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THE ROYAL ENGINEERS JOURNAL

CONTENTS

THE ROYAL ENGINEERS JOURNAL—MARCH, 1950 VOL. LXIV. No. 1

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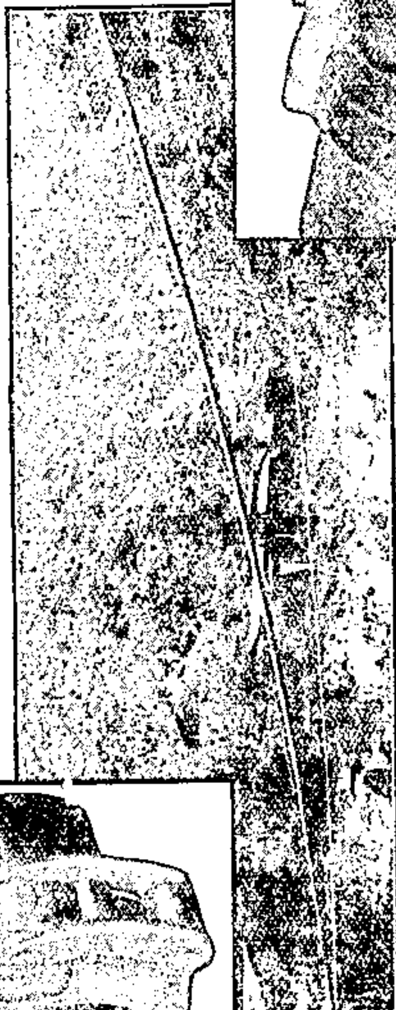

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Photo 14.—Brigadier Hill, Major-General Bols, Lieut.-General Dempsey and Field-Marshal Montgomery, 28th March, 1945.

Photo 15.—Lieut.-Colonel J. R. C. Hamilton receives the D.S.O., 28th April, 1945.

"GO TO IT"

THE STORY OF THE 3RD PARACHUTE SQUADRON, R.E.

(concluded)

By MAJOR J. S. R. SHAVE, M.C., R.E.

CHAPTER 7

OPERATION "PLUNDER"

THE RHINE CROSSING

General

The month of March, 1945, saw the allied armies poised on the west bank of the Rhine waiting to strike a crushing blow across the river into Germany. The first weeks of the month were spent in ardent preparation, the movements of 21st Army Group were shrouded under cover of a dense oil smoke screen, which was generated ceaselessly by thousands of burners on the river bank.

Back at home the 6th Division was making itself ready for another airborne assault.

The 3rd Squadron spent 1st-8th March on leave, and then returned to feverish activity at Bulford. Shortage of transport and engineer equipment, amongst other things, necessitated the reorganization of the unit into two troops instead of the three which had previously gone into action. No. 3 Troop was disbanded to reinforce Nos. 1 and 2.

We learned that there were insufficient sapper tasks in the coming operation to warrant the use of more than one troop per brigade. Accordingly, a troop each from 3rd and 591 Squadrons had to be selected to go with 3rd and 5th Para. Brigades. A second troop from 591 Squadron was selected to fly in by glider with 6th Airlanding Brigade, while the remainder had to return to B.L.A. by sea as quickly as possible.

The fact that Rosie selected No. 1 troop to take part in the operation, reflects great credit on Freddy Fox, its commander. As O.C. of No. 2 Troop I naturally held a different opinion at the time, and felt it very keenly. Taking all things into consideration, Rosie's choice was a fair one. In the Normandy descent No. 1 Troop had not been so fortunate as we, and their opportunities to shine had not been so frequent. Since we had more casualties than they, there were still remaining in No. 1 Troop a larger proportion of its original members than we had—although, in my opinion, what was left of the troop, which had been trained by Tim Juckes, was still the best in the squadron. Nevertheless, No. 1 was detailed for the operation and I became O.C. of the squadron sea party, which comprised squadron H.Q. and No. 2 Troop.

On the 11th and 13th March we had practice jumps on the divisional "DZ" at Netheravon. They were really enjoyable "Y.M.C.A." jumps, carried out in perfect weather, "kitbagging" was the order of the day.

For the purpose of the move, the squadron M.T. with myself, Geoff Smith and Lieutenant Franklin, proceeded as a separate vehicle party. The

personnel went by train to Purfleet on the Thames, where we spent the night of the 11th in a vast transit camp. The next day we embarked at Tilbury in an L.S.I. and were carried swiftly to Ostend where we disembarked the following day. The vehicle party proceeded on to eastern Belgium and we followed by train. We joined them eventually at Geldingen, near the Maas.

Meanwhile No. 1 Troop had spent a week, hermetically sealed in their transit camp near an airfield, being briefed and preparing for an operation.

Operation "Plunder"

On 24th March, 1945, 21st Army Group crossed the Rhine. The code name for the operation was "Plunder." The crossing was effected by Second British Army with 12 Corps, 30 Corps, 2 Canadian Corps, 8 Corps and 18 U.S. Airborne Corps under command. Corps tasks were approximately as follows :—

12 Corps :—To capture Wesel, cross the river at Xanten and relieve 6th Airborne Division on the line of the river Issel.

30 Corps :—To cross the river and capture Rees and Haldern. To link up with 12 Corps and extend a bridgehead to the Issel.

18 U.S. Airborne Corps (6th Airborne Division and 17 U.S. Airborne Division) :—

(*a*) To capture and hand over to 12 Corps certain key features in the area of Diersfordt and crossings over the Issel.
(*b*) To gain contact with 1 Commando Brigade in Wesel.
(*c*) To advance east, extending south to the River Lippe.

2 Canadian Corps :—To cross at Rees and capture hill features, to revert to First Canadian Army after constructing bridges at Emmerich.

8 Corps :—To relieve H.Q. 18 U.S. Airborne Corps on "D + 7," take command of the two airborne divisions and pass through the right of the Second Army bridgehead and be prepared to operate north-east.

The code-name given to the airborne operation was "Varsity." Both airborne divisions were to drop at 1000 hrs. on the 24th March, several hours after the land assaults had begun.

