappers" and to the Works Services as "The R.E's."?

I suggest that we absorb the "R.E's." into the "Sappers," and not vice versa.

R.E. Staff Work

I suggest that the greatest possible care should be exercised in the selection of Staff officers, R.E. A really good S.O.R.E. is the answer to the daily prayer of R.E. Unit Commanders. Age and long service are not necessary, but he starts with a great advantage if he has been an Adjutant or Second-in-Command of a Squadron. He *must* be a good mixer and the kind of man who is welcomed into other offices rather than be invited to go out again and close the door behind him. He needs to be quick to grasp a problem but he does NOT need to know the answer or to attempt to suggest that he does. He has probably received the problem from someone more experienced than himself. But he must know, and must have the ear of, the man who does know the answer.

Above all he must NEVER tell a Sapper who asks for his help that it is none of his business "because it is an 'A' matter, dealt with through formation channels." He is being asked for advice, and if he is in a position to obtain that advice it is his job to do so. He is justified in saying that he is too busy on his proper job at the moment, but will do what he can when he can find the time, but he is NOT justified in saying that it is none of his business.

I knew one young staff officer, R.E., of the type I am advocating, at a Corps H.Q. in France, and he was worth a guinea a minute to a Sapper Regimental Commander. Incidentally he was a reflection of his own Chief Engineer.

I began what I had to say with a quotation about Advertisement. This is an age of Advertisement, whether we like it or not. The Sappers have never deliberately advertised themselves, largely because there has always been just as big a job waiting round the corner as the one that has just been finished. I do not think the Sapper has ever consciously worked for the good of the Army, or of his Corps, or for the honour and glory of this, that, or the other thing. Generally speaking the Sapper is a highly responsible and self-respecting member of society, who sets out to do a thing solidly and well because he is a good craftsman who cannot bear to contemplate anything less. But that is not the spirit of the modern age, and the man who says that he is content to do a good job of work and leave it at that is liable to find himself regarded as "simple" or "eccentric." He may even give the quite erroneous impression that the whole thing is as easy as falling off a log.

If he is to survive as a craftsman who prefers that the quality of his goods should be his only advertisement, he must have a very competent "Manager." The job of this Manager is to tell the interested public (i.e., the Army), just what the craftsman has achieved, the extent to which it was done with or without the assistance he might have expected, and just what is expected of the interested public if the craftsman is not to lose his zest for craftsmanship. To do this properly the Manager needs to be in close and constant touch with the craftsman, and fearless of the reaction of the public.

I agree with the implications of the statement that we do not advertise ourselves properly, but not with the wording. I do not think there is anything the matter with our advertising technique ; on the contrary I think it could hardly be bettered. I suggest that it is our salesmanship which is at fault in its failure to follow up, quickly and confidently, the spectacular successes of our advertising campaign.

APPLYING MODERN WELDING METHODS

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Introduction

IN years gone by when the merits of welding were realized by comparatively few engineers, it was necessary to overcome a great deal of prejudice.

Although Davy discovered acetylene gas in 1836, it was not until Chatelier, a scientist, burned it with oxygen in 1895 that a hitherto undreamed-of source of intense heat was tapped.

Chatelier was not slow in realizing something of the far-reaching possibilities of his discovery, for he commenced to weld pieces of metal together by making their edges molten. This idea was not entirely original, for in 1881 an electrical engineer, De Meritens, succeeded in fusing battery plates together by applying an electric arc.

From these humble beginnings sprang the two main methods of welding in use today—gas and electricity.

During World War I considerable progress was made. Unremitted research was carried on so that when the second and greater storm broke in 1939 it was obvious that welding would play a vital part. This it did, but to a far greater extent than was at first envisaged. It is now general knowledge that the huge programme of ship production was possible only by the adoption of welding in place of riveted construction. Similarly, nearly all armoured vehicles, including tanks, were of riveted design in 1939. Then the worth of welding was proved in combat. It showed added resistance to shell-fire and facilitated repairs to an unbelievable extent. By 1944 riveting was rare with this class of fighting machine, welding, by reason of sheer merit, being overwhelmingly in favour.

Even greater laurels were won in the sphere of repair work, for a considerable proportion of important plant, vital to sustaining the war-time effort, was of foreign origin and most of it was cut off from the support of the parent factory for the supply of replacement parts. Welding was used with complete success to solve what, at first, seemed to be an insuperable problem. It was a similar story in regard to the maintenance ships built on the continent and sailing with the Allied fleet of merchant craft. Not only did normal wear and tear need to be faced but also fracture, often most severe, arising from torpedoes, mines and shell fire.

The careful building up of new technique and the creation of improved types of equipment during the past few years provides sufficient material to fill a book of formidable proportions. It is not even feasible adequately to precis the subject within the space of a single article, suffice it to comment that a knowledge of just what can be accomplished is an incalculable aid to all engineers.

Information Required

In most instances of repair and maintenance work, drawings are not available to help the operator, but in those cases in which there is time and opportunity for preparation of this kind they should be suitably marked with the generally accepted welding symbols and, at least, they should indicate the five essentials that arise in the case of the repair or reconstruction of a large steel erection such as a bridge, for example.

These are as follows :—

1. The size of the weld required to produce the necessary joint strength.
2. Type of weld to be used.
3. The length of the weld decided.
4. If intermittent welds are used then the spacing must be shown in the recognized manner.
5. Precise location of seam.

Springing from these main headings are many subdivisions. Some of the symbols differ according to the practice of the drawing office concerned. If a job is to be butt welded then the following information must be given on the cross section point :—

(*a*) Thickness of plate.
(*b*) The angle or shape of preparation.
(*c*) Depth of root face (if this point arises).
(*d*) The width of the gap.

The procedure in regard to fillet welds is obviously more simple, being covered by :—

(*a*) The size, that is, the length of any intended variation therein, with " leg " and " throat " dimensions.
(*b*) Shape of the surface, i.e., convex, concave or flat.

Among the factors that must be agreed in order to secure control of the welding procedure carried out by a contractor are :—

(*a*) Grade and type of electrode.
(*b*) The gauge.
(*c*) The run permissible with each electrode.
(*d*) Current strengths for each run.

It is also desirable to indicate clearly on the drawing any other relevant particulars such as stress relieving, radiography and flush finishing in the case of butt welds and so on.

Welding of Bridges

In regard to bridge work, which is of special interest to readers of this journal, there are certain cardinal rules with which operators must comply.

Any foreign substance on the steel such as rust, paint or oil in a quantity sufficient to effect the quality of the weld must be removed by brushing, hammering or chipping.

It is essential to keep the parts in position and in close contact whilst the work is being carried out. Clamps are usually sufficient, but when these do not meet the case then other means must be devised, such as temporary bolts.

When the welding is completed, or in some instances stage by stage, it is usual to test the thickness by means of a gauge to determine whether or not the welds are of the full size specified.

Once a run is completed the slag must be chipped off and a wire brush applied. When one run is superimposed upon another then the previous layer must have every vestige of slag removed by chipping and the metal brushed thoroughly clean before the next run is deposited.

The penetration depth is important as this must ensure complete and uninterrupted integration of the weld and parent metal. Also there must be no break in the continuity of the runs at points where one electrode is used and a new one inserted.

The use of welding for plate girder bridge construction, which has found considerable favour overseas, has been slow in development in this country. However, for many years the London & North Eastern Railway Co., used welding to a steadily increasing extent for strengthening and repairing railway bridges and, more recently, a number of plate girder bridges have been erected.

Of the many specific examples of welding repair that could be quoted, of special interest is the work done upon a lifting bridge that carries the Great Southern railway trains across the north channel of the River Lee in the City of Cork, Eire.

The bridge is lifted about three times daily to allow the passage of river traffic. It is operated electrically, the total weight of the lifted portion being 300 tons balanced by 300 tons of concrete ballast in a steel casing. The combined weight of 600 tons is carried on two curved steel tracks whilst it is rolling. These are 2 ft. wide, 2 in. thick and 27 ft. long, bolted to 9 × 4 in. angle irons $\frac{5}{16}$ in. thick. In turn these are supported by two straight tracks of the same dimensions. In order to prevent any tendency to slip the straight tracks are fitted with projections that fit into corresponding slots in the curved portions.

The rolling action, throughout a period of sixteen years, caused the flat track to lengthen and spread until it fractured, together with the 9 × 4 in. angle irons at the root, causing an opening of $\frac{1}{4}$ in. in the centre.

Owing to the formidable weight of the bridge it was not deemed safe to cut out the rivets and remove the broken angle irons. The work of repair was done in two stages and the bridge left open to river traffic for the first half of the operations. Dealing at the outset with the angles, the fractured horizontal webs only were removed but the edges of the vertical flanges were carefully cut away with an oxy-acetylene torch and then bevelled with a pneumatic tool. After this stage was successfully completed electric welding operations were commenced, current being obtained from a petrol-driven generator mounted on a 30-cwt. motor vehicle. Long strips of mild steel, 1 in. wide and $\frac{3}{16}$ in. thick, straight for the bottom and curved for the top cracks, were welded to make the 9-in. flange of the angle iron bear on the new track. Before the strips were welded they were machine bevelled and then clamped in position. In order to compensate for any risk of the old trouble arising in the future, the new tracks were made in sections and secured by cast steel angles and fitted bolts.

When this part of the job was completed the bridge was lowered and the same process repeated on the other section of the tracks.

The work was continued practically without a stop until it was finished. The length of the welding strips used was 215 ft. The electrodes were No. 8 and No. 6 Murex general service type.

It is an interesting fact that probably no country in the world has a greater number of road and railway bridges that have been constructed and repaired by welding than has Australia. The first design for a new bridge of this type was prepared no fewer than twenty-four years ago. Experience in this direction has proved certain important claims. The work is less costly although utterly dependable. There is much less interference with traffic than in the case with riveted work ; moreover, there is more scope for overcoming any weakness in design that may not become obvious for years after the bridge has been put into service. The effects of corrosion are also more easily overcome by welding than any other method.

In New Zealand, too, brilliant work has been done on similar lines. An outstanding example of this is the strengthening of the floor system of the Majohine Viaduct. This is located on the main trunk line in North Island. Although the main structure is of ample strength, the load capacity was limited by the rail bearers and cross girders which were weak in comparison with the safety factor for the rest of the structure.

Reinforcement by riveting was considered first of all, but this was found to be impracticable, short of replacing the entire floor system with new steel work.. The existing top lateral girders would also have had to be scrapped because their members are threaded through openings in the rail girders.

Still further complicating the situation was the need for maintaining normal traffic whilst the modifications were being made. Even the track level could not be raised owing to a tunnel entrance directly the viaduct is crossed in one direction.

After a number of schemes had been discussed and rejected it was decided to fit vertical sections to the main trusses and upon these uprights fit intermediate cross girders. By adopting this system it was found that the quantity of new material was less than that required by any other scheme, for the structure is comparatively simple and capable of analysis, which would not have been the case had the original girders and rail supports been strengthened.

A further point of appeal was that the new verticals allowed of sway bracing to be fitted and the bridge had hitherto been without anything of this nature.

To facilitate welding, movable false work was made and moved from bay to bay as the work of strengthening proceeded. On one of the upper platforms, on the falsework, a pair of beams was provided to handle the new verticals and allow a nicety of adjustment. When once in position each vertical was wedged so that welding could be commenced in the best possible conditions.

One could enlarge upon outstanding examples of similar work carried out upon bridges. In most instances the need challenges the skill of the engineers responsible, but the flexibility of welding application is invaluable to the fulfilment of brilliant work, much of which could not be achieved so satisfactorily by any other means.

Welding of Pipelines

Another phase of welding activity that has come much to the fore during the past few years is that which concerns pipelines.

A valuable background of experience was gained in oil-field development work, for by far the most economical means for handling crude oil and its various liquid derivatives is to pump it. This involves the use of pipelines, some of which are world famous, not only on account of their length but because of the difficult and sometimes virgin terrain through which the lines must pass.

The engineering problems are often most severe, for in many instances roads must first be constructed in order to get plant and the pipe sections to the site.

One of the most spectacular undertakings of this kind is the pipeline necessary in connexion with the Alaskan Highway. Having an approximate length of 1,600 miles, including various branches, the sections of pipe, which vary from 30 to 40 ft. in length, are welded in their entirety. The diameter varies from 6 to 2 in. The main crude oil line, which is a branch to the oil field at Norman Wells, is 4 in. in diameter for the first 500 miles of its length, but it is increased to 6 in. for the remaining 100 miles to Whitehorse.

Pumping stations are provided throughout the system at points roughly fifty miles apart.

The pipe sections were supplied with bevelled ends. All joints are welded, making the whole solid and continuous with no provision for flexible joints, as the irregularities of the run are sufficient to make up for expansion and contraction brought about by temperature changes. Incidentally the quality of the crude oil is such that it can be used in diesel engines without treatment. Still more important is the fact that it will flow at 70° F. below zero. There is, of course, no difficulty when petrol is being pumped ; the line being used for several types of fuel.

The pipe is laid upon the surface of the ground, except, of course, when streams are crossed. Sometimes bridges are used, but in other instances the pipe is dropped to the bed of streams and mud anchors are used if there is any danger from a fast flowing current in the larger rivers.

So far as possible the pipe lengths were strung out along the line preparatory to the arrival of the welding squads. The first operation was to connect the two sections of pipe by means of a special clamp which left the ends of the pipe open. A tractor with a crane attachment in the form of a side jib lifted the clamped sections, which were then tack-welded. After this stage the pipe was lowered on to blocks 2 ft. in height and the clamps removed. Welding was completed in two stages and operators had to lie on their backs to get at the underside, as it was not possible to turn the pipe. After completion the joints were hammered by hand in order to relieve any welding stresses.

The procedure adopted for crossing rivers and streams was to weld sections together on the bank until an adequate length was reached and then haul one end across by means of tractors on the opposite bank. Special difficulty was experienced with the Mackenzie river crossing, which is nearly four miles wide at Norman Wells. Fortunately an island made a convenient intermediate resting place. One end of the long length of pipe was anchored to a barge which was towed by a motor tug assisted by a winch on the far shore. In theory the pipe should have trailed behind and settled on the river bed with reasonable alignment. Due to the difficult conditions the pipe was badly kinked in some places. This necessitated its being raised on to barges, when the damaged sections were cut out and new lengths of pipe inserted.

This particular pipeline has been described in some detail because it is truly representative of this class of work plus those of variable factors which are brought about by local conditions.

Maintenance of Pipelines

The repair and maintenance of pipelines, once they are laid, is another field in which welding is pre-eminent. The pressure at which the fuel is pumped varies, but most main lines come within the limits of 300–1,200 lb. Many of these lines are buried, and where there is danger of corrosion, protective coverings are provided in the form of tar-base paper and dope. Corrosion is also caused in certain conditions by galvanic action and stray electric current, both of which can be countered, the first by waterproof insulation and the latter by means of pits filled with scrap iron in order to dissipate the current. The connexion between the main line and the pit is usually a 2-in. pipe welded to the outside of the fuel line.

The appearance of different forms of electrolytic corrosion varies considerably. A common type looks as if a channel had been gouged from the outer surface of the pipe. When this arises the most simple method of repair is to "sole" the pipe. This is done by taking a suitable length of new piping of equal diameter and splitting it longitudinally, clamping it on to the affected part tightly and then welding the edges and the ends. The whole of the metal is then cleaned thoroughly, wrapped and doped. Finally new soil is used to bury the pipe. If this procedure is followed it is seldom that there is a repetition of the trouble.

When a fault is unusually severe and might stop the use of the pipeline for a considerable time a temporary length is sometimes laid on "H" frames which straddle the defective section. The new pipe is temporarily welded into the main line allowing pumping to proceed whilst work is going on. Finally the repaired length is welded back into position again.

To prevent corrosion on the inner surfaces of pipelines running scrapers are used. These consist of a series of rubber discs, metal brushes and rowels. When one of these devices gets stuck in a pipe, as happens occasionally, and defies all ordinary methods for moving it, connexions are welded on to the pipeline above and below the obstruction. Valves are placed on the connexions and the line is tapped with a tapping machine. This form of by-pass allows of a continued flow of oil whilst the jammed scraper is being freed.

The repair of a leak in an oil pipeline has been reduced to more or less standard procedure. When the leak has been found it must be stopped temporarily, perhaps by the use of a wood plug, until a permanent repair by welding can be effected. The first step is to clean the pipe thoroughly and then determine the type of repair clamp to be used. There are several varieties from which to choose. A safety zone is then established in the vicinity of the repair and the clamp is welded to the pipe.

Hard Steel Welding

A totally different problem with which engineers are often faced is work upon rock. This may arise in the drilling of holes for blasting charges preparatory to road making or clearing obstructions.

Whilst the depositing of hard steels by welding methods has long been possible, rods are now available that enable turning and planing tools to be tipped and give results that are comparable with the work done by various high speed steels used for this purpose.

This is a development that has a wider use than is obvious at first. It can be made to substitute for a case-hardened surface in some instances, but even more important is the application to the bits of rock drills. It means that supplies can be made in the field from stock materials if proprietary bits are not available

General Repairs

It is, however, in regard to general repair work that scientific welding is seen in one of its most valuable aspects. At the same time this class of work usually makes the greatest demands upon operators.

Owing to the necessity for doing certain work in the field, of a class that would normally be undertaken only by specialist firms, during the war it was necessary to institute advanced courses of training so that use could be made of the more complex technique that has been developed to deal with the fracture, corrosion and wear of industrial plant of all kinds.

Due largely to the wholehearted co-operation of important welding concerns a large measure of success was achieved, but first-class operators cannot be trained overnight and natural aptitude is something that cannot be gained wholly by instruction.

The nature of the latest types of equipment make the practical knowledge of repair work by welding methods of paramount importance to engineers in the field.

Welding of Tanks

Turning from the general to the particular, with special relation to tanks and armoured vehicles, already mentioned briefly, there could not be a more significant fact than that all British designs are welded. At the outbreak of war only two armoured cars were welded and that largely because of the need for minimum weight. Any suggestion to extend this method more widely was not favoured. What then brought about this change of opinion? Sheer merit under actual battle conditions was the primary factor, but speed of production also weighed in the scale.

One of the most convincing proofs was that of comparative firing trials on pairs of tanks of similar design, but one welded and the other riveted. It was found that the former could take a greater measure of punishment.