Operation "Varsity"

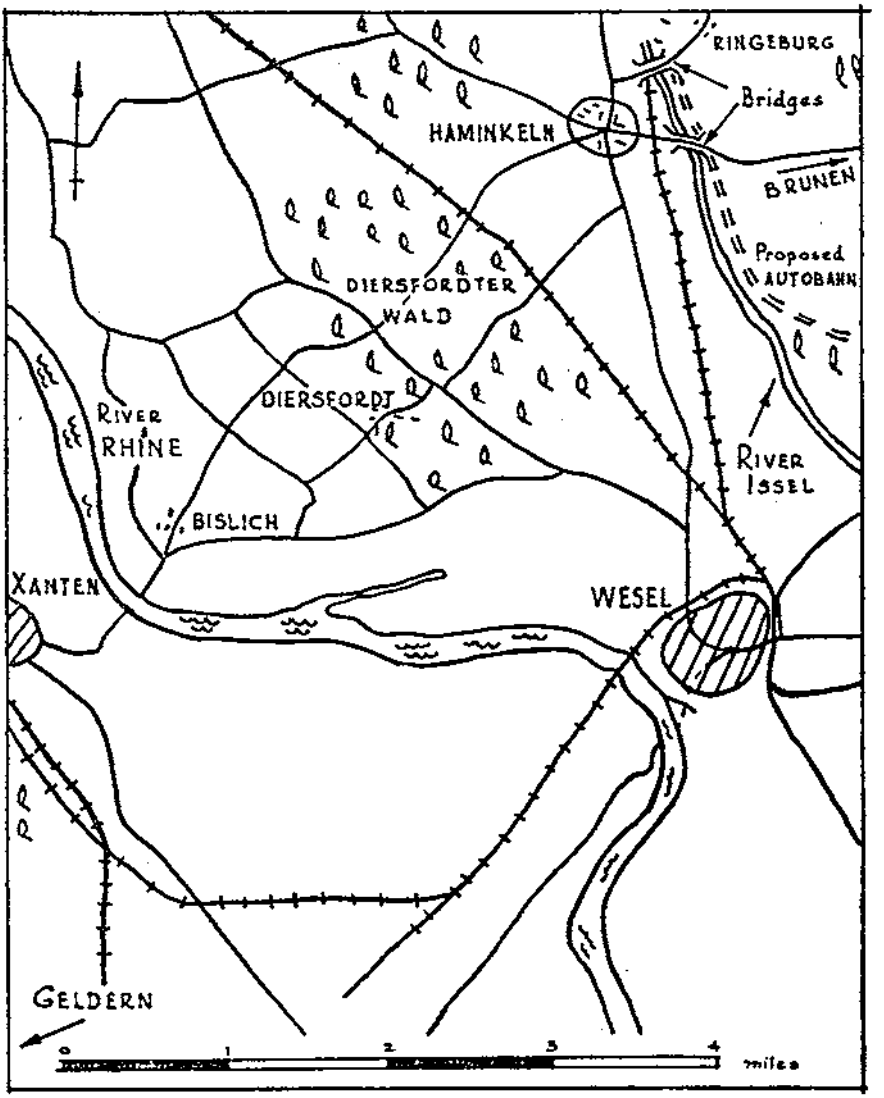
The 6th Airborne Division and 17 U.S. Airborne Division were to land east of the Rhine in the area of Haminkeln, six hours after the assault crossing of the river, with the object of :—

(*a*) A rapid extension and build-up of the bridgehead with a view to an advance towards Bocholt.
(*b*) Denying enemy observation of the Rhine crossing.

The plan was to seize and hold the line of the River Issel. The area of the landings was well wooded, a forest called Diersfordter Wald lay on the west. The guns of German divisions holding the Rhine were hidden in this area. The woods were broken by stretches of open farm-land served by a good network of roads.

The Issel was not a large river which would provide a good natural obstacle. There were three bridges in the area of the landings, one railway bridge and two road bridges. It was anticipated that these bridges would not be blown by the Germans until they were forced to retreat from the area. In any case, it was desirable that we should hold the bridges, to save or blow them as we deemed necessary.

THE RHINE CROSSING 24TH MARCH, 1945



Engineer tasks in an airborne operation in this area seemed to be few ; it was thought that the following engineer tasks would arise :—

1. To examine the three bridges and perhaps to prepare them for demolition.
2. To clear mines and obstacles encountered, and to assist brigades to dig in.
3. To dig in with bulldozers the wireless of Divisional H.Q. and the 75 mm. guns.
4. To carry out " opportunity " tasks of route clearing, mine laying and water supply, if they should arise.

The engineer elements included in the airborne force, and their tasks, were as as follows :—

(*a*) One troop of 3rd Para. Squadron, under command of 3rd Para. Brigade. Three officers and forty-seven other ranks to drop by parachute, while ten other ranks went in two gliders, with jeeps and trailers.

This troop was to give general assistance to 3rd Brigade and to to open up a route from 3rd Brigade to Division.

(*b*) One troop of 591 Squadron by parachute and glider with 5th Brigade, to give general assistance and to open up a route from 5th Brigade to Division.

(*c*) One troop of 591 Squadron with 6th Airlanding Brigade. This troop of three officers and twenty-five men was to be accompanied by the O.C. Squadron. They were carried in six gliders each with a jeep and trailer.

The engineer tasks of this troop were most important. Two gliders were to land with each *coup-de-main* party of the Oxfordshire and Buckinghamshire Regiment and 1st Royal Ulster Rifles, to assist in seizing the bridges over the Issel and, if necessary, to prepare them for demolition. Four of these gliders each carried enough explosive to destroy one of the road bridges over the River Issel.

(*d*) From 286 Field Park Company, four bulldozer drivers with two D.4 bulldozers were to fly in two Hamilcar gliders. The stores officer and N.C.O. were to fly with H.Q. R.E.

(*e*) The C.R.E. and a proportion of H.Q. R.E. flew in by glider with divisional headquarters. The remainder of the divisional engineers moved by land to the west bank of the Rhine and crossed on 24th, 25th and 26th March.

The main airborne landings took place soon after ten o'clock on " D " day (24th March). The battalions were involved in some brisk fighting, but the day went well and saw all objectives successfully achieved. A link-up with 15th Scottish Division was quickly and firmly established.

No. 1 Troop of 3rd Squadron dropped at ten minutes past ten, events affected them as follows :—

All sticks were very long and overshot their " DZ." Light flak and small arms fire greeted them before and during the drop. There was some slight " battling " on the " DZ " which was mortared by the enemy. Captain " Freddy " Fox was wounded on the " DZ," a bullet smashing his arm ; four men were wounded by mortar splinters. At 1045 hrs. 75 per cent of the troop had arrived at the " RV " and by 1115 hrs. there were only four missing in addition to the casualties. The missing men were all recovered the same

day, one of them having been wounded, captured and then recaptured from the Germans. Both jeeps and trailers arrived safely, so the troop was well equipped to carry out small tasks.

3rd Para. Brigade did not linger in the vicinity of the "DZ" but advanced to its objectives, which were successfully seized. No. 1 Troop moved with brigade headquarters and dug in with it. No. 3 Section was placed under command of 1st Canadian Para. Battalion. The section was employed in the construction of a road block and in the lifting of Riegel and Schu mines which were found buried in a main road.

During the night of the 24th March, 8th Para. Battalion cleared a way through the forest of Diersfordter Wald and discovered a crater which blocked the main divisional axis. With the aid of the D.4 bulldozer, which had arrived safely, No. 1 Troop repaired this and other craters on "D + 1" (25th March). The troop also neutralized a crater charge discovered on a bridge.

No. 1 Troop came through the operation very lightly when compared with the troops of 591 Squadron. H.Q. R.E. were also fortunate, the glider carrying Colonel Hamilton crash landed in the right place without hurting its occupants. The other H.Q. R.E. glider carrying the adjutant and I.O., came down in Holland, but its passengers managed to reach Divisional H.Q. the same evening. Of the two Hamilcars which carried bulldozers and drivers, one landed successfully and the bulldozer with both operators reported to Divisional H.Q. at about 1330 hrs. The other Hamilcar landed wide and its occupants fell into the hands of the enemy, one operator was killed.

The troop of 591 Squadron commanded by Captain Bob Beaumont, which dropped with 5th Para. Brigade, landed successfully. It came under fire from 88-mm. guns which were "shooting up" the "DZ" over open sights. At 1330 hrs. it had all assembled at the "RV," with the exception of one complete glider load. The glider landed in Holland and its occupants arrived later. One man was killed at the "RV" and five were wounded. The troop moved with 5th Brigade and dug in next to Brigade Headquarters. The guns which had fired on the "DZ" were soon captured and this troop blew them up; otherwise there were no engineer tasks.

The heroes of the engineer elements which took part in "Varsity," were the six detachments of No. 1 Troop, 591 Squadron, who went by glider with *coup-de-main* parties of 6th Airlanding Brigade. This troop was commanded by Captain Frank Harbord. Out of six gliders only two arrived safely, two were shot down by light flak and two were destroyed by shell-fire on the "LZ." Frank Harbord and Lieutenant Ken de Watteville were killed. Of sixteen men and eight glider pilots, only one sapper and one pilot escaped uninjured. Two lance-sergeants were wounded and evacuated, the remainder were killed.

One glider landed successfully with the *coup-de-main* party of the Royal Ulster Rifles, and one with Brigade Headquarters.

Having reached their road bridge, the *coup-de-main* party of the Royal Ulster Rifles, and the sappers under Lieutenant Peter Cox, were involved in heavy fighting. The bridge was captured at 1115 hrs. by the Royal Ulster Rifles after a stiff battle—it was found to be prepared for demolition with German shells. The sappers improved the charges and firing circuits.

No sapper party arrived at the road bridge which was the objective of the 52nd Oxf. and Bucks. Accordingly, Lieutenant Cox's party moved to this bridge where it was found that the enemy were holding the far bank. The bridge was under direct small arms fire at short range, so it was decided to

attempt to fix charges after dark. Explosives were obtained from the other glider at 6th Airlanding Brigade H.Q. and work was commenced after dark. This work was repeatedly held up by small arms fire and the job was eventually completed by one man who carried charges while crawling on his stomach. The demolition was ready at 0215 hrs., it had to be blown at 0300 hrs. because the enemy were attacking heavily with tanks. It is thought that the leading tank was destroyed on the bridge. Peter Cox was awarded the M.C. for his exploits.

24TH MARCH, 1945

It was a beautiful spring in eastern Belgium, mild and sunny. Our move to squadron location at Geldingen had been accomplished with as much secrecy as possible in order that the approaching airborne operation would not be jeopardised. We had packed all red berets at the bottom of our kitbags, vehicle signs were painted out and no one *en route* had been allowed to mention our name.

We did not know the date of " D " day, but after two days at Geldingen we knew the time must be drawing very close. At about nine o'clock on the 24th March we heard the old familiar roar in the sky and over came the invading army. Screened by hundreds of high flying fighter planes, the steadily moving mass of troop-carrying aircraft presented a wonderful spectacle. Serried, graceful ranks of Dakotas, Stirlings, Halifaxes and gliders passed over, followed by flight after flight of swiftly moving low flying Liberators. So low came the " Libs " that we saw through the large exit in their fuselages. There were the faces of dispatchers, ready to throw out supplies. I hope they saw us and felt a little easier in mind as we cheered and wished them luck.

Within an hour we were formed up in convoy and on the road north to cross the river and rejoin the division. As we left the village, out came our red berets and we were once again 3rd Para. Squadron. We felt very proud to be linked with those fine fellows that had just gone overhead. I like to think that our security was good enough to make this a big surprise for the villagers. They registered enough of it to make a good show anyway.