The utmost care is taken in designing the joints, for these must be no less able to resist armour-piercing shot, or blast from a high-explosive shell or mine, than the parent plate. In many instances the welded seam is actually more resistant to impact. When the heaviest types of plate make this more difficult to assure, then it is often possible, by means of good design, to give the weld protection from direct impact. A butt weld is used largely in relation to the thinner classes of plate, for heavier material a fillet union has been found more satisfactory, but there are exceptions to this general rule.

With thick armour heavy austenitic electrodes are used, up to $\frac{3}{8}$-in. diameter. Partly on account of the characteristics of these as well as the more obvious advantages, downhand welding is desirable to the greatest extent that is practical. It is of interest to note that about 500 lb. of electrodes of this type are used in the fabrication of a modern tank.

The actual welding is first of all the subject of most careful planning, not only in the matter of design but also step-by-step procedure in the factory. In this way uniformity is obtained, heat balance secured and stresses are cancelled out. Even the order and position of tack welds are carefully specified followed by the number of runs, size of electrode to be used for each joint and the order in which the union of the component parts is to be made.

Primarily because of the difficulty in procuring forgings and castings, early in the war a number of components were built up from flame cut mild steel plate. It was thought at the time that this practice, amply justified by the war, would hardly be an economic proposition in competitive business. Except in a few extreme cases this view has proved untenable, for nowadays the reduction in machining time, coupled with a substantial saving in weight, often makes welding the most attractive and dependable method of production.

To some extent the Germans did not meet with the same success with their welded tanks, for the interesting reason that the plate they used was harder than ours. This was good up to a point, but when subjected to extreme attack it cracked and broke up more readily and, of course, the welding could not hold it in these circumstances.

Special Repairs

Although specialist firms engaged in welding confine their activities largely to repair and general maintenance requirements, the variety of needs is so great that automatically a great many new developments spring from this source. This was particularly the case during the war when demands, which in earlier years would have been rejected on the grounds of being impracticable, were tackled with the utmost success.

It is not generally realized how big a part welding has played during the past six or seven years, both in boosting production and achieving a degree of dependability in repair work that could not be surpassed by any other method.

An illustration of clever work undertaken a short time ago concerns the large crankshaft of a diesel engine. The power unit was of overseas origin and no replacements were available. At the same time the welding repair was no makeshift.

The shaft, which had four throws, was 18 ft. 6 in. long and had journals $11\frac{1}{2}$ in. in diameter. The weight of the component was three tons. A web fractured through metal measuring 18 × 6 in. Strength combined with accuracy of alignment are fundamental needs with work of this kind. Both objectives were achieved considerably beyond the minimum specified. The shaft before and after repair is shown in Plate 1.

Particular care was taken with the multi-runs so that when the work was cleaned off prior to grinding, only metal that was fully normalized remained at the point of repair. The shaft was searchingly tested before being re-bedded on its bearings and the results were most satisfactory. The subsequent trouble-free performance of the shaft is the final confirmation of the efficacy of the work carried out.

It has taken a long time for engineers to realize that a broken crankshaft can be made completely dependable once more and that welding is not a temporary expedient to tide over a critical period until a replacement can be secured.

The record of shafts handled by specialists in this way is absolute proof of their trustworthiness, provided that those responsible really do know their job.

One of the most important aspects of this work is to obtain a fully normalized result that is quite free from internal strains or denaturization. The latter includes hardening to an extent that can become a weakness and not a strength with this class of work. When dealing with steel and using multi-runs, each succeeding layer of weld metal normalizes the previous one. The final layer may be applied solely for this purpose after which it is removed as surplus.

When the crankshaft of a locomotive, having inside cylinders, broke not long ago, welding engineers were asked to reunite it. The breakage was through a web and the two sections were sent, each with a driving wheel attached. In order to give greater accessibility they were pressed off. The usual tolerance for work of this kind, plus or minus 0·001 in., was accepted. When the welding was completed the wheels were shrunk on afresh, the whole of the work occupying only a few days. As is the regular practice of specialist firms, a money-back guarantee was given. Although the monetary saving on the cost of a replacement was substantial, as is so often the case, it was the avoidance of a long delay which shows even greater economy.

In passing it is of interest to mention that work of the type just described often affords an opportunity to recondition worn crankpins and journals. These can be built up afresh should the original dimensions have been reduced by successive grinding. Sometimes sufficient metal is deposited to allow of oversize limits. Thus, when the time comes to grind once more, this restores the shaft to its original proportions.

An example of an extensive repair to a cylinder block is shown in Plate 2.

Repair of Machine Tools

The repair and maintenance of machine tools sometimes presents some tricky problems. Often the effects of normal wear and tear must be countered as well as breakages that are liable to arise from time to time.

A short while ago an accident happened to a 60-in. boring mill. The main casting weighed 6 tons and a large vertical flange at the top was broken away. When this accident happened it also caused severe damage to the cross slides, each of which weighed 1½ tons. This job seemed to be quite straightforward but the need for extreme accuracy with ample strength called for special care. Nevertheless the mill was in service again within a week of this smash.

Another large machine involved in an accident was a special type of press used for straightening the crankshafts of aero and other engines. From the top of the main casting a piece weighing 15 cwts. was broken away. The jagged fracture measured over 8½ ft. long ; it was "U" shaped and in metal 1⅜ in. thick. Before scientific welding was considered as a means for repair, steel plates had been shaped and then bolted to the main casting and broken section, but the result was most unsatisfactory. The job was then handed over to welding specialists who removed the plates and studs, carried out preliminary preparation work and commenced to weld. As an additional margin of strength was desirable reinforcing plates were neatly welded in position. In this way it is sometimes feasible to double the original factor of safety. Details of this job are shown in Plate 3.

The technique for dealing with damaged castings having thick sections has been so highly developed during recent years that truly incredible work is accomplished with precision and absolute certainty of success. From recent brilliant examples it is difficult to select the most outstanding as almost every one has special features of interest.

Most of the serious trouble that has arisen, and which is not due to an error of judgment on the part of the operator or overloading, is directly traceable to fatigue caused by continuous operation. It was probably this kind of failure which caused the breakdown of a crucible charging machine. This is of familiar type in which the operator and the control gear are suspended from a vertical steel pillar on a horizontal beam and partially counterbalance the charge. This weighs up to 3 tons and is carried at the extremity of a metal tongue from which it is delivered by a ram. The breakage occurred in the complex casting which surrounds the foot of the column and links it with the cage and its weighty accessories.

The failure affected the entire output of a large firm and the position was too critical to allow of time for dismantling and dispatch to the works of the welding engineers. Therefore the job was done on the site with the aid of portable equipment.

Whilst fatigue fracture has become increasingly common during recent years and sometimes puts exacting demands upon welding service, certain machines are subjected to terrific strain for which full compensation is not always feasible. An instance of this kind arose recently involving a particularly large "Bull-dozer." This machine is fitted with a pair of 200 h.p. motors and when it is removing sticky clay the inevitable strains imposed require little effort of imagination. A heavy casting which forms part of the articulating mechanism was smashed into five pieces through metal of heavy section. No replacement was immediately available and, as is the case in so many instances of this kind, welding would have been almost useless unless the repair could be made at least as strong as a renewal. Actually the margin of strength was increased. The whole job was completed and machined where necessary by the welding engineers with so little loss of time that the

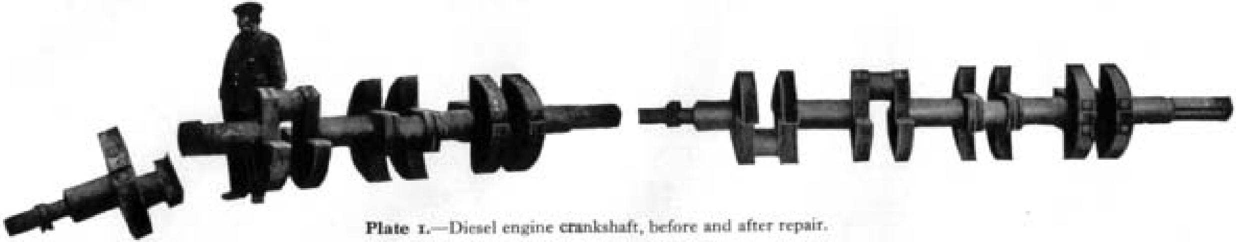


Plate 1.—Diesel engine crankshaft, before and after repair.

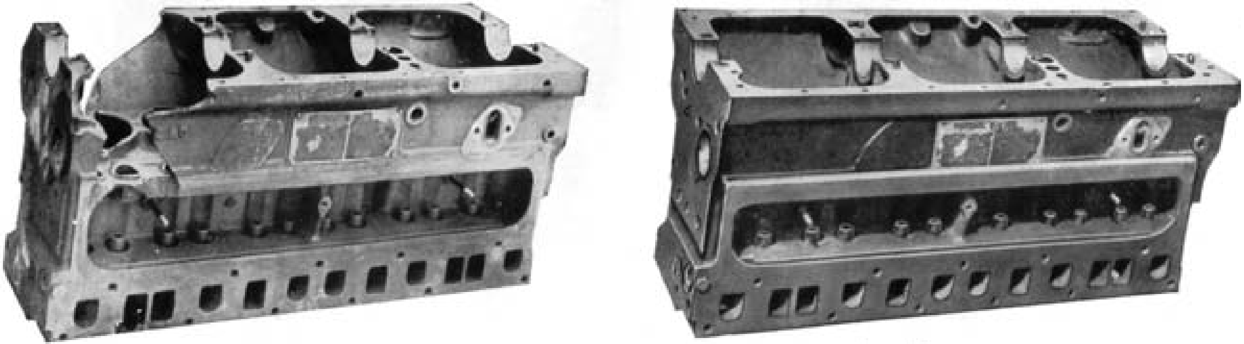


Plate 2.—Cylinder block of heavy type of motor vehicle, broken and repaired.

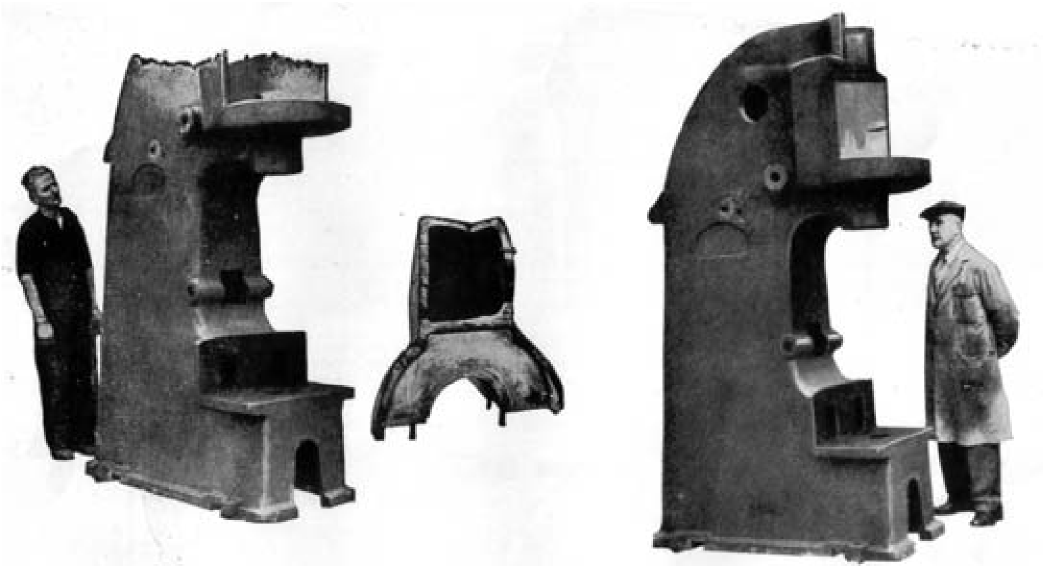


Plate 3.—Powerful press used for crankshaft straightening, before and after repair by welding.

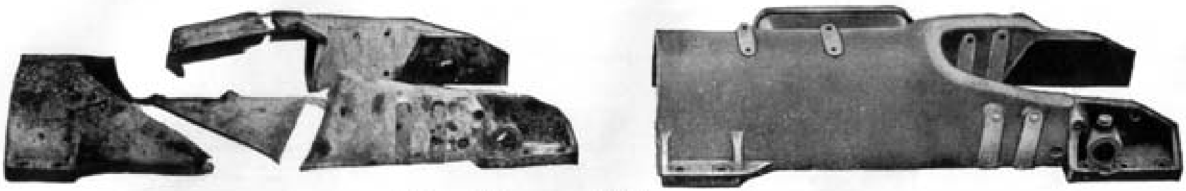


Plate 4.—Broken sump of Bull-dozer ; repaired sump.

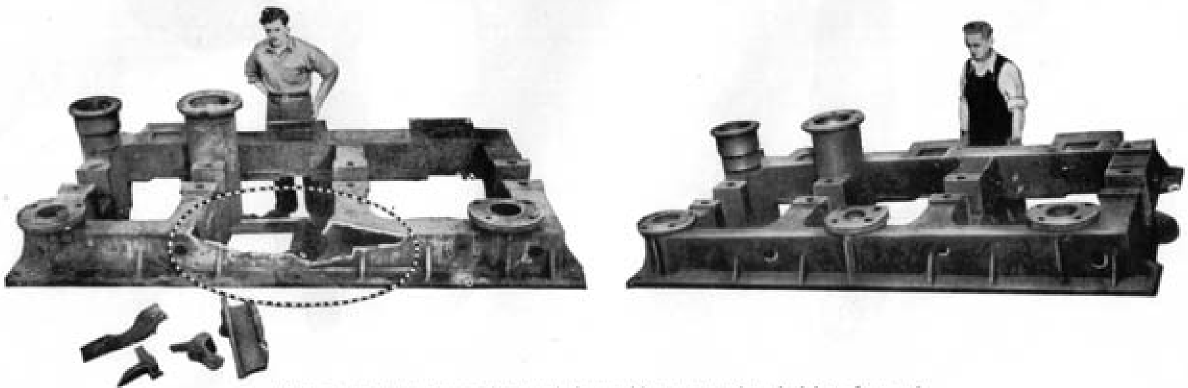


Plate 5.—Bedplate of sea-going vessel, damaged by enemy action ; bedplate after repair.

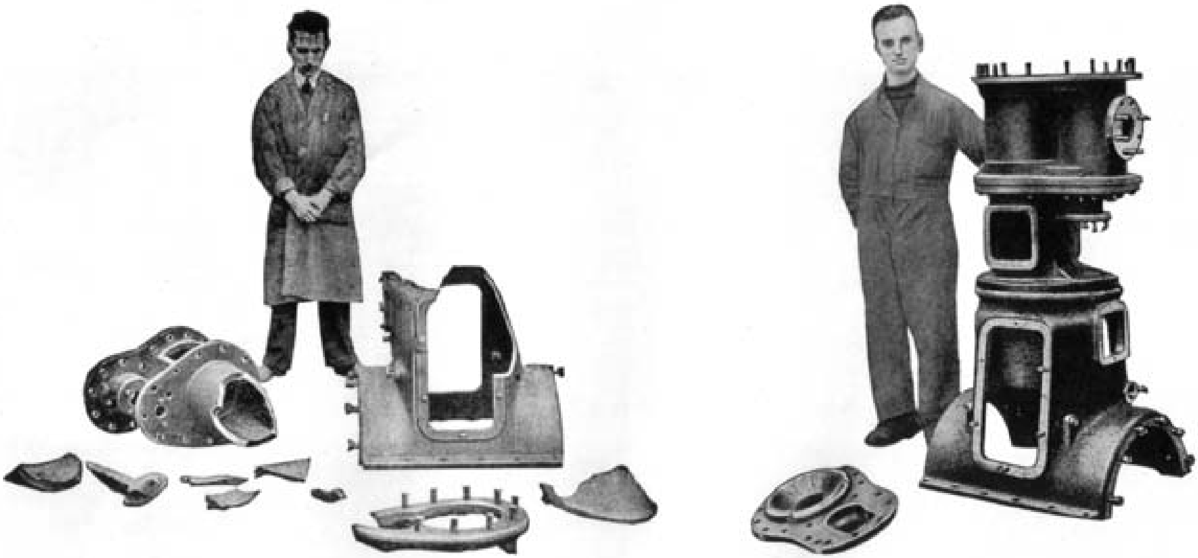


Plate 6.—Badly damaged steam engine ; repaired steam engine.

Applying Modern Welding Methods 6

"Bull-dozer" was in service again well within a week, most of the time being occupied by dismantling and reassembling.

In another case very extensive repairs were made to a broken sump case of a "Bull-dozer". This is illustrated in Plate 4.

Equally creditable work is carried out upon massive castings, for great thicknesses of metal have yielded to modern technique. In one such instance the main frame of a rock crusher was broken. This particular unit is probably the largest in this country and had been manufactured abroad.

To get it to its location, 1,500 ft. up a mountainside, must have been a Herculean feat. It was, therefore, impracticable to transport the broken parts, which comprised the major portion of the machine, and send them to the shops of the scientific welding specialists for attention and subsequent return. Therefore the work was completed on the site within a notably short time. The owners particularly desired to weld the cracks, which were many feet in length, not because replacement implied a delay of at least twelve months, but by reason of the increased strength which could be secured. That the safety factor was substantially raised was very far from being imaginary. Directly the work was completed and the alignment checked and found to be absolutely correct, the crusher was continuously overloaded for more than a week of constant operation in order to catch up with the arrears that had accumulated.

Illustrations of two other jobs are given in Plates 5 and 6.

Plate 5 shows the Bedplate of a small sea-going vessel, damaged by enemy action during the war. A temporary repair of plates was made to keep the vessel at sea for the time being, but at the first opportunity it was decided to have a permanent repair by scientific welding. This was eminently successful.

Plate 6 shows a particularly bad smash to a steam engine because almost every part was damaged, but even in a case like this, there is no need to consign all the "bits and pieces" to the scrap heap. This breakdown was serious because the steam engine was a "prime mover" in an establishment where there was no alternative form of power. The photograph of the repaired and re-assembled parts speaks for itself.

Blocks for all the illustrations to this article have been kindly lent by Barimar Ltd.

Spot Welding

One interesting line of advance is in regard to spot or resistance welding which, nowadays, is applicable to light alloys in addition to sheet steel. An arc is struck between the two sections of metal thus bringing about union without the need for adding extra material in the form of a feed rod. In general practice the electrode must be cleaned and reshaped at fairly frequent intervals, but a method of "refrigeration" has been devised which enables cooled electrodes to be used for much longer periods without the need for attention. In practice the time saved is considerable.