We followed the river Maas down to Venlo, passing straight through the area which we had occupied a month previously. At Venlo we crossed a Bailey pontoon bridge, alongside which a very good timber pile bridge was rapidly taking shape under the expert hands of an American construction battalion.

From Venlo we passed into Germany. Moving up slowly all day, we followed routes painfully wrought by the British and Canadian Armies during the consolidation of the west bank of the Rhine. For one stretch of several miles, the convoys bumped over the stones of a high railway embankment, from which the rails and sleepers had been torn to allow the passing of traffic. On this occasion, and on many others, one felt very proud to be a sapper in the presence of good work done by other sappers throughout the armies.

A folding boat bridge had been thrown across the river by engineer units before we arrived at the Rhine. We were not of sufficient priority to cross that day so we harboured in fields allotted to us some ten miles back from the river. There we sat waiting for news of our friends who had come down on the other side of that broad ribbon of water, friends whom we knew had landed right on top of the German positions.

By then we were surrounded by other vehicles and follow-up parties of the division. H.Q. R.E. and 591 Squadron were quite near by. Rosie went

forward to try to find out how No. 1 Troop had fared in the operation. The first news we had was jumbled and inaccurate, but it seemed clear that the gliders had been through a very rough time. 591 Squadron had sent in a complete troop by gliders ; Fergy Semple of 591 managed to get across the bridge and back again with news of his squadron. Two gliders had been totally lost ; they had carried men of Frank Harboard's troop—he and Ken de Watteville were lost with them. Light flak had played hell with the slowly moving gliders.

Rosie returned with good news of our No. 1 Troop. They had landed and concentrated with few casualties. Freddy Fox himself was wounded, his arm smashed by a bullet, Jack Nash and Tony Wade were carrying on with the troop.

Impatient to rejoin the division, we were glad to receive orders to move early on the 26th March. We crossed the Rhine on the folding boat bridge completed the day before by sappers at Xanten. Moving slowly up some four miles to the forward area, we found ourselves in the centre of the divisional area. For our squadron harbour we were allotted a wooded hillock containing heavy flak guns which had been an objective of the 9th Battalion. We were delighted to see No. 1 Troop soon after our arrival.

Operating with only two troops and full scale transport, the squadron was completely mobile. Now that we had arrived, No. 1 Troop was given a rest and was enabled to organize around its transport. The perfect weather broke into rain and we settled to sleep that night in the dugouts recently occupied by the enemy. I thought then how surprised those Germans must have been on the 24th at the sight of the vast airborne army which descended and swamped their positions. In the middle of the night No. 2 Troop had to go out to arrange a detour round a huge crater on the main road near by ; without rubble and tipper trucks we could not carry out any effective repairs. The obstacle was taped off and the route round it marked by the small green lamps we carried as part of our war equipment.

6th Airlanding Brigade, with a squadron of tanks in support, crossed the Issel on "D+2" and advanced 6,000 yds. against slight opposition. The remainder of the division side-stepped to the south and crossed the Issel on what had been the front of 17 U.S. Airborne Division. 249 Company constructed a ford for the crossing of 6th Brigade, and 3rd Squadron constructed a ford and improvised bridge for the crossing of 3rd Brigade. Both tasks were accomplished with the aid of the D.4 bulldozer which had come in by glider.

On "D+6," 6th Airborne Division came under command of 8 Corps. 249 Company constructed a Bailey bridge over the Issel on the main Wesel–Bruner road. This route became the divisional and finally the corps axis.

Before morning on the 26th, we were on the road advancing with 3rd Para. Brigade. The divisional axis lay across country, due east from the river. We passed through the northern part of what was left of Wesel, and on through part of the ground held by 17 U.S. Airborne Division. We were moving in a line which would take us just south of Bruner.

This was our first experience of the Rhineland proper and we thought it very beautiful, spoiled only by the presence of Germans—dead and alive. It was also our first taste of the German second-class roads which we were to follow for so many hundreds of miles in the ensuing weeks. One had heard so much about the autobahns during the years of the Nazi régime that there was a general feeling that German roads were the best in the world. That morning the map showed that our route crossed an unfinished autobahn. The troop moved about ten miles in two hours across roads which resembled good cart

tracks at home. Two trucks were ditched by slipping off the narrow wet muddy surface at sharp bends. We crossed the autobahn without realizing it. It was simply a wide swathe cut through a forest. I did not see an autobahn proper at all during the three months I was in northern Germany.

Our first task on this route was to improvise a small river crossing. The task itself was uninteresting, and was accomplished with the aid of a light bulldozer and bundles of faggots from near-by farms. The bridge lasted until we finally left the area some twelve hours later, but was probably soon washed away once the route became disused. Interest that morning came from either side of our improvised bridge. Ten yards upstream I selected the site for a tank " scissors " bridge which soon arrived. Over it trundled the squadron of Churchills which was advancing with 3rd Para. Brigade.

As this operation was being carried out, a terrific battle noise developed in a wood on the far side, some 300 yds. downstream. We had no idea of the presence of enemy there, and the only troops at hand were my sappers and the Churchills. Brigadier Hill, who was at the crossing, seemed as mystified as anyone. Coupled with incessant machine-gun and rifle fire, we could hear the roar of several tank engines. When bullets began cracking round the bridge site we took cover and made ready our defence. To our relief and great surprise, a moment later, we spied a clearing party of American Parachutists break cover, followed by some Sherman tanks. Feeling a bit stupid we carried on with our work ; later I had a quick look at the wood, but could see no sign of recent occupation by the Boche. From this I gathered that the Yanks had been using safety-first methods during their progress through the wood—every likely piece of cover was swamped by fire—just in case.

A large part of 3rd Brigade transport crossed our improvised bridge before we moved on. When we did so it was to the new squadron location, some three miles on up the woodland tracks.

The Start of the Grand " Swan "

The 28th March. After a night in a farmyard, the squadron was early on the road, moving by devious tracks to join the brigade column. That day everyone was in high spirits, the weather was perfect and the countryside very lovely—untouched by war. The advance continued some twenty miles to the village of Rhade. The divisional axis was swinging northward so that we were now moving in a north-easterly direction. Today began the irresistible forward surge of 21st Army Group which continued almost unchecked until the end of the campaign in early May. Throughout, 6th Airborne Division operated on the right flank, traversing the woodlands and by-ways of first the Rhineland and then the north German plain. Once the fever of the advance gripped the division, little could stop it. The cry was " bash on regardless," and on it went, twenty, thirty, forty miles per day. Now and then we faced obstacles, the infantry had a short, hard battle, or we had to rest a while, but never for long were we checked.

From the first day of this advance one could see how well stocked and preserved were the German farms compared with those of the impoverished occupied countries through which we had recently passed. Whenever possible we would harbour in farm buildings, and almost invariably found a dozen or so fine milking cows housed there. Bacon and hams were seen hanging, and eggs seemed plentiful. Needless to say, our " compo " rations were usually embellished by the tasty addition of an egg or two.

Rhade was packed with troops by nightfall, and I felt glad that we were chasing a different Wermacht from the one which had played such a stubborn

retreat in Normandy. On this occasion, as on many others, a few light bombing aircraft would have played hell with the concentration of troops.

6th Airlanding Brigade took over the advance the following day. It was an impressive order of march, led by the Churchill tank squadron of 6th Guards Tank Brigade, bearing a company of the leading battalion on their backs. On the tail of the tanks came the Brigadier's "O" Group, consisting of three jeeps; one of them was the sapper jeep. No. 2 Troop was again "up," the remainder of it, with a D.8 'dozer, travelled with the next body of troops behind the "O" Group. The advance progressed as fast as the tanks could go along fairly good roads towards Crefeld, until a demolished bridge was encountered north-east of a small town called Grosse Reken—a small town which had been heavily blitzed.

"Close Shave" Bridge

The demolition consisted of a tangled mass of twisted steel reinforcement and concrete blocks which projected above the level of the old bridge, half of which still stood. The bridge was of heavy reinforced concrete and I said at once, without calculation, that the remaining half, which completely spanned the small river, would carry a Churchill. The vehicles of the divisional recce regiment which preceded us, had already crossed. However, "higher authority" arrived and told me to prepare to construct a Bailey while the tanks forded the river.

We put several tanks over a hastily bulldozed ford and then extracted them from the field on the far side, in which they rapidly became bogged down. One tank then tried to cross in another place and we were unable to extract it. I asked if I might try one Churchill across what remained of the old bridge. The request was granted and over went one tank followed quickly by the remainder; the drivers did extremely well since there was only six inches clearance on each side of the tracks.

The Bailey soon arrived and the troop set to work to produce a bridge. After working some time we were told that this route would soon become a corps route. We therefore had to place the bridge so that there was room for another alongside it when a dual carriageway became necessary. This meant more work on bankseats and the removal of a line of heavy trees on the home side, in order to clear the approach.

Before we could begin construction the mass of the demolition had to be blasted out of the way. On a congested road with a continual traffic stream and a lot of bridging equipment cluttering up the two-lane approach, the work was not easy and was continually held up. Tom Marsh was made bridge commander and he and all ranks worked very hard.

At length we had the bridge ready for launching, but found that some of the old masonry still obstructed the line of the new bridge. By swinging it "over a bit" and chipping away at the concrete with our light compressor tools, we managed to complete it. The total time taken in construction was sixteen hours—from 1200 hrs. on the 29th to 0400 hrs. on the 30th.

We then moved on to join the squadron in a large farm nearer Coesfeld. By this time the troop was very tired indeed—we had been supporting the forward troops for three days.

No. 1 Troop was given the next task which consisted of making a detour round the bombed town of Coesfeld. This little town really was a shambles, it seemed to be a series of huge bomb craters from one end to the other. The only way to get vehicles past it was to fill in craters on cart tracks on the outskirts of the town. No. 1 Troop slaved away at this diversion through the night of the 29th March and soon had it opened up.

The speed of our advance through Germany was as phenomenal as it was exhilarating. Sometimes we represented the right flank of the Second British Army and at others we became the left flank of the American Army operating on our right. We just "bashed on," seemingly oblivious of opposition and using one route only as the divisional axis. What went on on either side of this route, I feel sure few, if any, knew.

Early on 30th March, No. 2 Troop returned to the bridge to maintain it and put the finishing touches to it, which included its name: "The Close Shave." This done, we rested until early on the 31st when we once again went forward with 3rd Para. Brigade. We were approaching the first serious obstacle in our advance—the Dortmund–Ems Canal. Some six miles on our side of this ran a small river which crossed our axis at Graven. Entering this town on the 31st, 3rd Brigade found it evacuated by German troops but under fire from 88-mm. guns, and with all main bridges in the town blown. 249 Company moved up and commenced strengthening the one light bridge which remained. Unfortunately, as soon as the first scout car of the recce regiment ran on to this bridge, it went through the decking. This held up operations for a considerable time, during which the infantry went forward on foot.

It was decided that 249 Company would construct a Bailey bridge where they were working. Further delay was caused by the fact that bridging lorries were unable to get through the congested roads.

Graven was being subjected to a steady bombardment with airburst shells which were fired from quite close range. Going to inspect the main road bridge of the town, I found Jack Bence, an officer of 249 Company, on the same errand. I had gone forward on the pillion of Lance-Corporal Worgan's motor cycle. We parked the machine above the demolition and then climbed down the river bank to look at the obstacle. At that moment the guns began firing over this bridge and we were forced to take cover beneath it. There we "quaked" for about fifteen minutes until the "stonk" finished. Going up to the road again, we found the motor cycle had been hit by several splinters.

Making our way back to the troop, we sat at the roadside for an hour or two until the bridge could take us. The congestion in Graven was frightful, and we felt thankful for our air superiority. However, our faith was rudely shaken at one point when the column was spattered by bullets without warning. All we heard after, was the whine of the disappearing jet plane (an ME 210), which had been responsible. So fast had this plane been moving that its bullets were around us before we heard its engine. The speed also affected the accuracy of the shooting so that no one was hurt—the experience was definitely exciting.