Electrical Welding

Apart from a few announcements in that section of the technical press directly concerned, little has been published so far in regard to a new type of welding that seems likely to transform certain classes of work in the future. The method is purely electrical, but it borrows some of the best points of oxy-acetylene welding. Either A.C. or D.C. current can be used and in some ways procedure is not unlike the older system of employing two carbons and using the arc between the extremities of these to meet the feed rod. It could be described as an electrical equivalent of the oxy-acetylene blowpipe.

Although there is a superficial similarity of procedure carbon electrodes are not used nor are they at all like the electrode fitted to a spot welding machine; actually the electrode is a feed rod, the arc being struck between the point of this and the parent metal. The chief departure from previous practice is the introduction of an additional feed rod. This is in no way an electrode but a simple cast iron stick, or maybe a length of round steel, depending upon the work to be done. The end is thrust into the arc where it melts and amalgamates with the molten metal from the electrode. In this way it is possible to deposit at three or four times the normal rate. A notable degree of hardness is obtained, work is done much more quickly whilst the resultant saving in man-hours reduces the cost substantially.

It is not suggested that this system can cover every welding requirement, any more than any other single process can do this. Obviously too much hardness can be a drawback when subsequent machining is required, or a component handled in this way is subjected to shock load. To meet needs of this kind there are other effective methods and a wide range of suitable materials. At the same time the field for the new process is extensive, particularly where large areas of hard surfacing material are required.

A typical application of great importance is in relation to the rapid and heavy wear that arises in connexion with tracked vehicles. With no possible means of avoiding this deterioration the next best thing is to provide a quick and efficient means of repair.

The process just described is well able to deal with worn track. It is by no means uncommon for areas of 40–50 sq. ft. to represent the combined total of parts needing attention on a single vehicle. Obviously this opportunity is capable of considerable extension.

A point that should be remembered is that skill and experience on the part of the operator remain an inflexible condition toward success where repair work is concerned. In no sense can automatic methods be applied when dealing with fracture, wear or corrosion, for which welding is the chief remedy apart from replacement at far higher cost.

Flame Cutting

Flame cutting is far more than a medium of destruction. From steel plate, sprockets and pinions are flame cut to a master pattern. The rate of travel is, of course, automatically controlled, but the results are so accurate that a gear wheel formed in this way may be fitted without the need for any further treatment.

On a modern machine used for degreasing and polishing, the writer recently counted no fewer than forty gear wheels and sprockets, each one of which was flame cut.

There are many instances of brackets of complex design together with numerous other parts previously made from drop forgings but now superseded by this rapid method for cutting from the solid without trace of ragged edges.

The entire framework of several types of machine is built up of flame-cut steel plate. There is a substantial saving in weight as a consequence and a greater shock load can be carried without risk of fracture.

Bedplates for auxiliary machinery with box mountings for pumps and dynamos having different centres are less liable to fracture when they are built up from steel plate. The cost is higher than a casting, but only in cases where the price of the patterns cannot be spread over a number of identical items; up to a total of about six, welded sheet metal is the cheaper method.

Welding of Non-ferrous Metals

Welding work applied to non-ferrous metals is another highly important sphere of development. In these days materials having so large a magnesium content that they are inflammable in the form of filings or small fragments can be welded successfully.

Equally striking is the welded combination of totally dissimilar materials. For example, aluminium can be welded to steel perfectly and with such certainty that the area of union will prove stronger than the weaker of the two parent materials in a test to destruction. Other similarly remarkable combinations are feasible.

Inspection of Work

Obviously the extremely wide scope of modern welding and the variations in technique tend to emphasize the desirability of careful inspection in relation to certain classes of work.

Some welds will be in their virgin state and they will be subject to a certain standard of neatness. The inspector will, therefore, have to decide what is, and what is not, a passable weld from this point of view. Also he will have to detect cracks and occluded flux in the weld and this will not always be easy by visual examination. For some types of work X-ray, magnetic flux and fluorescent compound apparatus will be needed for crack-detecting purposes.

In the case of machined welds certain flaws and blemishes will be detected fairly readily, but in other cases the crack-detecting apparatus may be needed. Standards too will have to be fixed, especially in the case of joint faces, and if the component is subject to pressure in use, hydraulic or air tests may be necessary. The inspector will also have to make himself conversant with welding technique and symbols which are now becoming standardized.

The use of radiography for inspection is virtually indispensable with certain classes of work; for this reason it is necessary for inspectors to understand the use of X-rays and gamma rays for examination purposes.

There is no need to emphasize the variety of opportunities that welding affords for dealing with repairs in the field, but, if a high quality of difficult work is to be achieved, careful training of operators is imperative. It is precisely for this reason that so much commercial work is passed to specialist firms who are staffed and equipped to deal with the most complex requirements.

" RELOOK "

THE HISTORY TO DATE OF LIPHOOK ENGINEER STORES DEPOT

By LIEUT.-COL. H. E. WILLIAMS, M.B.E., R.E.

LATE in 1943, when the planning for the actual invasion of Europe was being considered, the provision of all plant and machinery and its production and supply had already reached an advanced stage, apart from the fact that considerable quantities of plant and machinery for R.E. uses had already been supplied and shipped against a global commitment. These latter R.E. Stores, together with those assembled against the D-day and subsequent demands, were stored either at Long Marston or at one of the forty civilian warehouse or wharfinger depots which had been requisitioned to accommodate them.

Unfortunately, all of these requisitioned depots, as well as Long Marston Depot, were not designed to store heavy machinery in properly constructed buildings. Indeed, in most cases the sites were badly drained and lacking hard standings and storehouses. These unsatisfactory conditions and the resulting deterioration to the stocks were fully appreciated by the Director of Engineer Stores and by the Chief Engineer, 21 Army Gp., and his staff.

Conferences were convened, and when the seriousness of the situation had been investigated, it was decided that a depot would have to be provided without delay, equipped to receive, service, test and " temporarily " preserve all R.E. plant and machinery needing attention before shipping for D-day.

The selection of a depot site in this country is a difficult matter, if due regard is to be given to the numerous requirements that have to be fulfilled. It must be realized that at the time this project was undertaken the whole country's labour force was mobilized, and practically all R.E. units were taking part in intensive field training preparatory to D-day. After consultation with the Ministry of Labour, the War Office decided that such a depot should, as far as possible, be manned by civilian labour. The location of the depot had, therefore, in general terms, to be sited :—

(1) As near as possible to a railway, so as to reduce permanent way construction to a minimum.

(2) Convenient to a main road, to permit the heavier traffic (low loaders, etc.) to approach and enter the depot without difficulty.

(3) Adjoining an inhabited area where water supply, sewage system and drainage were available.

(4) As far as possible accessible and central to the invasion base ports from London Docks around the south coast ports to Bristol.

(5) To interfere as little as possible with War Agriculture, and on land which in wet weather would tend to drain naturally.

(6) In an area where civilian labour could be collected with a minimum of trouble.

(7) Where the engineering problems incident to construction and maintenance would be as small as possible.

Obviously there had to be sufficient acreage to accommodate the stores to be handled.

It will be seen, therefore, that to fulfil these various conditions must have set the officers making the reconnaissance a difficult problem, and whilst there are shortcomings which have become apparent as a result of operating the depot, the selection of the site at Liphook was apparently a good choice, and reflects credit on those concerned. The selected area that was converted into the depot was originally Chiltlee Manor, Liphook, Hants.

Liphook is a scattered parish of about 4,000 persons. It is fifty miles from Southampton, and forty-five from London Docks by road or rail. The actual depot is 400 yds. off the London–Portsmouth road, and Portsmouth is twenty-five miles distant. The majority of the population is employed agriculturally, but skilled labour from the towns within a twenty-five-mile radius can be brought to the depot on the Southern Railway electric service. Liphook Railway Station adjoins the depot.

The village itself is at the intersection of three main roads: London–Portsmouth, Haslemere–Midhurst, Bordon and Longmoor (where No. 1 Transportation Stores Depot was installed).

It is of interest to digress here, and quote the local folk lore regarding the somewhat peculiar name of the village. In the good old days when smuggling was a recognized and lucrative occupation (always excepting when one was caught!) the smugglers operating at ports roughly between Chichester and Poole utilized the cross road as a clearing house; a posting house, now the Royal Anchor Hotel, being the hub of operations. The preventative men, together with the soldiery, were quartered at Hindhead, about five miles away. When information was received that a consignment was approaching "Liphook" the preventative men and the troops descended from Hindhead, and, if plans were successful, rounded up all or some of the smugglers, who were incarcerated in a barn under guard. This barn became known as the "lock-up" and from this, so it is alleged, the name "Liphook" has been derived. Its only modern claim to notoriety is the Royal Anchor Hotel, a most excellent hostelry, where Admiral Lord Nelson (en route for Portsmouth) brought Emma, Lady Hamilton, and stayed the night.

The code name "Relook" is a combination of "R.E." and "Liphook." It illustrates the depot's activities, and is used as telegraphic address, file title, and serial prefix on machinery cases, etc.

The depot site of Chiltlee Manor consists of an area slightly over eighty acres, generally falling from N.E. to S.W. at a grade of about 1 in 10. It is bounded on the western side by the London–Portsmouth line of the Southern Railway. (See Plate at end of article.)

The soil is sandy near the surface, the result of leached-out low quality ironstone. At depths of from 6 to 10 ft. a clay stratum follows generally the same incline. The ground, therefore, does permit of a good degree of natural drainage, and in point of fact, twelve hours after heavy rain the surface is relatively dry (see Photo 1). However, the natural slope had to be modified to permit the laying of railway tracks, and resulted in a fair amount of cut and fill.

Early in 1944, as soon as the site was requisitioned, a tented camp was set up and the following units of 21 Army Gp. arrived to commence operations under the direction of Canadian C.E. Works:—

3rd Batt. Royal Canadian Engineers.
1 Canadian Road Constr. Coy., R.C.E.
873 Mech. Equip. Coy., R.E.
486 Tipper Coy., R.A.S.C.

The greater part of the work was completed in two months. This consisted of all earth moving and levelling, the laying of railways, the provision of all concrete roads and the hard-standing areas, the erection of four Nissen huts, six Romney huts, one low Marston shed and one high Marston shed, water supply, sanitation and drainage, and a small 75 kw. power station with overhead transmission. This was a most creditable performance.

About this time, No. 5 E.B.W. arrived, and simultaneously machinery and plant requiring attention began to come in, in ever increasing flow.

The first problem was cranes, and until these were in operation life was hectic, and only on account of the foresight of those responsible for the layout was it not even more confused. The railway sidings are arranged with one platform at truck deck level, and the other at rail level, except 4 and 5 platforms, which are both at truck deck level (see Photos 2 and 3). This permitted unloading without cranes, but of course at a comparatively low speed.

Having put eleven 19 R.B. cranes into use, it was decided to lay Decauville track to facilitate the movement of stores from railway sidings to the store parks, and from thence to the workshops. It was realised that much waste of time in handling was still taking place, and requests were made for Fork Lift trucks, which were known to have been developed in America, and to operate with very considerable saving of time and labour. For these the depot had to wait, but it was, however, the first depot in this country to employ them.

Recruiting of civilian labour was being actively carried out. Eventually the depot was granted " bottleneck preference " which was the highest degree of preference, and the same as that enjoyed by an aircraft factory. With the gradual increase of civilian employees, the proper facilities required by the Factory Act and the Ministry of Labour had to be provided, i.e., ablution facilities for women and men, a civilian canteen, an assisted travel scheme for road and rail travel, protective clothing, first-aid room, and women's rest room. These were all built by the depot personnel with stores supplied by the D.C.R.E., whose labour apparently had left him to join the depot staff.

In June, 1944, seven more Romney sheds were erected along No. 5 platform, and consideration was given to constructing a hutted camp for the winter. Owing to the lack of personnel to build the camp, the Director of Labour drafted in to do the work the following batches, each of about thirty men, and one batch relieving the other. First, German P.O.W., next Italian P.O.W., next Russian subjects of the Todt organization captured in France, and finally Poles. The construction of that camp was an outstanding exhibition of dumb charades and precept.

Shortly after D-day No. 5 E.B.W. received orders to embark for Europe. When they moved out, the serious depletion of the labour force, particularly of skilled mechanics, practically brought the work in the depot to a standstill. In one week it was only possible to dispatch 350 tons.

Instructions were then issued that four men from every R.E. unit in the U.K., none of whom should be above medical category " C," would be detailed to report to E.S.D., Liphook, on a certain date in August. Everybody except the depot knew about this, and one evening 280 woebegone Sappers, without N.C.Os. or unexpired portion of their rations, arrived at the camp. There was no food, no palliasses, no blankets—only discontent and bad temper. At the time there were only three officers left at the depot, and for about a week life was very difficult. Of the 280, about forty finished up in jail on civil charges, within six weeks of joining the depot. The remainder, bereft of their influence, were more tractable, and, in fact, eventually worked up

Photo 1.—Part of tractor park, 4 hours after 8 hours' rain.

Photo 2.—Nos. 1 and 2 sidings.

Relook 1-2

Photo 3.—No. 5 siding.

Photo 4.—No. 3 plant park with workshops in background.

to a most efficient team, and it was due to this team spirit that the depot was able to reach peak tonnages of about 11,000 per week, and to average 8,000–9,000 for weeks on end.

It is of interest to note that much was done by providing entertainment and an occasional " dinner " and smoking concert to improve the morale of the men, and eventually by making labour teams and working them in friendly competition. The inspiration given by the depot officers was also a potent factor in achieving co-operation. On joining the depot, all officers were taught to drive mechanical equipment, for at this period the R.E., and not R.A.O.C., were handling it, and very considerable quantities were passing through the depot. When a train-load of tractors arrived in the depot, all officers would turn out in overalls, and each collect his gang of Zombies (lost souls—the name given to the troops) and proceed to unload, drive and park as many machines as possible, in competition with the other team. One train of 36 D.4 tractors was cleared and the tractors parked on dunnage in thirty-five minutes from start to finish by ten teams.

By September, 1944, the depot had settled down and arrangements were commenced to draw up suitable standing orders, orders for the operation of depot plant and machinery, organize a fire service and brigade, draw up civilian standing orders, and equip and open the civilian canteen.

The tempo of handling of stores and development of better packaging and preservation began to improve.

Information was now trickling through from the U.S. forces regarding the American Service of Supply and their methods of packing, and more particularly preservation, to meet the rigorous tropical conditions of the Pacific war. It was evident that the British forces would have to adopt something on the same lines.

As time passed, the sizes and weights of generating and pump groups, and also of cable drums and tractors, increased, and cranes of greater capacity had to be obtained. A 40-ton electric gantry was installed to deal with road and/or rail transport, and a 33 R.B. and a 23-ton Lorain tracked crane were put to use. All these three cranes have given outstanding service, but of the two crawlers it has been found that the Lorain is a rather better machine to handle.

Up to this time, owing to the limited covered space, much work had to be done in the open. This was, of course, most unsatisfactory, but it was the only way. Similarly, engines requiring to go to the workshops for complete overhaul and/or test were impeded due to plant having to be retained in the shops to be preserved and packed.

The provisions of B.S.S.1113 for the construction of packing cases, etc., had to be applied to all cases dispatched overseas. Most of the cases for the older machines fell far short of the specification, and new cases were required. It was decided to reorganize the woodworking machine shop, and take the machinery from the existing woodworkers shop and move it to an adjoining Romney hut. This gave more space for case building.

Simultaneously, arrangements were made to provide a new shop designed and equipped as far as the knowledge of preservation had progressed, with special regard to the variety of type and size of stores to be handled. A high Marston shed was provided for this purpose, and was erected by the depot staff and equipped in three months.

With the changing situation subsequent to the Japanese collapse, the military strength of the stores personnel has decreased, and the civilian staff, industrial more than non-industrial, has increased. The depot activity has, of course, decreased, but at the same time the closing down of other depots has been carried out operationally from Liphook. The work of preserving and repacking the large quantities of machinery and plant to be held as War Reserve will occupy the present staff for about four years at least, probably longer. If covered storage were available, the life of plant held under such conditions when properly preserved,might be as much as fifteen years, whereas if it still has to be stored outside, on dunnage, and covered with tarpaulin sheets, it is expected to be not more than five years. If proper store buildings cannot be provided, then preservation will have to be undertaken every four or five years on a rotational basis, with practically no reduction of the present staff.

The electrical test arrangements now installed are sufficient to absorb 500 kw., A.C. or D.C., and the pump testing gear will take up to 35,000 g.p.h., artificial head being imposed by fitting suitable valves to the pump under test.

With the growing power load, additional plant was installed in the power house. This installation now consists of a Petter/Brush 125 kw., a Bellis & Morcom/G.E.C. 105 kw., and a Lister/Maudsley 25 kw. This station has a very bad diversity factor owing to the use of two 10-ton E.O.T. cranes and one 40-ton gantry, in addition to machine tools and current used for motor testing. It is not unusual to see the main bus-bar ammeter hard over for several seconds, and often holding 360 amps per phase for several minutes. The normal load in summer is 120/150 amps., and in winter 250/280.

The station is fully costed. It is run under the care of the I.R.E.M. and his mechanists, by two permanent R.E., and three others passing through on training. The all-in cost including rent, depreciation of building and plant, and all fuel, stores and repairs, averages about 2·5 pence per unit. During the winter, with the higher loads, the cost drops to 1·5 pence. Outside supply from the Public Utility Coy., is only available up to 30 k.v.a. single phase. Due to the Canadian construction, the wiring in the camp is split single phase, and since, when the generating plant is operating, it takes over the lighting load, a certain amount of out-of-balance is inevitable. However, this is economical to carry because the cost of outside supply substantially exceeds the generating cost, apart from the fact it makes the depot independent of the grid and load shedding.

It is to be noted that the different makes and sizes of generating sets, each with its own characteristics, make the operation of paralleling and engine control a matter of great care and thought, and consequently is most useful for training.

The accounting system of the depot is a dual one. On the stockpile side a special system which has been evolved is used, and records are maintained in the depot on tally cards by the stockholder, and on Kardex cards in the depot accounts office.

On the other hand, the depot-use stores of A, A1 and B stores, hand tools, depot-use plant and consumable stores, also civilian protective clothing, are accounted by tally card and ledger system (the same as the system used in D.F.W. Command Storehouses). Issues of consumable stores are made against A.B.43, and temporary receipt for "A" stores on A.B.108. This particular section involves an unusual amount of detail to ensure proper accounting.