My responsibility was to get up to the Dortmund–Ems Canal with the leading infantry, to recce the crossing there and get a report back to the C.R.E. It was anticipated that bridges would be blown, and 591 Squadron had moved up into Graven in readiness to dash forward to put a Bailey across the canal five miles beyond. 249 Company were mending the hole in the wooden bridge before constructing their Bailey. Sandy Rutherford had promised to give my jeep priority over it as soon as it could take traffic. I received a "telling off" from the C.R.E. for not going forward on foot, but I preferred to wait, since I couldn't see how I could get the report back quickly without a jeep or motor cycle, even if I did walk to the canal. In the end I was glad I did wait, 249 Company allowed my jeep over and off I went, chasing the 9th Battalion who were well away by now. 249 Company suffered several casualties from shell-fire whilst bridging.

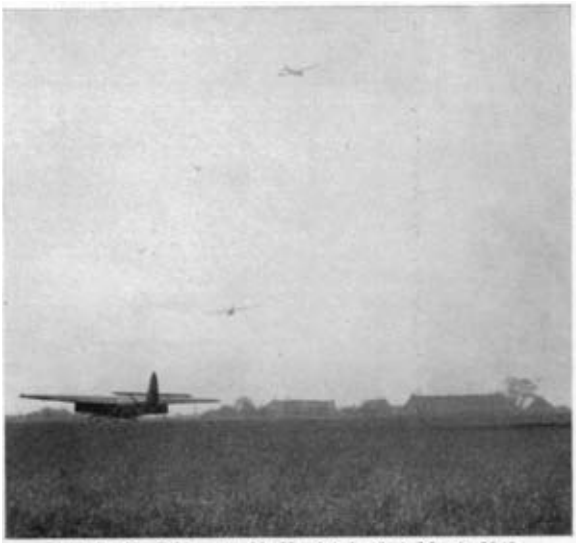


Photo 16.—Gliders outside Haminkeln, 25th March, 1945.

Photo 17.—Preparing to move into Haminkeln, 25th March, 1945.

Go To It 16,17

Photo 18.—No. 2 Troop preparing to bridge at Grosse Reken, 30th March, 1945.

Photo 19.—No. 2 Troop after crossing the Dortmund-Ems Canal, 4th April, 1945.

Go To It 18,19

The Dortmund–Ems Canal

Accompanied by Lance-Sergeant Doyle in my jeep, driven by Driver Malmsjo, with a wireless operator in the back, I arrived near the canal and found 9th Battalion H.Q. There I left the jeep and went forward on foot with Doyle—we carried a few items of recce equipment. We reached the canal bank at the same time as the leading platoon of the 9th Battalion went over. As usual, Brigadier Hill was there, on the pillion of a motor cycle. A light A.A. gun was firing straight down the road from somewhere the other side of the canal, the bridge site was under slight mortar fire.

Doyle and I walked down the ditch beside the long straight road leading to the bridge which we knew had been blown. In our progress we had to step over the infantry who were taking cover. Our first view of the canal was impressive, it was almost dry, having been emptied some time previously by R.A.F. bombing. The gap from bank to bank was about 120 ft. The road ran along a high embankment, and at road level where the old abutments were, the gap was a clear 160 ft. The bridge itself, a massive steel girder affair, was completely destroyed, and obstructed the passage of any new bridge. Doyle and I climbed down and "recced" a site as near as possible to the old bridge site. It was clear that considerable work would have to be done on approaches each side of the canal, and bridging would be long and difficult. We were thankful to get out of that spot after some twenty minutes. As we returned to the jeep a "stonk" came down on the bridge—the infantry just sat "taking it," as usual.

Squadron H.Q. was the other side of Graven, out of range of our wireless. We lost no time in roaring back to Graven the way we had come. Crossing the bridge without difficulty, we were then nearly three-quarters of an hour reaching the farm, such was the congestion en route. Before reaching the farm, however, I contacted Rosie on the "blower" and we both nearly went frantic as I tried to pass a message about the bridge site—the air was filled with the buzz and crackle of a thousand sets, against which we could not hope to compete. By that time it was pitch dark, a condition which made travelling none the easier, Malmsjo did wonders at the wheel.

Reaching the squadron, I reported to H.Q. and found half the officers of the divisional engineers, from the C.R.E. downwards, gathered there. I made it quite clear that I considered bridging was out of the question until things were quieter around the canal, also that the site was unsuitable. My report was not a good one, and I felt that all were sceptical about the conditions under which it had been compiled. Everyone was madly keen to get over the Dortmund–Ems Canal and to get "cracking" down the road again. I was told to go back to Graven and to stand by at 591 Squadron to tell them all I could about the site, and to be prepared to help them with my troop. Two jeeps raced back to Graven, the first driven by Fergy Semple, second-in-command of 591, carried Allen Jack his O.C. My Jeep, driven by Malmsjo, followed. Traffic was solid on the road and only side lights were allowed. Fergy drove as fast as possible, weaving in and out of the dense column with Malmsjo hot on his tail. We were heartily cursed by many who had been waiting patiently in the queues of vehicles.

Later on, Allen Jack and the C.R.E. went forward to recce a site on another route some hundreds of yards further along the canal from where I had been at the main road. They decided that this was a better site, but not until they had been severely mortared. They were then convinced that bridging was "not on" until the far bank was cleared. They returned late in the night and I was allowed to go off to rejoin my troop which had moved up with

3rd Brigade and now lay somewhere up the main road to the canal. Tom Marsh was in charge of the troop in my absence.

Action by No. 2 Troop, 1st April

At 0300 hrs. I reached the troop in their billet at a farm some 300 yds. down a side road, 2 miles north of Graven. After turning in, dead beat, I was awakened by Tom Marsh at 0600 hrs. and told that Sergeant Poole had been sniped at from further down this side road. Telling Tom to send a section to winkle out the sniper, I turned over and went to sleep again. A few moments later I was lying awake listening to continuous firing. Soon, on the edge of the troop's position in the farm buildings, I found the situation as follows :—

Tom had gone off down the road with a section and had been fired at from the left. They discovered that in the rough ground and trees, 300 yds. down the road, were concealed the two batteries of 88-mm. guns which had shelled Graven the day before.