The occupational record of each parking area or store shed is maintained on a separate circular diagram. The diagram is a 4 in. dia. circle drawn on a sheet 8 in. × 6 in. and the particular data relative to the specific park or shed is inserted in a space below the circle. The chart is divided by fifty-six equally spaced radial lines and on fifty-two of them the position at each week-end is noted with the date. The charts are of standard size (printed from a tracing) and the radius of the circle represents the area of the relevant park. Obviously the scale must be computed to suit the particular park. The scale between the disc's increments on the radius is given in square yards. This allows the storeholder to pace out and square up all unoccupied space, sum it up and advise the drawing office each Thursday. The draughtsman, commencing from the circumference, counts in towards the centre to the scale which is marked on the card, according to the uncovered space on that week-end line, and colours in red the segment to illustrate the covered area. The office staff who have access to the charts, can therefore see at a glance how the parks are occupied.

As a result of observations made during the operation of this depot from its commencement to date, the following points emerge :—

(1) If efficient stores personnel are required in a static stores depot, bearing in mind the need for expansion in emergency, then most of the officers and all the operating personnel, including clerks, should be civilians.

(2) Great importance must be attached to proper inspection on reception, during servicing and testing, whilst being preserved and packed, and finally when being dispatched. This is essentially a matter for military personnel (I.R.E.M. and Mechanists) who are, after all, the users' technical representatives.

(3) Opportunity may be taken in such a depot to instal a competent military instructional staff to act as a training unit in R.E. storekeeping and depot operation.

(4) Mobile flood lighting, generating sets and pylons are a most useful, adjunct in war, provided air raid warning arrangements can be made to allow early dowsing.

(5) Trees are objectionable in the depot. Stores must not be parked near them and falling leaves are a nuisance in autumn, resulting in choked drains. Their presence is no aid to camouflage.

(6) The provisions of B.S.S.1133 for packing case construction, if adopted, caters for stowing in ships' holds of case upon case, so that cased machinery can be stowed to approximately 25 ft. high, without danger of the lower tier collapsing.

(7) R.E. Stores are somewhat the "Cinderella" of Military Stores and have had to operate and function in abnormal conditions, particularly lack of proper storehouses equipped to house and economically maintain the various classes of plant and machinery in properly ventilated and dry atmosphere. Proper hardstandings are a rarity in R.E. Store depots. They are most necessary.

(8) The cost of preserving and packing plant and machinery in accordance with the code laid down in B.S.S.1133 amounts on the average to about 15 per cent of the prime cost of the item concerned, above that normally involved in peace-time practice. From a commercial standpoint, manufacturers in competition with foreign firms for world markets, are unlikely to adopt the B.S.S. code, with the risk of losing the market. The conditions in peace do not justify the cost, because, due to speedy transport and the buyer being likely to put the article into use on delivery, the pre-war standards are adequate. Therefore it would seem probable that the Services will have to make arrangements to effect their own provisions for their adherence to the B.S.S. code, and possibly consider the setting up of even more comprehensive and larger preservation installations to which machinery can be delivered for treatment and packing. The experience at the depot is that, even in 1946, very few firms were supplying machinery which had been

preserved and packed to the standard that was required by the code. In fact, it is probable that the installation and equipment required to do the work properly was not available at the majority of the factories.

(9) Crane drivers capable of handling cranes efficiently are scarce. They are the most important members of the store-handling staff and generally the lack of a crane operator means the machine and about twelve other stores personnel come to a standstill. The importance of training crane drivers and maintaining sufficient numbers in the Corps is worth consideration.

(10) The use of fork lift trucks for loads up to six tons is again stressed. Where hard standings are provided they are much more effective than crane and decauville combination. At this depot, one 16,000-lb. Ross Fork Lift, with a female operator aged eighteen when trained, has in three years moved over 30,000 tons, and travelled over 5,000 miles. It should be realized that only one assistant is used with the fork lift, whereas a crane gang is five men in addition to the driver.

(11) Loading of parking areas and floor space in store sheds. In either case it has been found that about 25 per cent of the total area must be allowed for movement and handling within the park or shed. In stowing uncased plant and machinery, each square foot of usable parking area will take approximately 2 cwts. When plant is cased, however, in cases conforming to B.S.S.1133, stacking up 20–25 ft. is permissible. Under these conditions, each square foot will carry approximately 5 cwts.

As a "rule of thumb" to compute the space required for cased and uncased plant and machinery, the following can be used.

Sq. yds. of area required =

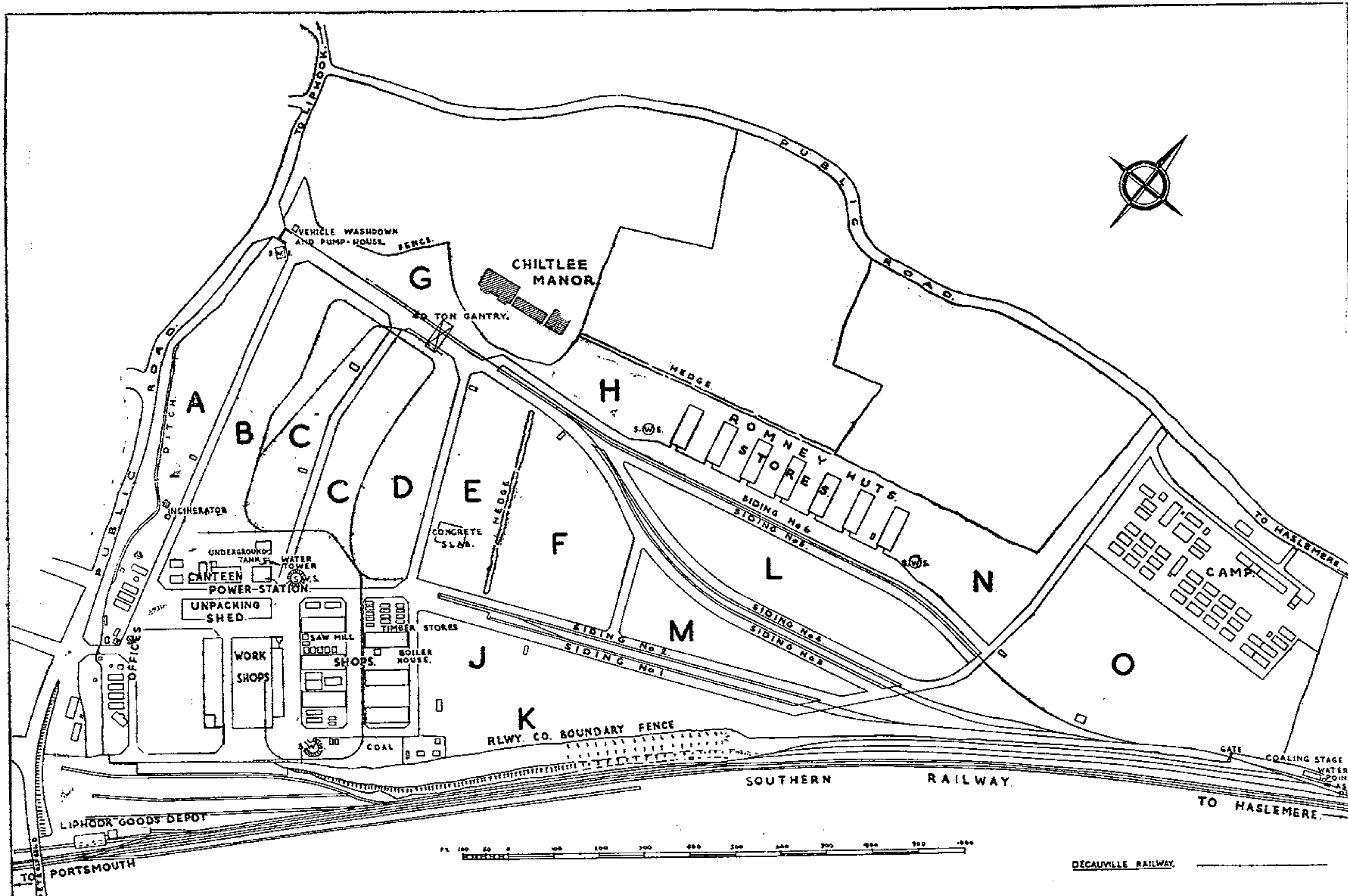
$$\frac{\text{Number of cased machines} \times \text{Weight of packed case in cwts.}}{40}$$

or

$$\frac{\text{Number of uncased machines} \times \text{Weight per machine in cwts.}}{12}$$

(12) The proper marking of cases to permit rapid and correct identity and consignee's address, etc., is most necessary, and in the interests of all concerned, a standard arrangement of the markings should be adopted. All four sides should be marked, so that complete markings are visible from any corner.

The foregoing does not, of course, form anything like a complete record of all the transactions and difficulties that had to be overcome but it is hoped it gives an outline, and a few useful points that may be of general interest and use.



GENERAL LAYOUT No.2 E.S.D. LIPHOOK.

ANTIMALARIA FIELD ENGINEERING

By MAJOR W. E. C. PETTMAN, R.E.

"*If abolition of breeding places is the method to be pushed, the engineers must be instructed in detail as to what the breeding places are and also the methods most suitable for dealing with these; if the choice of sites for bungalows is important, such selection should not be left to inexpert persons.*"

MAJ.-GEN. SIR GORDON COVELL,
Director of the Malaria Institute of India.

MALARIA FOR ENGINEERS

WHEN the recent Burma operations began, about half our casualties were due to malaria. At the end, any unit whose malaria incidence exceeded about 5 per cent attracted serious and unpleasant attention. This improvement was the result of an intensive antimalaria campaign, which included some novel work for sappers. Technical details have been recorded elsewhere and the following is a general outline of the subject.

Malaria influenced engineering long before the last war. The Panama Canal scheme, for instance, was impracticable until yellow fever and malaria, both mosquito borne, were overcome; the Singapore base has malarious memories for those who built it; during the building of the Zambesi Bridge, in one of the most malarious parts of the world, not one European employee suffered malaria, because the Cleveland Bridge Company took antimalaria precautions before starting the work. Sir Malcolm Watson, when Principal of the School of Tropical Medicine, declared that engineering which spreads malaria is bad engineering—a statement which makes one think. Borrow pits and dams exemplify this, and it seems that some acquaintance with malariology is as necessary for an engineer in malarious countries as some knowledge of flying requirements is to one who constructs an airfield, or of enemy methods to a field company sapper. The motto "know your enemy" applies as forcibly to an antimalaria as to any other campaign, and since the sapper's part is concerned chiefly with the attack on mosquito breeding places, we will now consider these.

KNOW YOUR ENEMY

Not all species of mosquito carry malaria to man. Those that do are called *vectors*. All vectors belong to the genus *Anopheles*, whose appearance is easily distinguishable from that of the other genus—the *Culicines*. Different species abound in different localities, and it is seldom that more than one or two vectors are active at the same time and place, though there may be seasonal changes during the year, since the species vary as to their choice of breeding conditions. The eggs are laid on water, where they remain for at least eight days before hatching into adult mosquitoes. The egg changes first into a *larva* and then into a *pupa*, which is the same thing as a chrysalis as far as the lay mind is concerned. During this period it floats and is vulnerable to many methods of destruction. The egg has no external life, but the larva, which lies just below the surface, feeds on minute particulate matter and breathes air through tubes. It can be poisoned by "paris green," a floating arsenical powder, and it can also be choked by oil on the surface. Pupae, too, can be choked, but not poisoned, since they do not eat. All three forms are practically immobile and helpless, and can also be killed by violent disturbance of the water or by stranding on the bank after a wave. If washed into the current of a stream they may be swept away and probably killed in the process.

Only the female carries the malaria parasite, which she absorbs when sucking blood for nourishment before laying eggs. Some species prefer the blood of cattle or birds, but vectors take it from man. If a blood donor has had malaria within about three years, his blood contains the parasites, some of which thus enter the female mosquito, in whose stomach they thrive and soon become ripe for activity in another animal's blood stream, which they may enter at a later blood feed. The proboscis through which the blood is sucked is so thin that if the blood congealed in it the female would be choked. Therefore, before commencing to suck, she injects through it, into her victim's blood, some saliva which is so composed that it prevents coagulation. It also contains the parasite. It is the arrival of this saliva beneath our skin that we feel when we are—as we loosely call it—"bitten" by a mosquito, but by that time the damage is done, and the subsequent swatting of the pest will not undo it. A mosquito in a crowded room may be hunted from man to man and infect several while seeking her feed. The parasite, however, does not pass to the egg, so each mosquito is born free from malaria and does not become dangerous until after sucking infected blood.

The Antimalaria Campaign

The campaign against malaria resembled a military campaign, in that all ranks of all arms were trained to combat the enemy ; the steps taken were offensive as well as defensive ; calculated risks were accepted ; and the ultimate success was achieved by the combination of all weapons, each of which had its peculiar characteristics. D.D.T. and Mepacrine, for instance, burst on the lay mind as sheer magic, yet each had its limitations, just as bombs, torpedoes, and chemical warfare have in actual war. D.D.T. was popularly expected to win the game off its own bat by exterminating all mosquitoes, but practical considerations prevented this, notably the quantity required and the difficulty of applying it to some of the places concerned. Aerial spray, for instance, needs many aircraft and elaborate arrangements, is not always accurate, and does not penetrate buildings or dense jungle. Further, although it kills infallibly, it does not kill instantly, and a doomed mosquito can spread malaria before "passing out." Mepacrine certainly suppresses the unwanted effects of malaria, but it does not kill the parasite within, and one day's break in the dosage is enough to release the latent trouble. Moreover, it does not prevent the parasite from infecting a vector and thus passing malaria to others who may not be protected. Incidentally, simple minds react curiously to rumours about Mepacrine. Inconvenient religious scruples appeared, and many petty ailments were unfairly attributed to the little yellow tablets. A Calcutta chemist quite untruthfully warned his customers that these caused impotence, while elsewhere in the same city a quack was selling them as aphrodisiacs. Obviously, proper understanding is essential. Mepacrine, however, is now replaced by Paludrin, about which there is much to be learnt. It promises to do great things.

Antimalaria "small arms training" for high and low consisted of the use and repair of mosquito nets, timely application of mosquito cream, correct use of "Flit," regular consumption of Mepacrine in the war area, and "shorts and shirtsleeves" drill. From dusk to dawn, bare arms or knees were a crime. Shorts, kilts and skirts gave way to slacks. Even on peaceful club lawns back in India, officers of considerable seniority were interrupted at their "sundowner" and sent off to change from tennis kit into safer clothing.

An effective precaution, and one which concerns engineers closely, is "Evasive Action." Few tropical oriental mosquitoes travel more than about half a mile from their breeding places, which are easily recognized by malariologists, so it is often feasible to site a camp or base out of reach of the local vectors. Unfortunately this was not done when the L. of C. through Assam was planned, and casualties were consequently heavy during the first few years. Later, this factor was better appreciated, and a few changes in layout saved not only casualties but also the expense of elaborate drainage systems. Expense here is not measured by money, but by the active service coinage which reckons L.S.D. as "Lorries, Labour, Stores and Days." It was largely from engineer statistics and estimates that the significance of this became apparent, and when the antimalaria engineers acquired a working knowledge of rudimentary malariology they were able to contribute much to the siting and layout of some of the camps. The lesson from this seems to be that a malariologist should have a large say in the *original* planning of a campaign in malarious country instead of being called in *afterwards* and credited with magic powers. A really expert malariologist is necessary for this, and he should be consulted at the outset, since not only is an experienced eye necessary on the spot, but also much entomological data about the country is required, which may take some time to collect. Incidentally, the dodging of malaria vectors can influence war considerably. Troops fighting in the Burma jungles avoided, when possible, the neighbourhood of villages at night, since that was where infection was rife, and mosquitoes abound in the dark. When the Japanese advance was halted at Kohima, the defenders were fortunate in being too high for mosquitoes to live, while the attackers suffered horribly from malaria in the warm jungles below. In Sicily each side enjoyed occasional immunity in the hills. The Chindits were better equipped with antimalaria drugs than the Japanese around them. Nearer the L. of C. engineers' purview is the case of a hospital at Palel, on the L. of C. through Assam, which was on a hill 150 ft. above a prolific breeding ground. Had it been only a little higher, mosquito nets would have been unnecessary. In fact, war in malarious country is more influenced by entomology than most people realize, but this digression has gone far enough. Back to our mosquito war.

Birth Control for Mosquitoes

The search for breeding places is helped by the fact that mosquitoes are fastidious about the water on which they will lay their eggs. They cannot, for instance, breed in the stagnant swamps with which they are commonly associated, though they may flourish in the slowly moving cleaner water which is usually found in such localities. Temperature, light or shade, floating vegetation, and chemical impurities affect different species differently. One, for instance, favours a *soupçon* of sewage, and a few abound in slightly brackish coastal water. Any strong flavour repels them. One example of this is water hyacinth, which otherwise has little claim on our thanks, and another was furnished in Imphal by a bobbery mule, who upset a load of perishable rations into a malarious stream and thereby robbed potential vectors of an ideal home for several months. Mineral salts affect the matter too, and so also do physical conditions, some species being better able than others to survive turbulence. One is deterred by grass growing more than a foot above the water, since this annoys the female when zooming in to drop her eggs; this species practically disappears from paddy fields when the rice reaches the critical height. All these peculiarities not only assist the search for breeding places, but they also determine the work required to neutralize them, and it will be appreciated that any discussion of the subject involves frequent reference to the habits of the local vector.

Another point to remember about breeding control is that it does not begin to check malaria until the vector density is so reduced that the few surviving females can find all the blood they need from a portion only of the human population, thus leaving the remainder unscathed. The extent of reduction required to effect this cannot be calculated exactly, nor can the result of the work be measured. In Assam the malariologists assessed the target as a 95 per cent reduction, and the work must have been fairly successful since experts attributed to drainage a major share of the conquest of malaria. It was recognized that the vital base of Manipur Road would not have been habitable at all without the 600 miles of antimalaria drains which permeated the surrounding jungle.

The business of identifying the local vectors and describing their habits is the responsibility of the malariologist, who may or may not be a doctor but is, in war, a member of the Medical Services' Antimalaria staff. The spoiling of the vectors' breeding places is also a medical responsibility, but engineers may be wanted for such matters as drainage, jungle clearance, survey, contract labour, and dams. The Medical services are, in fact, the " G " staff of the antimalaria campaign, the malariologists are their " I " branch, and any engineers who work for them must be well briefed. Malariologists with practical engineering experience are too scarce to be always available throughout the theatre of war, and their representatives in small formations cannot always appreciate the technicalities of the Sappers, who must, therefore, learn enough science to make sound decisions for themselves as their work proceeds. Not only does this entail a thorough knowledge of the local vector, but also of others which may be encountered, otherwise the steps taken against one may encourage another. In the Federated Malay States, for instance, before the war, a shade-loving vector named *A. umbrosus* was successfully attacked by jungle clearance, whereupon a more dangerous vector, *A. maculatus*, for whom the light of day has no terrors, took up residence. This last named vector would have confronted the Fourteenth Army if the advance had reached the hills east of Burma, and the engineers were coached by the malariologists in the steps to be taken in that case. *A. maculatus* is a tough customer, and it was fortunate that the course of the war removed this species from our visiting list.

Other surprises await the vector hunter. Some malaria carriers, for instance, prefer cattle's blood to man's, but will feed from man when the cattle are removed, which often occurred during the Japanese invasion of Burma. Again, the damming of a stream enables waves to be released, which interfere with breeding in the pools along its banks, but the larvae which are washed into the current may hatch out downstream and spread malaria elsewhere. A gap cut in thick jungle may admit vectors to a hitherto healthy spot. Outbreaks have even been traced to vectors inadvertently transported in vehicles. So wide is the field of possibilities that engineers working—as they must do in war—very much on their own responsibility need a briefing so thorough as to amount to a study of the relevant entomology, as well as a certain amount of botany and geology. This is no more abstruse than the lore of shootin', fishin' and huntin', and is merely the normal business of studying the customer's requirements. It is, incidentally, interesting, and sometimes forms a refreshing change from more humdrum forms of field engineering. It has, however, the military disadvantage of bringing Engineers more under the control of the Medical Service than of their own Corps, owing to the dependence of their planning on factors which few engineers study. If, for instance, the antimalaria engineer considers a scheme impracticable or extravagant, he turns first to the A/M staff. His C.E. is only concerned with the " General Idea," and his C.R.E. with the " Special Idea." " Narrative " and " Problems " are more technical.

ENGINEER TASKS—DRAINAGE

Drainage is usually the Sapper's chief antimalaria task, and it is important to appreciate from the start that this is not at all the sort of thing that the word usually suggests to an engineer. The method is different because the object is different. It is seldom a matter of drying out a site or protecting a road. It is the collection and removal of countless small trickles of water seeping out of the ground, in which breed many vector species. Although these species have their various fads, yet they all favour slow moving or constantly refreshed clean water, and *A. minimus*, the chief vector in Assam, shares with many others a partiality for " speckled light " in the undergrowth and for small particles of vegetation in the water. Other vectors' peculiarities include the robust vigour of *A. maculatus*, which flourishes throughout South East Asia, even in bright light and comparatively rough water, and the long range of *A. elutus*, an Iraqi type which can travel three miles for a blood feed and thus necessitates a vast drainage system. These various peculiarities must, of course, be borne in mind, but the immediate concern is with the seepage from which the trickles usually start. Undulating country provides plenty of seepage, and the drainage system to collect it forms an intricate and irregular pattern, looking in plan rather like a lace border, and following the general line of the foot of the hills. Such drains may be less than a foot deep at their source, where the digging of them is simple compared with the siting of them.

Revetment is impracticable under service conditions, so particular care must be given to scour and silt, levels and falls. The layout, too, of the local camps, roads and drains must be considered, and close liaison is necessary with several authorities, notably other engineers engaged in local construction. Once the seepage is collected into a main drain its removal becomes a normal drainage problem except in one respect, which is that where no suitable outfall is available, the water may be collected into a pond, which can be oiled, if it does not of its own accord become too stagnant for breeding. Such a pond is called a " lido." One word of warning here:—" Never underestimate your enemy " means " Never neglect proper care when planning drains." This type of drainage sometimes appears so simple that mistakes have occurred through failure to take a few essential levels or through delegating the alignment to unskilled N.C.Os.

Returning to the top ends of the drains, which follow the seepage, we find the engineer's work more complicated. Not only must he fit durable drains to the seepage as he finds it, but he must also anticipate in dry weather the seepage that will appear after rain, and that is where botany and geology are useful. When the monsoon breaks, most of the seepage area will become inaccessible, and that is also the time when labour will be at a premium. Jungle clearance may also be necessary, and paths must be made to provide access for the inspectors and oil sprayers of the Medical Service. Maps, too, are required of the work as it proceeds. In practice this work falls largely on N.C.O's., whose training and supervision must be thorough.

Antimalaria drainage is a menace to cultivation. The terraced paddy fields in Assam provided large areas of perfect breeding conditions for *A. minimus*, but were rendered harmless by cutting off the water from them, with the result that local cultivators grumbled, until the arrival of the Claims Commission, whom they troubled exceedingly! On the other hand, some properties are improved by drainage.

The use of the common word "drainage" to describe all this has the unfortunate effect of inspiring engineers with a distaste, almost amounting to contempt, for the subject. Malariologists enthuse over it, but for the average Sapper it has about as much appeal as a kit inspection has to an ambitious Staff College candidate. This antipathy, combined with the subservience of the drainers to the Medical Service rather than to their own Corps, leads to difficulties in organization, which are discussed later on. It seems a pity that no more descriptive title could be found, but this seems impossible. "Water Control," and "Breeding Control" have other implications; "Antimalaria Work" is too wide. To a malariologist, "Drainage" means just this type of drainage, so the only solution is to call it "Drainage" or "Antimalaria Drainage," and to ensure that those who use the term in this connexion know what it means.

Maintenance of Drainage

Antimalaria drainage, being usually unrevetted on active service, needs constant maintenance or it will become ineffective through collapse or overgrowth, and may even cause breeding. The amount of maintenance required depends on the rainfall, on the nature of the soil, and on the care taken over silt and scour when the drains were planned. In Assam, maintenance was found to absorb annually from about half to two-thirds of the original labour cost of the work, the bulk of this occurring during and just after the monsoon. The size of this commitment had not been sufficiently appreciated when the camps in Assam were originally constructed, and towards the end of the war, when the L. of C. was thinning out and labour was scarce, much attention was paid to the evacuation of those areas which needed most drainage—a good example of "Evasive Action."

Since an egg takes at least eight days to become an adult mosquito, any obstruction which will permit breeding must be removed within this period. In practice a week is convenient, and allows a margin of safety. The drainage system must be divided into sectors which the maintenance units can cover once a week, having regard to their size and experience and to their distance from their respective sectors. This work needs much less supervision than the planning and digging of new drains, and is easier for the antimalaria staff to inspect. Their responsibility for maintenance inspection is therefore greater than for new work. Military labour is preferable, but good results were obtained from contractors who had carried out the original work. The contractor was paid an agreed sum each month, from which deductions were made for any defect not rectified within twenty-four hours of its being noted in a maintenance book keep for the purpose. Inspection was the duty of the local Antimalaria Officer, who was given a copy of the contractor's map, marked into sectors for each day of the week. The sum to be paid for each month varied throughout the year, according to the average rainfall records, and was estimated by a proportionate subdivision, throughout the year, of a sum equivalent to two-thirds of the original cost of the work. The contractors used this estimate as a basis for tendering. The result was probably rather more expensive than necessary, since the contractors were villagers and had kept no records to guide them, and safeguarded themselves by tendering as high as they dared. During maintenance, small items of new work occasionally became necessary, and rates for this were included in the tenders. Contract work, however, is not ideal for maintenance, since in a war of movement the need is unlikely to last long enough for the arrangements to reach perfection. When a system is to exist for a few years, some form of revetment may be added to the drains. Old tentage, pegged to the sides, is a useful precaution against scour, the materials being obtained from salvage.

Flushing

Another form of antimalaria work for engineers is flushing, or the damming of a stream so as to release every week a wave which swamps or strands the eggs, larvae, and pupae in the pools along the banks. This is an important measure in "*maculatus* country" since that is a tough baby and survives in water too rough for most other species. Flushing was at first considered impracticable as a field work in close country, since antimalaria works did not reach high enough priority for the elaborate structures visualized. Later, however, a touring research malaria laboratory produced more knowledge and ideas, and some simple earth dams about 3 ft. high were made as a trial, the sluice gates being improvised from salvaged petrol drums. These caused waves only a few inches high, but experienced malariologists approved, since the larvae and eggs need not necessarily be killed by being swamped by a violent wave, but can also be killed by being floated over the adjacent dry ground by a small wave and left stranded there. They can also be washed by eddies into the main stream and carried away by the current, a process which may cause them to spread malaria further downstream, preferably beyond the war area. Experiments were made to measure the larvicidal effect of such dams, and hence to find out the proper intervals for them along a stream. The end of the war curtailed those experiments, but enough data were obtained to suggest a theory and indicate an approximate rule. This investigation produced some new work on the subject, and an article on it has found favour in medical circles. The steeper the fall of the stream the more effective will the dam be, and a stream with many pools along its banks is less favourable for flushing than one with smooth banks. In fact, smoothing of banks and canalization of the beds of small streams form part of the work of antimalaria engineers. In peace-time, flushing is a recognized measure and well known to tea planters. Automatic flushing sluices, on the same principle as a public lavatory, are sometimes used, but were not made in Assam during the war for fear of obstructions and inconvenient adjustments.

Reconnaissance

The drainage commitment of a new area is too widespread to be explored both quickly and accurately. In close or jungle country it may at first only be possible to distinguish between those parts of the area where little or no work is required and those where such heavy and prolonged engineering would be necessary that they should be avoided if possible. Speed in noting this is more important than accuracy since the layout of the camps may depend on it. This stage of the preliminary discussions is largely the concern of the malariologist, who will probably be senior and experienced, but the Sapper will be asked for quick rough estimates, and for these he needs experience of similar work elsewhere, preferably in the same theatre of operations. Some rough estimating data, collected in Assam, have already been recorded elsewhere, but these will require modification according to circumstances, and are a poor substitute for the practised eye of one already used to the work.

The preparations for such a reconnaissance therefore include discussion with "Q" and "M" staff, study of air photographs, liaison with other engineers in the area, and the preparation of several copies of a map to a scale of about 16 in. to 1 mile. A quick enlargement will suffice for this, showing only the main features, since accuracy is not vital at this stage. The reconnaissance party should include some experienced men, both for estimating by eye, and for the jungle clearance and rough mapping that will probably be necessary. This party forms the nucleus of the detachment that will stay on the site, to continue the planning and to start the work as soon as labour becomes available.

Other Tasks

The field works so far described are not the Sappers' only effort against malaria, though they are probably the commonest, since many vectors share the breeding habits of *A. minimus*. In the coastal regions, however,—West Indies and the Arakan for instance— tidal sluices are required. There is also occasional scope for the invention of gadgets. D.D.T. sprayers and a portable mosquito trap proved this in Assam, and there are other demands for ingenuity. Training too, is always with us. A camping expedition among Burmese villages with a small research party was not only instructive but a very good substitute for leave. One R.E. officer had the strange experience of lecturing on drainage at a course for senior medical officers. A large scale model of a drainage system was made for a Malaria School, together with a wall chart and lecture notes to correspond. On the whole, there is plenty of variety both in the work itself and in the contacts it involves.

The Military Setting: Theory *v.* Practice

This work is too slow for mobile warfare and belongs essentially to the L. of C., where staff work does not always reach *p.s.c.* level. This applies especially to the static offices of technical services, which, in a war-expanded army, contain a high percentage of officers whose technical ability outruns their military experience. Another feature is "knickerbocker government" or the "sway of the stooge." Antimalaria engineering so far overlaps the technicalities of both the Medical and the Engineer Works Services that there is plenty of scope for argument between the engineer and the customer, and since there is seldom a qualified referee, there is danger that the mosquito may benefit. This sort of thing is not taught in text books but it should not be ignored, and since it directly affects the conclusion which follows, it will now be illustrated by some examples from real life.

Example 1.—A drain had been, wrongly, cut to enter a main drain at right angles. The engineer Staff Sergeant M.F.W. ordered his contractor to cut a short length across this angle, so as to make the tributary enter the main drain at an acute angle. The Antimalaria Officer, a Second-lieutenant, came and knocked the men off. The Staff Sergeant found this out and put them to work again, and later told the A/M Officer that this new cut was necessary for engineer reasons connected with silt and scour. The A/M Officer said that this was a waste of A/M money, and again knocked off the men. The next day the Staff Sergeant's O.C., a Major, saw the A/M Officer, and explained the details, and peace was restored.

Comments.—No tempers were lost. The A/M Officer, being young and inexperienced, did not appreciate the Staff Sergeant's position, nor the fact that so long as the coolies were present they would have to be paid, nor the contractor's need to take orders only from the engineer operating the contract.

Example 2.—Another A/M Officer, a Captain, complained to the Engineer Officer, a Major, that a certain drain, about 5 ft. deep, had been scamped by the contractor, since some vegetation remained high up on the inside slope. He agreed that this would not cause breeding, but wanted neater workmanship from the contractor. The Engineer declined to order the contractor to return and clean up the vegetation.

Comments.—Enterprise again by an A/M Officer. The Engineer, however, was thinking of speed in getting the essential work done, and considered that this was not a suitable occasion to fuss the contractor, who was working well. No quarrel ensued.

Example 3.—On a steep slope with much seepage, an R.E. Warrant Officer M.F.W. in charge of a detachment, had cut two nearly horizontal drains each about 3 or 4 ft. deep and only about 20 ft. apart. This was criticized by a very senior and experienced touring malariologist, who considered that one deep drain would have served the purpose as well as the two, and with greater economy. On a later tour, this same malariologist examined further the local conditions of seepage, scour and silt, and generously agreed with the Warrant Officer.

Comments.—This shows the value of local knowledge of the soil when siting drains. It also shows how engineers, provided that they have experience and understanding of the principles of siting antimalaria drains, may be able to make sound decisions for themselves.

Example 4.—An R.E. Staff Sergeant M.F.W., consistently planned drains in his area in such a way that many breeding places remained undisturbed. His trouble was reluctance to learn. He always " knew better," and stuck to his previous ideas of drainage. He later became useful elsewhere.

Comments.—Proficiency must not be taken for granted. Training and supervision are as necessary for this as for any other work.

Example 5.—In Iraq an R.E. L/Cpl. kept rigidly to the ½-mile radius taught to him on a course as a general guide. The local vector, however, was *A. elutus*, a Mediterranean species with a range of 2 or 3 miles.

Comment.—A little learning is a dangerous thing.

Example 6.—In high ground there was a small marsh with no outfall. The local A/M Officer said that this would not breed *A. minimus* and might be left alone. Nevertheless the engineers drained it for fear of seepage lower down when the monsoon raised the water level.

Comments.—It is not known whether seepage would have resulted if the marsh had not been drained. This is one of the problems which engineers, especially with local experience of the soil, may have to decide for themselves.

Example 7.—In open country a series of steep re-entrants necessitated an extensive system of seepage drains, fairly easy to plan. A native contractor, with a passion for gambling, cut a length of drain without being instructed, and offered to forgo payment if it were not approved. He got his money.

Comments.—The principles are easy to grasp, and the work has a definite fascination, especially for country folk. It is preferable to keep the labour on the same class of work, so that they may acquire skill and need less supervision. Frequent changes of labour are sometimes inevitable, but they always reduce the speed and efficiency of the work and absorb more engineer attention than trained labourers would need.

Example 8 (*a*).—A very senior officer of another Service chased the " ditch diggers " out of his camp, saying that the work was unnecessary and that he was not used to being argued with by a subaltern. The Sub-Area Commander ruled that he was legally right, but that if malaria should ensue in his camp *or within half a mile of it*, his responsibility would be serious.

Example 8(*b*).—A Lieut.-Colonel objected to the smoothing of the river bank beside his camp, on the ground that it muddied the drinking place. The R.E. Subaltern of the detachment referred the case to the local Station Commander, and the engineers turned to other work until this C.O., whose departure was imminent, had left. Temporary arrangements were then made for watering the unit, and the work proceeded.

Comments.—Tact is not wasted on this work. The engineer also needs a reputation for technical soundness. Fortunately the subaltern who featured in both these cases was outstanding in both respects, but he was overtrumped by seniority. An N.C.O. would have been quite helpless and might have got into difficulties with his own O.C.

Example 9.—The Viceroy presented medals to four generals. A level parade ground for this was made by bulldozing a gentle slope, thus obliterating some antimalaria drains. Fortunately it happened to be easy to site new drains in fresh soil, and even to improve some football grounds in the process.

Comments.—Game and set to the staff.

Example 10.—The O.C. of an A/M engineer unit was asked by the Sub-Area A/M Staff Officer (D.A.D. Hygiene) to clear weeds from a short length of stream, near which there had been some recent cases of malaria. The O.C. did so, but suggested that stagnation and the large quantities of water hyacinth just upstream rendered this an unlikely breeding ground for any mosquito, particularly such a fastidious species as *A. minimus*. D.A.D.H. agreed that this was possible but not that it was certain. Evidently this was a borderline case, and it takes experience to distinguish between "clean enough" and "too dirty" water. Before starting the clearance, therefore, the O.C. and one of his N.C.Os. improvised some apparatus and searched the stream for larvae. They found countless *Culicine* larvae (another genus of mosquito, not associated with malaria) but only three *Anopheles*, which the local A/M unit hatched out and identified as *A. vagus*, which can stand plenty of mud and pollution but feed almost exclusively on cattle. There was a farm nearby.

Comments.—This does not prove that the clearance of the stream was unnecessary, but only that *A. minimus* was not breeding there at that particular time.

The presence of *A. vagus*, although in small quantities, justified the precaution required by D.A.D.H., while the absence of *A. minimus* showed that the engineer's suggestion was reasonable. Honour was satisfied all round. This test by the engineers was made partly for interest, time being available just then, and the relations between the two officers being cordial, but mostly for propaganda, in order to convince both A/M and engineer authorities that the unit had acquired the right to express an opinion, and were not mere coolie drivers.

Anyone familiar with the "back area slums" or "stooge belt" of an L. of C. will recognize the atmosphere in which not only these incidents but many less harmonious ones are liable to occur. The usual solution is for some senior officer to give a simple decision and knock everyone's heads together, but in this case few officers can give the right decision, and the target is so high that mistakes may spread malaria. The problem therefore is how to ensure correct work within the normal organization of the Army.