Posting 3 L.M.Gs. in the buildings, to fire directly down the field, I sent Corporal Turner with another section to cover the withdrawal of the first one. Things were warm enough during the next few minutes, until word came back that both Tom Marsh and Corporal Turner had been hit. Tom was down the road some 200 yds., Turner only half that distance. I sent Lance-Corporal Gibson, my wireless operator, in my jeep to pick up Turner. Gibson accomplished this task very well, but received a bullet in his buttock in so doing. Shot through the chest, Turner died five minutes after reaching us.

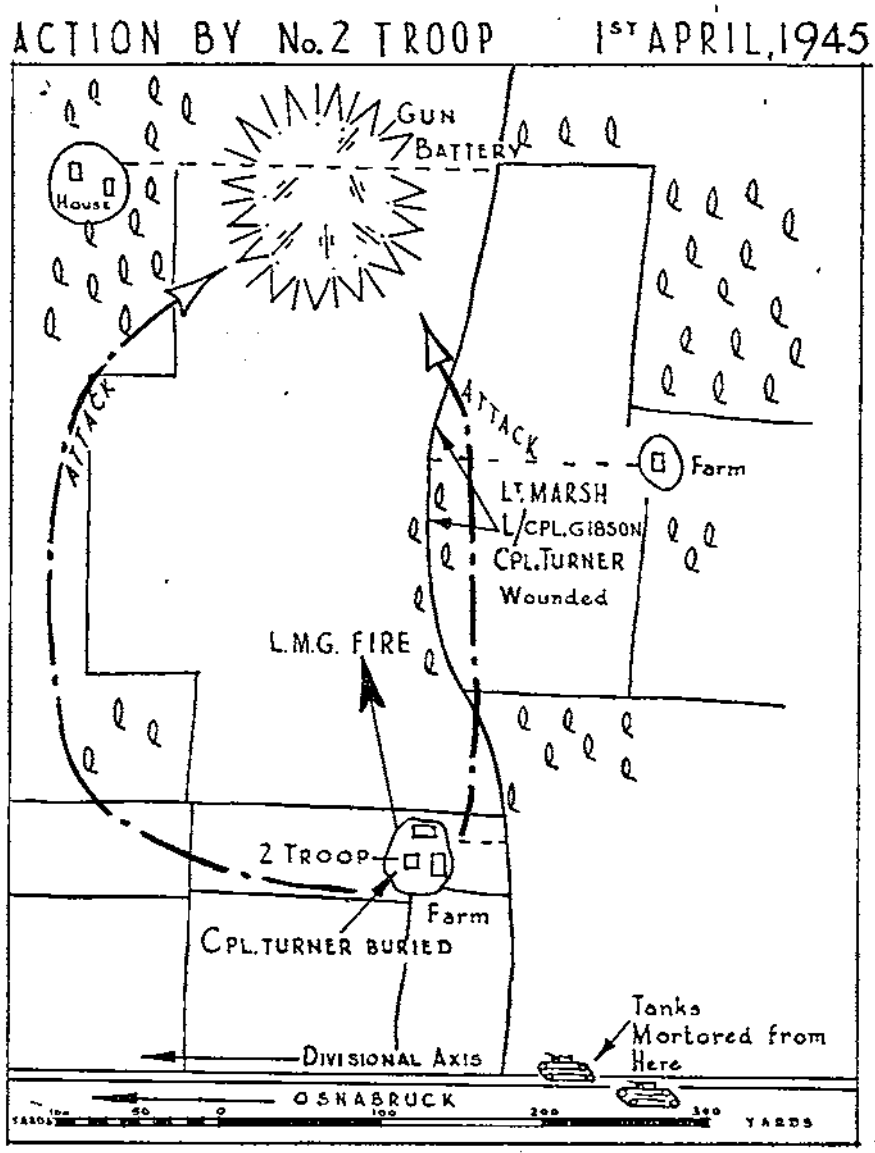
Taking another section, I went down the road to get Tom. After we had moved 100 yds., using the " fire and movement " principle, we were relieved to find ourselves opposite Tom and his section who had managed to crawl back. Tom Marsh had also been shot through a buttock—a much deeper wound than Gibson's. He was raving mad, having been shot at from the wood to the right of the road whence an L.M.G. had been rushed by the Germans—under cover of a white flag.

Knowing that some Churchills were parked on the main road near its junction with our side road, I ran over and asked if the enemy position could be mortared. After some " humming and hawing " this was agreed upon and forthwith an O.P. officer began to give orders on the " blower " from his armoured carrier. He wouldn't listen to me when I asked him to come up to the farm from which he could see the gun positions. The result was that the heavy mortar projectiles fell to the right of our road and short of the target, setting alight a small farm which had been most inoffensive.

The morale effect of the fire was enough to produce partial surrender, and white flags appeared. Soon, about thirty Germans came across the fields with their hands up. There were still further troops in the trenches round the guns so we could not leave them. This time we made a " pincer " movement on the position with two L.M.Gs. first working their way down to a wood on the left. This party, under command of Lance-Sergeant Doyle, worked very hard and gained a good position.

After we had closed in on the enemy position with a bayonet charge, which proved to be enough to cause all the enemy to surrender, Sapper James of Doyle's party, found he hadn't " fixed " his bayonet !

The O.C. arrived at our farm in time to inspect the gathering of prisoners. The total " bag " was three enemy killed and fifty prisoners. Our casualties were one dead—Corporal Turner—two wounded—Lieutenant T. B. V. Marsh and Lance-Corporal G. Gibson. The two batteries of guns comprised


ACTION BY No. 2 TROOP 1ST APRIL, 1945
GUN BATTERY
House
ATTACK
ATTACK
Farm
LT. MARSH
L/CPL. GIBSON
CPL. TURNER
Wounded
L.M.G. FIRE
2 TROOP
Farm
CPL. TURNER BURIED
DIVISIONAL AXIS
Tanks Mortored from Here
OSNABRUCK
YARDS
YARDS

twelve 88-mm. dual purpose flak guns. They had been blown up the previous evening, the major commanding the position had made off with one hundred of the best men, ordering the remainder to defend the position to the last round and last man.