Organization

Specialization here rears its ugly head. How can we curb it without cramping progress? The obvious answer is to ride it on a snaffle, but this requires both a well-trained animal and an understanding master, neither of which can be guaranteed in war. The normal military solution would be a set of rules—a manual, textbook, or at least a pamphlet—but any addition to existing literature might be a nuisance, and this one could only be kept concise by omitting much detail. Yet it seems inescapable that engineers detailed for antimalaria work must know at least as much as has here been written, plus fuller details about the vectors which are their immediate enemy. It also appears that they should comprise at least an officer's command, large enough to admit of trained replacement of casualties, the education of new members, and the pooling of fresh knowledge. Another requirement is that the engineer commander under whom they work should have some general idea of the sort of work they are doing and what it involves, though he cannot be expected to hamper his other activities by studying malariology. If there were enough antimalaria engineering to justify a C.R.E. A/M, all these conditions would easily be fulfilled and the difficulties of a widely dispersed command would also be overcome, but it seems unlikely that such a necessity would arise. A subaltern's command is rather small for complete efficiency, especially when the work is spread over a large area. The happy mean seems to be a captain's or major's command—a squadron or works section, as was the case in Assam. The ideal organization for any particular theatre of operations must depend largely on the amount and on the dispersion of the works involved, but the minimum amount of specialization seems to be that which will ensure correct workmanship and a recognized voice in discussions of the subject, i.e., a knowledgeable officer in charge. To these requirements must be added enough understanding in local engineer circles of the general nature of the work to ensure fair recognition without encouraging "line shooting." "High priests of the inner cult" must not develop into a "racket." This last need could be met by a very little literature—just enough (*a*) to introduce the subject, and (*b*) to lay down enough rules to enable local problems to be solved when no authoritative malariologist is available. It is hoped that this article may suffice for (*a*) and that the technical notes recorded elsewhere may provide a nucleus for (*b*). If so, a few topical details from the local malariologist would complete the mixture.

Conclusion

The object of these notes is to introduce to Sappers a job which might come their way in war, and to enable them in that case to start where the unit in Assam left off. It is hoped that such employment may be found interesting and may not be described with a contemptuous sniff as "mere drainage," since there can be no doubt of its importance whenever it is found necessary. The bug-hunting principles have been emphasized because the work depends on them and on liaison with the Medical Services and with other Sappers. If this account should have either interest or value, the writer would like to associate them with 924 Indian Works Section, R.I.E., who really did the work and whose scribe he is, as well as with several malariologists of the Medical Service in India who directed, taught, and encouraged—notably Brigadier M. K. Afridi, O.B.E., and Dr. T. T. Macan, and others who helped to compile this article.

THE KHASSADARS AT KHUSHAL KHEL CAMP

By " SENATOR "

I OFTEN used to wonder, when listening respectfully to my seniors of a generation now long lost to India, at the evident joys of their existence in the country to which they had given their lives. As time goes by, and I find myself recollecting, with the greatest pleasure, occupations and occasions which, when they occurred, were never even noteworthy, I begin to understand. It seems to me that it is our happy British characteristic to receive most deeply the impressions of joy which life can give, and to resist and discard those which are repugnant to our memory, till they are quite forgotten.

This tendency is the easier to understand when one considers that it takes the discomfort of muddy boots and tired feet to provide the right background for a wash in clean cold water, soothing socks and favourite slippers ; or that a dusty mouth and raging thirst are essential to the full enjoyment of unlimited iced beer. Rare moments of initiative and ingenuity in dull and stupid servants are as islands in a featureless sea, and a few flashes of chivalry and humour can transform the reputation of a cunning and cruel enemy into that of a romantic and respected figure.

Perhaps it is this fact which makes one day stand out among a series of which I have not a single other notable recollection. Little was more monotonous than the routine of road building on the North West Frontier, when the unseen presence of the tribesman imposed constant vigilance unrelieved by even a modicum of active opposition. For weeks on end the only change we knew was in the shape of the road which followed our Field Engineer into the barren hills.

On that particular day we had a holiday.

Sapper's coolies, swarming in the straggling camp below our fortress, had struck work. It was a domestic quarrel between one contractor and his men, as far as I can remember, and of no account to this tale. But it gave us a chance to avail ourselves of an offer, made by Landai, the son of Arsal, to arrange a chicor shoot for us in his hills. How that Waziri tribesman, a one-time sworn enemy of the intruders from British India, and son of a man who then languished in a down country gaol, came to be our host, is another story. All day we three tramped the hills to his direction, Jo who commanded our detachment of Scouts, Sapper and myself, sharing the open air and blazing sun, covering together in keen anticipation, back-breaking climbs, precipitous descents and sideslopes. Together we had heard the sudden whirr of the frightened bird, and one had shot or shouted to the others, " Mark, left ! " or " right " or " over." The comradeship of such a day is best experienced years later, at an unexpected meeting with another who was party to it.

The cool night air followed the brassy heat of the day and I bathed and " dressed " for dinner, my " dinner clothes," designed entirely for comfort, were without irksome restrictions at ankle, neck and waist. The beer before my bath, while making that operation one to be undertaken without undue haste, was merely a reminder of another, and another, beer to come. I knew they were waiting for me in the mess tent, unlimited ice-cool cans of Barclay's lager.

Jo, the Scout, Sapper the Field Engineer, and I, the general stooge, made up the whole of our small mess. Jo's thirst, which was invariably greater than Sapper's or mine, drove him there before us. He had lit the fire which was blazing merrily when I entered the tent. The flies, a perpetual curse by day, had now retired in drowsy thousands, covering the inner fly, ropes and poles. We were free of them for a few blessed hours, except occasionally when one of them, overcome possibly by the fumes of Jo's pipe, fell into our food. Sapper came in, and we fell into a discussion of the day's sport. Eventually the conversation turned to Landai, our host for the shoot, and in general to our friendly enemies and changeable friends, the transfrontier Pathans. There was a pause, I remember, when Jo's pipe disappointed him by failing just when it should have been giving him greatest enjoyment.

He had been telling us how in a previous "show" he had been commanding a detachment of Scouts which was working with regular troops engaged in penetrating into a little-known part of Waziristan. The country was difficult and unknown save to him and his little band. One night the force had to scale a steep hill, with the likelihood of opposition. The Scouts with their superior knowledge of the country led the advance. Knowing Jo, we guessed that he had led everything. Progress had been good when, in the early hours of the morning, the tribesmen in ambush opened fire at short range. Jo was severely wounded and fell, unable to rise, into a small pocket in the hillside. He found himself out of view of his own men, but in the company of one of the enemy. He decided all was over, but to his amazement, the tribesman spoke to him in quite a friendly manner.

"Sahib, I was in the Scouts once."

He started gently pushing Jo up the side of the pocket beyond which the Scouts were.

"If I do thus, so that I push my lord up this small slope, then he will roll down the hill again to his men."

This the ex-Scout duly did.

The refractory pipe was now in operation, and Jo continued, while puffing tremendous clouds of smoke:

"Did I ever tell you about the Khushal Khel Khassadars?

"It was before I joined the Scouts. I was doing Quartermaster in a two-battalion camp in Bhittani country on the Frontier. It was one of those road-making 'shows' where the 'tail' very definitely 'wags the dog.' In other words, our strategy was dictated mainly by considerations of the road which trailed heavily behind us. One woke up in the morning to the sound of the popping auxiliary motors of the monstrous machinery with which the Sappers played, graders, autopatrols, angledozers and the like. In the evenings the pickets had to wait for Wilfred, the diesel roller, to rumble slowly into camp, before they could come down from their hilltops.

"We had the usual gang of Khassadars, provided by the political agent, but as I had only just come out from home, I didn't really understand how they worked in with the rest of us."

As I was as green as Jo had been then, if not more so, I interrupted to ask him what a Khassadar was. He described them as members of the enemy whom the British Government bribed to refrain from opposing us. I gathered that they were an irregular force of tribesmen, recruited and paid by the Political Service in independent territory for escorting representatives of the Government who ventured into their jealously guarded hills.

"I did come into contact with them in one way," he went on. "As 'Q bloke' it was my job to issue them periodically with their ration of rifle ammunition. My Quartermaster Havildar, who was only doing the job temporarily, actually handled the rounds and accounted for them. His name was Jai Datt and he came from Garhwal. He had twenty-one years' service and more medals than the Colonel, including the I.D.S.M. He was full of common sense. As you will see, it was he who really found the Khassadars out.

"Khushal Khel camp was a favourite target for enemy snipers. They usually took their sport at dinner time, when we had those bright petrol lights burning in our messes. There would be a short burst of firing from somewhere in the surrounding hills, and bullets would 'zip' through the camp, seldom doing any damage. Then there would be a pause followed by an answering fusillade of shots fired from where we believed the Khassadars to be, presumably at the snipers. We noticed that the latter chose their vantage points on the flanks which were held by Khassadar pickets, and not those which had the regular troops on them. This seemed natural enough.

"In the morning the Khassadars would bring in reports of how they had driven the snipers away; once even, the blood of an alleged sniper was found on the hillside. Their story was always followed by a request for more 'Kartus' to replace those which they had expended in the fight.

"On those occasions Havildar Jai Datt doled out the ammunition with an ill grace. 'It is great foolishness Sahib,' he used to say, 'to give these men Sarkari ammunition, for it is surely they themselves who shoot at the Sahibs in their mess tent at dinner time.'

"'How can that be Havildar?' I replied on one occasion. 'It is the order to issue them with so many rounds, and they are our friends, paid by the Sarkar to defend us.' So Havildar Jai Datt went to the ammunition tent and I heard him breaking open a box, and the clinking of the cartridges as he and his assistant counted them out. I remember that this seemed odd to me at the time, as there were sufficient loose rounds available without starting on a new box: but I thought no more of it. Then he came out and doled out the rounds to the khassadars, I thought somewhat more eagerly than usual.

"Several nights passed without the usual volley at dinner time, and we began to think that perhaps the Khassadars had really hit one of the snipers. Then one night when I was in my tent 'dressing' for dinner, they started again. I heard a voice outside saying, 'Look at that, they're using tracer!' During dinner we discussed this extraordinary occurrence. How had the enemy got hold of the tracer ammunition, and why did he use it when it gave away, so completely, his whereabouts? But the Colonel said nothing. After dinner he took me outside the tent and asked who issued the ammunition to the Khassadars when they came into camp the last time. I told him, and he sent for Jai Datt.

"'Havildar,' he said, when the old soldier came up to him and saluted, 'those rounds which you gave to the Khassadars last Wednesday, were they in every respect the same as the ones which are customarily issued.'

"'They were the same in every respect, Sahib. Only in one small matter was there a difference. That is to say that whereas the ones I have previously issued have a small blue ring at the cap, those about which we are speaking had a ring of red.'

"'Tracer,' the C.O. muttered, 'I knew it!' Then, with a twitching face, he turned to the Havildar, 'Why, Havildar, did you issue those rounds with a red ring?'

"'Sahib, there is no order to the contrary, and I have been doing this work but a short time.'

"The Colonel thought for a moment.

"'It is true, Havildar, there is no such order, you have permission to go.

"Then as we turned towards the tent, I heard the Colonel growl, 'The old rascal.'"

Jo stopped to apply another match to his long burned-out pipe.

"And that," he said, was how we got the Khushal Khel Khassadars. I never mentioned the matter to Jai Datt again. Years after though, towards the end of a very trying hot weather, I was short with the patient old man over a wrong entry in a recruit's conduct sheet. He had mixed up a 'red ink' and a 'blue ink' entry. The former, as you know, is for the more serious offences.

"I asked him how it was after all his years of service, that he could not tell red from blue."

"'Sahib,' he said, 'you know well that I can tell the difference. Did I not do right in the matter of the ammunition of the Khassadars at Khushal Khel camp?'"

THE RIGHT TYPE OF R.E. OFFICER

By "Methuselah"

The right type of officer? What is he,
That every young Sapper should aspire to be?
The ruthless commander, efficient and brave,
Or the learned technician, hard-working and grave?
Perhaps the highly-trained "G" staff brain,
(Who will never return to the Corps again?)
The clever researcher, or subtle mechanic,
The reliable planner, cool-headed in panic,
Or just the good mixer, frank, carefree, and gay,
With a fund of good stories, and most winning way?

It's a difficult question. I must truly confess,
I wouldn't know, and could hardly care less!
We own a most wonderful stamping-ground,
For all who are out to do "something all round;"
And we've also a habit of meeting our needs,
From the stuff that we get, whether fliers or weeds.
If we made our own life become more entertaining,
With some really good practical engineer training,
I can't help a feeling there need be no fears,
That we'd fail to attract quite the right volunteers.

AIRBORNE SAPPERS COME HOME

By Captain N. F. Dixon, M.B.E.
(Military Observer in Palestine)

RECENTLY arrived in England, and one of the last units to leave Palestine, was the 1 Airborne Fd. Sqdn. R.E. This "crack" unit, more than half of which are regulars, can boast of nearly three years continuous service in the Holy Land, since they originally disembarked at Haifa on 6th November, 1945.

When I visited them in their camp to the south of Haifa, the great "packing up" had already begun. As Major E. C. O'Callaghan, M.C., the officer commanding the squadron, showed me round, he told me something of the unit's history.

Formed at Netheravon in October, 1940, they were originally known as the I Air Troop R.E., the name being altered shortly afterwards to that of the 1 Para Sqdn. R.E. which was not changed to its present title until September, 1944. After taking part in the Bruneval raid the squadron went to North Africa, and for the six months, up to April, 1943, served in the 1st Army. From July until November, 1943, as part of the famous 8th Army, the 1 Airborne Sqdn. moved in the spearhead of the attack across Sicily and up into Italy.

It was during this campaign that their brigade earned the highly complimentary nickname, "The Red Devils." The bestowers were the German Army.

The following January they were incorporated into the 21 Army Group, which brought them, nine months later, to their greatest testing ground of the war, the Arnhem "drop." Here, within a few grim days, 90 per cent of the unit became casualties.

During their three years in Palestine the squadron have been kept continuously on the move. Their first big job was the bridging of the River Jordan at Jericho. The date was the 17th June, 1946, and the Jordan Valley lay sweltering in the sun like a gigantic baking dish. For two long days the sappers sweated and toiled in temperatures of over 115 degrees. Although five casualties from heat were incurred, the bridge, a Bailey, was completed by the end of the second day.

From then on they were kept busy by the idiosyncracies of the local populace. In an attempt to stamp out gun-running and thuggism they carried out a number of vigorous arms searches. Safes and strongrooms in Jewish headquarters were blown open. The houses of Tel Aviv were combed for secret caches. In addition to finding several important arms dumps, including one in the Central Synagogue, the men of the 1 Airborne Sqdn. were instrumental in arresting several notorious gangsters, including the second-in-command of the Stern Gang.

The next chapter in their Palestine story could well be headed "Mines." From September, 1946, the calls on the squadron's mine recce patrols became increasingly numerous. The Jews mined roads, railways, cables, and verges. Booby traps, anti-handling mines, anti-personnel mines, all began making their appearance. On the 17th November, Captain J. M. Newton, of "B" Troop, was killed while dealing with a new type of railway mine. The Lance-Corporal with him was wounded by blast and splinters. A week later a similar mine was uncovered and "taken to bits" by another officer of the squadron. This mine yielded up the secret of its mechanism, thereby reducing the risk of further casualties from that particular type.

1947 found these maids of all work with yet another job. The scene was Haifa docks, the task helping in the transhipment of illegal Jewish immigrants; 4,500 Jews on one ship, being the largest single commitment they ever handled. This operation was followed by a nine day curfew, during which the Jewish gangsters began using delay action mines against the cordoning troops. The squadron were kept busy. Many new types of mines came to light, including one spotted by an N.C.O. in the grass verge, within six inches of his feet. Investigation proved it to contain fifteen pounds of explosive and a very sensitive fuse.

Between carrying out these operational roles the men of the squadron kept up to date with their parachute and sapper training. Bridging camps in Egypt, practice "drops" from Halifax bombers, battle drill in the Palestine hills, and, most welcome of all, courses in the U.K. made a pleasant respite from the cold war against tyranny and civil unrest. The highlight of the year was Christmas, their last in the home of all Christmases. For the squadron it was a really festive occasion.

As the end of the Mandate approached the tempo of life daily quickened its beat. The attacks on British troops and vehicles became increasingly frequent. The 1 Airborne Fd. Sqdn. R.E. however had an answer to this, as to most problems. For every outrage against the British they retaliated by blowing up snipers posts and strong points in Haifa.

Typical of the impartial help which the army gave to both factions in Palestine and of the price they so often paid for it, were the tragic happenings of the 4th March last. Lieut. Bailey, of "B" Troop, with a party of twelve jeeps, was engaged on escorting civilian vehicles through Haifa. While travelling through one of the town's "hotter" spots he espied a young Jew, lying, seriously wounded, by the roadside. Lieut. Bailey stopped and, without a thought for his own safety, went to the man's aid. Unfortunately other eyes had seen his action and, as he turned back towards his truck, a rifle cracked. His reward for being a good Samaritan was an Arab sniper's bullet through the heart.

Right up to the end the unit were kept busy with high priority jobs of which one of the more unusual was the destruction of 650 Armoured Fighting Vehicles. These tanks and armoured cars, whose transhipment from Palestine would have cost more than they were worth, and whose sale to Jews or Arabs was impossible for political reasons, had to be so completely destroyed as to render them quite valueless to either side. The squadron's method of dealing with the problem was as dramatic as it was effective. Having been "bulldozed" over the edge of a rock strewn mountain side the vehicles were sent hurtling down into a narrow gorge, hundreds of feet below. Here the battered hulks were split open with ninety pound charges of gelignite, and then, just to make sure, the whole mass of twisted metal was flooded with flame thrower liquid and reduced to a blazing inferno. As one officer remarked "The expressions of thwarted avarice and frustration on the faces of Jew and Arab onlookers added considerable zest to the whole operation."

Whatever the future of the 1 Airborne Fd. Sqdn. may be, it can always be said of them that they made Palestine a far better and a far safer place for all those stationed there during the last three years.

Editor's Note. It is hoped that this short article will encourage some officer of this famous squadron to write up some details of the squadron's activities in Sicily, Italy, and Arnhem.

AN OFFENSIVE DEMOLITION

By MAJOR H. N. F. PATTERSON, R.E.

HASTY bridge demolition seldom calls for the use of a variety of types of charge. An exception was provided by the destruction of Mawhun railway bridge in North Burma by a detachment of Wingate's Special Force, in March, 1944. This afforded an opportunity for the use of cutting, cratering, underwater and borehole charges (see Sketch).

The bridge was selected as an objective before the expedition left India and full details of its construction were available from the Burma Railways' records. Low-level photographs, taken by the R.A.F., gave further details of the approaches and the amount of water in the chaung bed. This information enabled the demolition to be thoroughly planned and rehearsed.

Rehearsals were carried out in the first place on a sand model of the bridge and its approaches, constructed from the low-level photographs. This gave every man a clear picture of the ground and enabled him to feel at home, even in the dark, when he eventually reached the bridge.

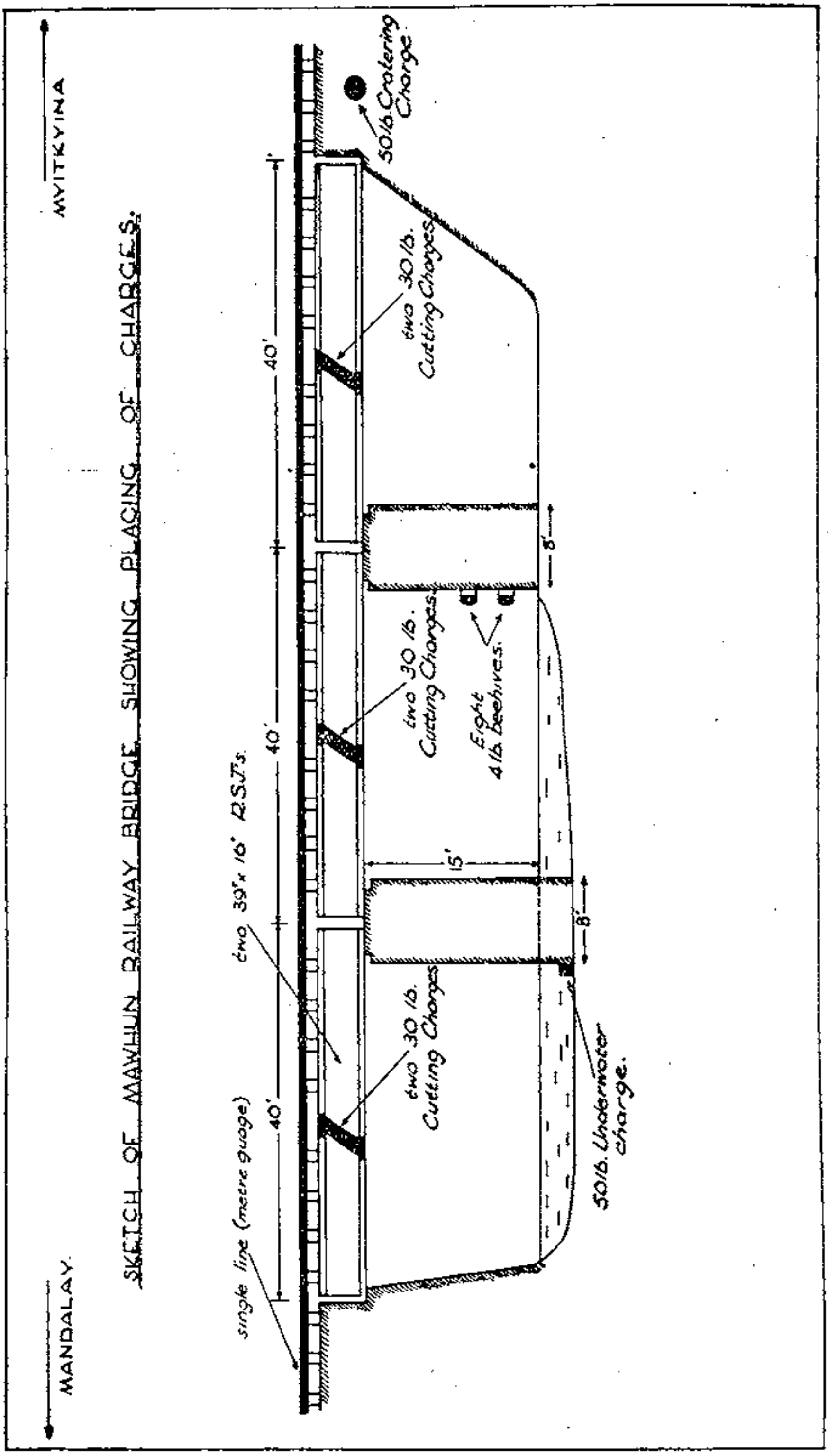
Practice in fixing charges was given on wooden mock-up girders of the same section as those on the bridge.

Finally, full-scale rehearsals were carried out by night on a similar bridge in Assam. Dummy charges, made of putty, were used instead of live explosives. There was no dummy primacord and this fact made the last rehearsal rather more spectacular than had been intended. The charges had just been fixed and the leads connected up, when a passenger train full of Indians came down the line and (rather surprisingly) detonated the primacord, of which there was some 200 ft. Whilst there was no serious damage, the noise was considerable, and caused the train to halt with a scream of brakes, whereupon some 2,000 panic-stricken Indians jumped out and disappeared into the jungle under the impression that they were being subjected to an air-raid.

Efforts to pacify the guard and driver of the train were not helped by the fact that the primacord had set fire to the sleepers on the bridge, lending colour to the air-raid theory. Eventually they were persuaded to continue their journey, but of their late passengers no more was seen. Compared with the rehearsal the real demolition seemed a tame affair.

The details available made it possible to prepare and waterproof all charges and leads in advance, so that the minimum of time was required on the site. Nobel 808 (with primer) was used for all charges, in conjunction with primacord leads. The charges were connected, herring-bone fashion, to a central main running the length of the bridge. For working in the dark, this was found quicker and more fool-proof than the ring-main method. Calculated charges were increased by 50 per cent in case they should have to be blown in the face of opposition. Initiation was by two separate 3-ft. lengths of safety fuse, fired by igniters. Electrical equipment was also available, in case it should be decided to attempt to wreck a train, but this was not used, for reasons given later.

The demolition was carried out by ten sappers and ten specially trained infantry, covered by a protection party of a platoon and a M.M.G. detachment. Five mules carried the explosives. The demolition group was divided into six parties of three men, each party being responsible for a span, a pier or an abutment. Party commanders were to report to the O.C. detachment when their charges were fixed and connected to the central main. After these had been checked, the demolition parties were to take cover 100 yds. down the line.


MYITKYINA
MANDALAY
SKETCH OF MAWHUN RAILWAY BRIDGE SHOWING PLACING OF CHARGES.
50 lb. Cratering Charge
two 30 lb. Cutting Charges
40'
40'
40'
8'
8'
15'
Eight 4 lb beehives.
two 30 lb. Cutting Charges.
two 30 lb. Cutting Charges
two 39' x 16' R.S.J's.
single line (metre guage)
50 lb. Underwater charge.

Enemy interference had been expected, but this did not materialize. The Burmese guards bolted when the detachment arrived at the bridge at nightfall. If they told the Japanese in Mawhun village (one mile away) of the happenings at the bridge, the latter decided to do nothing.

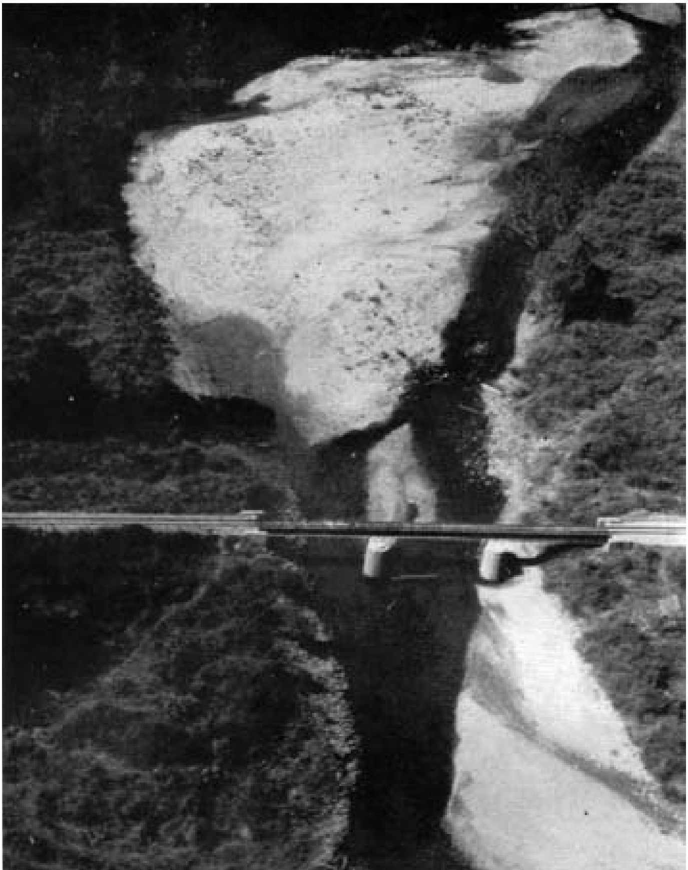
The bridge was ready for blowing an hour after arrival. It had been hoped to catch a train on the bridge, but according to orders, it was to be blown at the earliest possible moment if our presence in the area was known to the enemy. As there had been a skirmish with an enemy patrol shortly before reaching the bridge, there appeared to be no alternative but to proceed with the demolition. As all seemed quiet, however, and as the desire to " bag " a train was very strong, it was decided to ask permission from Column H.Q. to wait for a train. It proved impossible to contact Column H.Q. by wireless and the bridge was reluctantly blown. The would-be train wreckers were tantalized to hear, in the small hours of the next morning, a train approach from the north, halt short of the bridge, and then shunt hurriedly back in the direction from whence it had come.

The effect of the charges was satisfactory. The girders were cleanly cut. The underwater charge had removed most of the south pier. The eight 4-lb. beehives had driven 6-in. diameter holes to a depth of 3 ft. into the northern pier, which disintegrated when the borehole charges were subsequently fired.

The cratering of the north abutment was less successful. Difficulty was experienced in excavating quickly with entrenching tools, and the 50-lb. cratering charge was fired at a depth of only 3 ft. A 10-ft. crater was, however, achieved. The abutment wall was damaged, but not destroyed. In retrospect, this abutment would have been better dealt with by beehives and borehole charges.

The firing of the total of 300 lb. of explosives gave some anxiety, as dispersion outside a radius of 100 yds. was not possible in the dark without losing tactical control. No one was hit, however, and the mules took the disturbance in good part.

Before leaving, the site was thoroughly infested with traps and time bombs. It is hoped that these were all " killed " by the monsoon before the arrival of our troops in the area six months later.



Mawhun Railway Bridge.

An Offensive Demolition

Colonel H.G.K Wait CBE DSO

MEMOIR

Colonel H. G. K. Wait, C.B.E., D.S.O.

HUGH GODFREY KELLIGREW WAIT, who died on 28th January, 1948, was the son of W. K. Wait, Esq., of St. Vincent Hall, Clifton, and was born on 8th February, 1871. He was educated at Winchester College and the R.M.A., Woolwich, and was gazetted into the Corps in 1889. After completing the normal course at the S.M.E. he was posted to the 35th Submarine Mining Coy., at Pembroke Dock, where he began his long association with submarine mining and electrical services.

In 1895 he went to Malta as a subaltern in the 28th S.M. Coy. ; four years later he became Director of Telegraphs and Telephones. Promoted Captain in 1900, he became O.C. 24th Coy. in addition to his other job.

On his return to the U.K. in 1901 he was appointed Inspector of R.E. Stores at the Ordnance Depot at Woolwich, where his practical experience of electrical apparatus in action was of great value. During his time at Woolwich he married, in 1905, Helen Mary Lothian, the youngest daughter of a distinguished Sapper, General Sir Lothian Nicholson, K.C.B. Those who had the great pleasure of knowing her well will always remember her quiet unassuming manner, her kindliness and her outstanding charm, everyone who met her felt the better for doing so, and her influence on Godfrey Wait's whole life was unquestionably very great.

In 1906 he went to Hong Kong as O.C. 40th Fortress Coy. and O. i/c Telephones and E.L. He was promoted Major in 1909. On his return home in 1910 he was selected as Chief Instructor at the E.L. School at Gosport, a job for which he was both technically and naturally fitted. This was followed, in 1912, by that very important appointment, Chief Instructor in Electricity at the S.M.E.

The outbreak of war in 1914 found Wait at the S.M.E. and there he had to stay, much to his disappointment, till 1916, when he went overseas as A.D.W. for Stores. It was largely due to his technical and administrative ability that he managed to carry on with a very small staff until new Establishments were got out. It is certain that no better man could have been found for the job, and he was awarded the D.S.O. later in that year.

In 1918 he went to Italy as Deputy Director of Works. He was awarded the C.B.E. in 1919 ; on returning home that year he was appointed a D.D.F.W. at the War Office.

In 1923 he became President of the R.E. Board, an appointment for which he was particularly suited and in which he made full use of the experience he had gained in his previous service.

He retired in 1927, and settled down to a quiet country life in Sutton Veney, near Warminster, where he took a lively interest in all matters connected with his village home. He was a Churchwarden, Chairman of the Parish Council and a member of the Rural District Council, where his experience was most useful on the Housing Committee. During the war he ran the A.R.P. in the village.

All who knew Colonel Wait agree that his somewhat reserved manner was quite a thin shell, under which soon appeared a kindly, helpful nature, and they admired him for his quiet resolute manner and shrewd common sense ; he was an eminently sound and honest sort of character with a good deal of dry humour.

The death of his wife, in December, 1946, was a very great blow to him, from which he really never recovered.

He leaves an only son who served during the war in the R.N.V.R.

The photograph facing this memoir, taken about 1901, is the only one now available for reproduction.

A.R.A.I.

BOOK REVIEWS

SEVEN ASSIGNMENTS

By Brig. Dudley Clarke, C.B., C.B.E.

(Published by Jonathan Cape, London. Price 12/6.)

This book has an introduction by Field-Marshall Lord Wavell in which he says "When I commanded in Palestine in 1937–38, I had on my staff two officers in whom I recognized an original, unorthodox outlook on soldiering. One was Orde Wingate and the second was Dudley Clarke."

I personally saw an instance of Dudley Clarke's originality when we were serving together on Sir John Dill's Staff in Palestine in 1937. He showed us a film he had made entitled "Through Darkest Africa." This was a most exciting film showing a most difficult journey through wild and desolate country with excellent pictures of lions, elephants and other wild animals apparently taken at very close quarters during the journey. It was only later that we discovered that the film had been made during a journey from Palestine to Egypt and the animals were all inhabitants of the Zoo in Cairo.

It was perhaps this film that influenced Field-Marshal Wavell in selecting Lieut.-Col. Clarke, as he then was, to carry out his first assignment at the end of 1939 to reconnoitre a supply route from Mombasa to Cairo.

His second assignment was with the force that went to Norway in 1940. Here we have an instance of his unorthodox methods. Having been sent from the War Office to deliver some orders to Brig. Morgan at Rosyth before he sailed for Norway, Clarke sent a telegram to the War Office to say that he considered that he could be better employed with Brig. Morgan in Norway than at the War Office, and proceeds accordingly to sail with him the next day. He gives a very interesting account of the fighting in Norway as he saw it and gives a lot of detail of which little information has been published previously.

His next unorthodox procedure was at a meeting of the Chiefs of Staff at the Admiralty, when the arrangements were being made for the evacuation from Dunkirk. He was sent to the meeting to give a message to the C.I.G.S. and remained while the most important instructions were being phoned to Lord Gort. Towards the end of the conversation Mr. Churchill was talking to Lord Gort and telling him of his proposed visit to France when Clarke disconnected the phone in the middle of this conversation for security reasons.

Somehow he gets away on both occasions with his unusual actions.

His last assignment is the creation of Commandos in 1940, which idea apparently originated in his own mind, with a view to recreating the offensive spirit. The C.I.G.S. was at once impressed with the idea and Clarke was instructed to organize this entirely new and original form of fighting so far as British troops were concerned. He was responsible for planning and training the first Commando Units and organized the first two raids.

An interesting and very readable book, of special value for the particulars of the Norway Campaign and the start of the Commandos.

C.C.P.

NAPOLEON'S MEMOIRS

Edited by SOMERSET DE CHAIR
(Faber and Faber. Price 42/-)

Napoleon spent most of the last six years of his life in dictating his memoirs to the members of his entourage. Several periods were tackled simultaneously and each writer had his " bit ". Nearly everyone at Longwood, St. Helena, seems to have been made to take a hand.

Among the writers were Gourgaud and de Montholon, who eventually tried to collaborate over a complete edition of these dictations, but only succeeded in producing separate volumes based on their own notebooks. Worse still, in each volume they included so many asides and digressions that the result was a hotchpotch. In this form the work appeared in England in 1823, and was never published again. Until now, therefore, although other Dictators have given us their best-sellers, Napoleon's one great book has remained in obscurity.

What Mr. de Chair has done is, as he says, to present the self-portrait scientifically cleaned and hung in a good light. He has re-arranged the material in attractive form—as no doubt Napoleon (fine showman that he was) would have done if he had been alive at the time of publication. He has removed the irrelevancies and sorted out events into their proper sequence. Best of all, while using the script as dictated by the Emperor and covered with his almost indecipherable corrections, he has had the happy idea of transferring the narrative into the first person. No longer does the story read, as did the Gourgaud—de Montholon version, like a muddled biography. It is now pure Napoleon—calculating, clear, confident.

After a short chapter on Corsica and the Bonaparte family, the narrative moves steadily over the whole period from Toulon, 1793, to Marengo, 1800, and thus includes the Italian campaigns, the expedition to Egypt, and Napoleon's seizure of power on the 18th Brumaire. There is also a dissertation on Neutral Powers and their maritime rights; the Armed Neutrality ; and the Battle of Copenhagen—precedent for Oran and Dakar.

After Marengo there is a gap of fourteen years and we jump to the Hundred Days. Napoleon's recollections of this campaign were originally dictated to Gourgaud, smuggled to Europe and published in 1820—comparatively soon after the event. Unlike the rest of the memoirs no editing has been necessary here ; the story flows dramatically to its sombre end, just as Napoleon dictated it.

Students of war and politics have every reason to be grateful to Mr. de Chair. It is true that the book is a retrospect and to a large extent an *apologia* ; in fact, the Emperor's infallibility is at times ridiculous. His enemies make so many mistakes that they cancel out, and even produce a credit balance! At Waterloo, Wellington is decried for having chosen such a bad defensive position that he was unable to retire from it, as by all the rules he ought to have done. But it is only fair to admit that Napoleon never contents himself with saying that so-and-so made a mistake ; he tell us what should have been done and why. This adds colour to his estimates of his opponents and subordinates—not forgetting the Admirals! The many appreciations and plans are of great interest as examples of the working of his mind, while the descriptions of the battles are, of course, from his point of view masterly. In particular, the Commander's appraisal of the things that really mattered, and how he personally acted to ensure that they went right, is never in doubt.

After reading this book one's first inclination is to throw away all the manuals. On second thoughts, it is perhaps better to keep them, with Napoleon's as an illuminating and vivid companion volume. I.S.O.P.

THE EFFICIENT USE OF STEAM

By O. Lyle

(Ministry of Fuel and Power, 820 pages, 438 diagrams, 82 tables. Published by H.M.S.O. Price 15/-)

The correct use of steam for heating and power is now of such importance from the point of view of fuel economy that many users of steam will welcome the appearance of this handbook, which assembles within a single volume facts and figures hitherto available only to those with time and access to a considerable library. It is a companion work to the "Efficient Use of Fuel," first published four years ago, and, with a minimum of theory and mathematics, deals very fully with the properties of steam; its distribution, control and measurement; also the maintenance and operation of the types of steam plant and accessories used in industry.

Excellent chapters are included on steam traps, condensate handling and the Heat Balance, together with comprehensive tables and formulae needed for reference by Works Engineers. Considerable care has been taken to make the Index complete.

This book is essentially practical and is not a text book. No attempt is made to describe the design and construction of the more important items of steam plant, such as boilers, engines, turbines etc. Written in a clear and lively style it can be confidently recommended to all those responsible for the design or operation of steam-using plant, or concerned with steam as an item of works management.

H.H.N.

THE CIVIL ENGINEER IN WAR

A Symposium of Papers on War-time Engineering Problems

(Published by the Institution of Civil Engineers, London, S.W.1, Price £2 2s. 0d. for three vols.)

This book, which is published in three volumes, covers engineering work carried out during the war, all of which can be considered of interest to engineers, due to the various branches of engineering dealt with.

The volumes comprise sixty-eight papers sent to the Institution on war-time engineering problems, of which, twenty were selected for discussion at a special conference held at the Institution on the 4th to 6th June, 1947.

The majority of these papers have been written by those engaged on the work, so more detail has been given on the particular problem than would otherwise have been possible, also the discussion notes have been included on some of the papers giving the experience of other members including many R.E. Officers.

It was largely due to military necessity that many novel engineering problems were experienced and considerable ingenuity had to be exercised in their solution, and these volumes deal with the solution of some of these problems.

The subjects dealt with include airfields, roads, railways, military bridging, materials, structures, hydraulics, tunnelling, docks and harbours, including papers on "Mulberry" and "Phoenix."

The Admiralty, War Office, Air Ministry and other Government Departments co-operated with the Institution in the preparation of the book and it presents a comprehensive and authoritative account of the chief engineering works of the war.

J.R.S.

TECHNICAL NOTES

OPERATION EARTHMOVER

(*Construction Methods* (*U.S.A.*)—August, 1948)

Sapper officers especially those with earth moving experience will be interested in an astounding feat, performed, needless to say, in America recently. On a 160 acre site, a levelling job involving the moving of no less than 250,000 cu. yds. of earth (or a volume of earth about half the size of the War Office) was completed in forty hours. One hundred and thirty-seven pieces of earthmoving plant were used, including twenty motor scrapers, with their two or four wheeled tractors, thirty-five crawler drawn scrapers, twenty crawler tractors and seven motor graders. Scrapers ranged from 6 yd. to a mammoth thirty yard Le Tourneau ; tractors were represented by all well-known makes, but were mostly D7s and D8s.

Plant was operated continuously with breaks only for servicing and repairs. Plant operators worked by shifts, six hours on and twelve off, with no break for meals, the change-over of shifts being carried out on the site with no stop in the working of the plant.

The occasion for this titanic effort was the week-end preparation of a site for the Exposition Gardens for a nine county community fair-ground project in Peoria, Illinois. The cost to the authorities was precisely nil. Local engineers surveyed and staked out the site free ; fuel companies gave oil, petrol and grease ; contractors, manufacturers and distributors lent plant and flood lighting equipment ; while operators and mechanics, union and non-union, worked without pay. Plant came from more than thirty owners and from as far away as Cedar Rapids, Iowa.

No reasons are forthcoming or advanced for the phenomenal generosity on the part of all concerned, but there is no doubt about it that a spirit was shown which we, in post-war Britain, could do with in no small way.

THE NEW PITCH MASTIC FLOORING SPECIFICATIONS

PAPER BY T. WHITAKER, M.Sc., MINISTRY OF WORKS

Pitch mastic flooring was developed as a wartime substitute for Mastic asphalt, and continues to be used for flooring on account of its low cost. Pitch is a by-product in the carbonization of coal, and although similar to bitumen in appearance has quite different characteristics. The most obvious difference is that pitch is brittle at normal temperatures, as compared with the plasticity of bitumen.

For pitch mastic flooring compound, it is necessary to modify the physical properties of the pitch by adding tar oil to the pitch when molten, as a flux. The pitch after fluxing has to some extent similar properties to bitumen.

The change over to pitch mastic flooring from mastic asphalt flooring was not popular with the craftsmen, owing to the objectional fumes arising from the compound during application. After the war, work was commenced on the elimination of these fumes, and a simple test was evolved in heating the compound to 20° C. above normal working temperature, smelling it at close range (2 in.) and noting the effects of the fumes on the eyes, lungs and skin.

Two satisfactory non-fuming pitch mastic compounds were produced and standards issued as mentioned below. Work is also continuing on a wood filled variant of coloured pitch mastic.

B.S. 1375, *Red and Brown Pitch mastic.*—This is made from low temperature pitch, fluxed with a specially treated tar oil. Supplies of low temperature pitch limit the use of coloured pitch mastic to housing.

B.S. 1450, *Black Pitch mastic.*—A high temperature pitch is used, treated by steam distillation and fluxed with a particular aromatic oil. All ingredients that previously caused fuming have now been eliminated, and the material is now comparable with coloured pitch mastic. Supplies of high temperature pitch are plentiful and there are no limitations on its use.

Coloured wood-filled Pitch mastic.—Work is still proceeding on this type of flooring with a view to producing a more resilient surface. Difficulties that have not yet been overcome are the acrid fumes given off by the sawdust.

SHORE-BASED RADAR FOR HARBOURS AND FERRIES

(*The Dock and Harbour Authority*—July, 1948)

In the summer of 1946, the Admiralty, in conjunction with the Mersey Docks and Harbour Board, carried out experiments with naval radar equipment set up ashore at Liverpool, which demonstrated the potential usefulness of shore-based radar. It became obvious that if the installation was sited properly to enable it to "see" all parts of the channel and harbour, the shore authorities would be able to determine the position and movement of all ships and other craft in the area concerned and be able to plan berthing, docking, departures and other harbour operations, more quickly and more efficiently. They would also be able to know whether buoys, light vessels and other navigational marks were in position and to locate the exact position of any casualty.

The experiments proved that shore-based radar was a feasible project and that it would be invaluable in all conditions, but especially when visibility was bad and ships were held up. This article describes the history, functions and technical requirements of shore-based radar and gives the capabilities of the standard Marine Radar sets used. A specially designed radar set has recently been installed at Liverpool and this is described in the August issue of the same magazine.

CONCRETE TIES (SLEEPERS) ON THE BRITISH RAILWAYS

(*The Railway Age*—5th June, 1948)

Because of the shortage of suitable timber supplies, substitute units made of prestressed wire reinforced concrete are now being manufactured on a mass produced basis for use on the British Railways. First introduced during the 1939–1945 war, the concrete sleepers have given satisfactory results in service tests on mainline tracks and are being introduced on railways in Ireland, Egypt, India and other countries.

The article, written by the Assistant Engineer of Structures, London Midland Region, for this American periodical, gives details of the history of the scheme, the manufacturing plant and the specification of the reinforced concrete used.

A SKEW BRIDGE CONSTRUCTION

(*Modern Transport*—7th August, 1948)

A bridge of 500 ft. skew span, carrying four mineral lines over Western Region track, has recently been constructed in South Wales. The old bridge, built in 1884, consisting of wrought iron main girders and cross girders with steel trough flooring, was strengthened in 1924 to take the heavy traffic both under and over the bridge.

The new superstructure consists of steel main girders and reinforced concrete deck units, the largest of which are approximately 35½ ft. long and 2½ ft. deep, weighing thirty tons. The total weight of the units is 475 tons.

The skew of the bridge and the conditions at the site, together with the weight of the deck units, necessitated the use of two forty-five-ton steam cranes. The operation was carried out in two consecutive week-ends.

THE HEYSHAM JETTY

(*The Dock and Harbour Authority*—August, 1948)

Heysham Jetty is a berth, for ocean-going tankers, exposed to the open sea at high tide and to wind and wave action resulting from eighty-mile per hour on-shore gales.

The site was chosen in order to give submarines difficulty in pursuing tankers to their berth, and for convenient proximity to a refinery site. By normal standards it is not a very suitable site for a large tanker berth, but for wartime purposes, with the help of special construction and a new design of shock absorbing dolphin, it proved satisfactory in spite of all the technical difficulties which had to be overcome.

The contractors adopted a policy of carrying out as many operations as possible from floating craft, partly in order to accelerate the work and partly to minimize the risk of loss or damage to plant during rough weather. The construction was completed over a period of eighteen months, at a total cost of about £275,000.

This article describes in detail the special methods of construction which had to be used to counter the exceptional gales, 30-ft. tide rise, four-knot current, narrow channel approach and a silt and boulder-clay sea bed.

GIRDER SPANS FLOATED TO NEW SUPPORTS

(*Railway Age*—29th May, 1948)

By adopting a special bridge pier design, the Louisville and Nashville Railway in America recently found it possible to renew the substruction of a long, multiple, open girder bridge carrying a single track line, without changing the alignment and without interference with or by traffic, thereby effecting a large saving compared with conventional designs and methods.

The bridge carries the track across a river approximately half a mile from the Gulf of America, but fortunately at this point, the river is not classified as navigable and no provision for a moveable span is necessary. The renovation became necessary because the original timber piling was under constant attack by teredos, making frequent replacement of damaged piles necessary.

In the scheme adopted the new piers, constructed of composite steel pipe and concrete piles, were sited half way between the old ones, on the existing alignment. The existing spans were floated into position on to them on barges. The construction involved new types of equipment and design, all of which are described in this article, together with photographs taken during construction and elevation drawings of the old and new bridges.

A SHUNTING APPLIANCE

(*Modern Transport*—31st July, 1948)

B.S.A. have manufactured a vehicle for moving railway wagons at marshalling yards, sidings and places where there is normally a considerable amount of truck movement, but where it is uneconomical and a waste of effort to use shunting engines.

The truck mover can easily propel a rake of empty wagons with an aggregate weight of one hundred tons on the level, and it is, of course, equally capable of moving loaded trucks of the same total weight. Tests during the development stages have demonstrated that this remarkable little vehicle will also tackle quite serious gradients, provided use is made of the three speed gearbox incorporated in the design.

This article describes the vehicle in detail and it is interesting to note that the Army hopes to obtain two of these machines for work in depots at home and in the Middle East.

CORRESPONDENCE

MILITARY CEMETERY IN SOUTH AFRICA

"Windsor Shell Hole,"
P.O., Newark, Natal,
S. Africa.
14th August, 1948.

To The Commandant, Royal Engineers.

Dear Sir,

Under separate cover I am posting to you two photos which may be of interest to your regiment.

On the banks of the Tugela River on the Natal–Zululand border is an old military cemetery in which some members of your regiment are buried. They died during the Zulu War of 1879. This cemetery has been long forgotten and was reverting to original bush. The "Windsor Shell Hole," which is an ex-service men's organization, would not allow this to happen, so we have erected 80 headstones and a granite memorial tablet, and put the cemetery in good order, and will always keep it so.

In the early part of the year we had a memorial service and the cemetery was re-dedicated by the Bishop of Zululand. Unfortunately we were unable to trace the names of each individual grave, so on the headstone we had inscribed "Here rests a brave British soldier."

Yours truly,
(Sdg.) Eric Addison,
Shell Hole Commander.

From General Sir Guy C. Williams, K.C.B., C.M.G., D.S.O., Chief Royal Engineer.

To The Commander, "Windsor Shell Hole," P.O., Newark, Natal, S. Africa.
30th September, 1948.

Dear Sir,

Your letter of 14th August, 1948, addressed to the Commandant, Royal Engineers, forwarding photographs of the Military Cemetery on the banks of the River Tugela, South Africa, has been passed to me.

It is most gratifying to the Corps of Royal Engineers to know that the graves of their late comrades, even after such a lapse of time, are still preserved and well-tended.

The photographs which accompanied your letter show very clearly that your Association has taken a very great deal of trouble in restoring the Cemetery ; and, on behalf of my Corps, I send you our grateful thanks.

The photographs will be published in the next issue of *The R.E. Journal* and will be kept as a valuable record of a Corps whose active service has taken them to all parts of the world, and earned for them the motto, *UBIQUE.*

Yours truly,
G. C. Williams, General,
Chief Royal Engineer.

General view of cemetery as restored by the *Windsor Shell Hole.*

(Photograph by Gaston Henri, Stanger, S.A.

Fort Pearson Military Cemetery, Natal

View of large Memorial Tablet with individual headstones in background.

(Photograph by Gaston Henri, Stanger, S.A.

Fort Pearson Military Cemetery, Natal 2

SITTANG RAIL FERRY

Chief Engineer's Office,
Cameroons Dev. Corporation,
Tiko.
13th August, 1948.

To the Editor, *The Royal Engineers Journal.*

Sir,

The Journal for June, 1948, contains an article on the Sittang Rail Ferry, but omits one most important practical point which would be of vital interest to any officer attempting a similar problem.

It is essential that there should be no appreciable vertical angle between the rails on the ramp and the rails on the ferry, or between the rails on the ramp and the rails on the approach track. In the latter case damage is done to vacuum brake cylinders or similar equipment under the frame level of bogie vehicles. In the former case a locomotive being placed on the ferry is at one period carried only by its bogey and trailing wheels, the drivers being suspended in mid air. Apart from the damage which such treatment does to the locomotive, this temporarily deprives the locomotive of all its brakes except those on the tender, so that the locomotive is completely out of control and is quite likely to rush across the ferry and plunge overboard on the far side. This very nearly happened in the experimental loading of a loco to which the authors of the article refer, and disaster was only averted by a combination of good fortune, fine driving by a Burma Railways driver, and the fact that the cow catcher, which had not been removed, embedded itself in the ferry floor boards. Finally it should be pointed out that if this vertical angle exists, even slightly, the locomotive driving wheels will be deprived of adhesion and the locomotive will be unable to leave the ferry under its own steam.

It is unfortunate that no further constructive criticism can be offered by me on this design. The monsoon broke a few days after the ferries were completed by Tn., and both ferry terminals were washed away with the result that the ferries themselves became unusable. Their large size made them unhandy in rough weather, for which the Sittang is renowned, and after nearly losing one of them out of control and being swept down on to the old bridge piers, the Burma Railways converted the two into three—" Sorcerer " being added to " Patience " and " Pinafore "—and transferred them further up river to operate as lorry ferries.

I am, sir, etc.,

J. C. B. Wakeford,
Brigadier (retd.).

Lately Chief Railway Commissioner Burma and Technical Adviser on Railways to the Governor of Burma.

GUERILLA OR PARTISAN WARFARE

(An extract from *Battles and Leaders of the Civil War* by R. U. Johnson and C. C. Buel)

SUBMITTED BY "L.E.C.M.P."

"LEST the most effectual and expeditious method of destroying railroad tracks should become one of the lost arts, I will here," says General H. W. Slocum, "give a few rules for the guidance of officers who may in future be charged with this important duty.

"It should be remembered that these rules are the result of long experience and close observation. A detail of men to do the work should be made on the evening before operations are to commence. The number to be detailed being, of course, dependent upon the amount of work to be done, I estimate that a thousand men can easily destroy about five miles of track per day, and do it thoroughly. Before going out in the morning the men should be supplied with a good breakfast, for it has been discovered that soldiers are more efficient at this work, as well as on the battlefield, when their stomachs are full than when they are empty. The question as to the food to be given to the men for breakfast is not important, but I suggest roast turkeys, chickens, fresh eggs, and coffee, for the reason that in an enemy's country such a breakfast will cause no unpleasantness between the commissary and the soldiers, inasmuch as the commissary will only be required to provide the coffee. In fact, it has been discovered that an army moving through a hostile and fertile country, having an efficient corps of foragers (vulgarly known in our army as 'bummers'), requires but few articles of food, such as hard-tack, coffee, salt, pepper, and sugar. Your detail should be divided into three sections of about equal numbers. I will suppose the detail to consist of three thousand men. The first thing to be done is to reverse the relative positions of the ties of iron rails, placing the ties up and the rails under them. To do this, Section No. 1, consisting of one thousand men, is distributed along one side of the track, one man at the end of each tie. At a given signal each man seizes a tie, lifts it gently till it assumes a vertical position, and then at another signal pushes it forward so that when it falls the ties will be over the rails. Then each man loosens his tie from the rail. This done, Section No. 1 moves forward to another portion of the road, and Section No. 2 advances and is distributed along the portion of the road recently occupied by Section No. 1. The duty of the second Section is to collect the ties in piles—place the rails on top of these piles, the centre of each rail being over the centre of the pile, and then set fire to the ties. Section No. 2 then follows No. 1. As soon as the rails are sufficiently heated Section No. 3 takes the place of No. 2, and upon this devolves the most important duty, viz., the effectual destruction of the rail. This section should be in the command of an efficient officer, who will see that the work is not slighted. Unless closely watched, soldiers will content themselves with simply bending the rails around the trees. This should never be permitted. A rail which is simply bent can easily be restored to its original shape. No rail should be regarded as properly treated till it has assumed the shape of a doughnut; it must not only be bent, but twisted. To do the twisting, Poe's railroad hooks are necessary, for it has been found that the soldiers will not seize the hot iron barehanded. This, however, is the only thing looking towards the destruction of property which I ever knew a man in Sherman's army to decline doing. With Poe's hooks a double twist can be given to the rail, which precludes all hope of restoring it to its former shape except by re-rolling."

R.E. Kitchener Scholarships Fund

This fund exists for the purpose of assisting with the education of the children of officers or other ranks of the Corps of Royal Engineers who have been killed or died on service.

Demands have recently increased and donations are urgently needed to provide the necessary funds required for these scholarships, and will be gratefully acknowledged by :—

The Secretary
The Institution of Royal Engineers
Chatham, Kent