Tom Marsh and Gibson were sent by jeep to the M.D.S. set up by 224 Para. Field Ambulance in Graven, and we then prepared to bury Dick Turner. We dug a grave for him in a quiet field by the farm and were fortunate enough to obtain a chaplain to perform the offices. Another of our original band, Corporal Turner was a very fine N.C.O. Unlucky from the start, he had suffered a knee wound in Normandy and had only rejoined us in Holland. His passing was mourned by many friends, and we were glad to get away from that farm.

The squadron moved up to us and we joined them in the large house and farm concealed by the wood behind the gun battery.

Despite our previous exertions there was to be little rest that night. 591 Squadron commenced bridging in the afternoon and, since the road beyond the bridge was to be conserved as much as possible, a tank route for some three miles was required. No. 2 Troop was given the task of taping out this route and clearing it of obstacles where necessary. No. 1 Troop was standing by to aid 591 Squadron.

Crossing the canal after dark, Lieutenant Franklin and I, with three sections, set to work. It was an eerie business—we were prepared as a fighting patrol and were ready for anything. At the end of our route we were three miles beyond our leading troops on the canal. We need not have worried however, as the work ran quickly and smoothly. It was a brilliant night of yellow moonlight, soft and warm. Skirting woods and crossing fields, we eventually ended up in a maze of light roads, well beyond the canal. There were two small obstacles which required "dozing." They were removed by a D.4 which was the first piece of equipment to cross the bridge during the early hours of the morning.

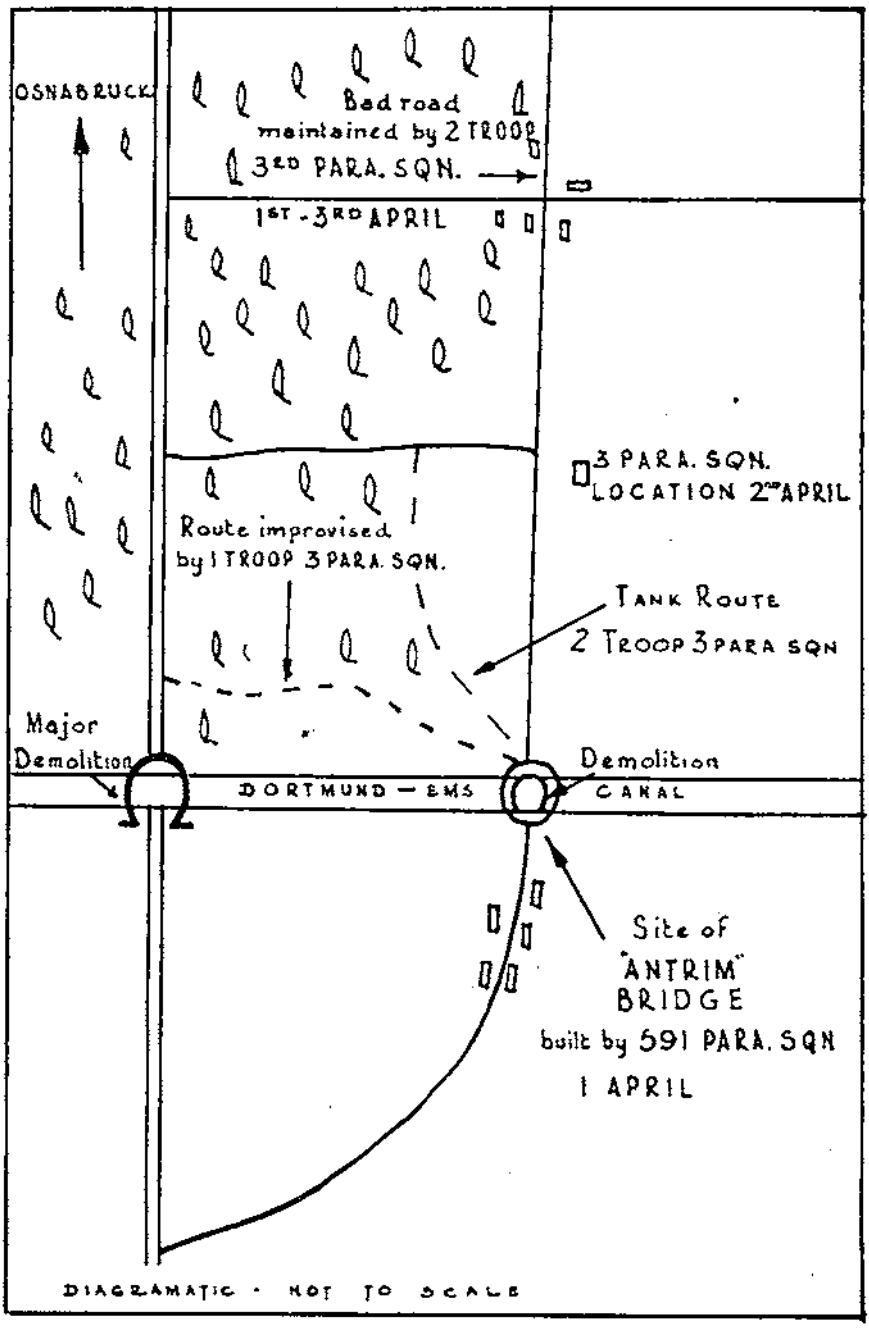
Although it took them rather a long time to build, a word of praise is due to 591 Squadron for their bridge. The first Bailey across this canal, it was used on the morning of 2nd April, not only by the whole of our division and a large part of 8th Corps to which we were attached at that time, but also by a strong armoured column from the U.S. Army to our right. They had, as yet, no bridge across the canal and used ours in order to outflank the enemy on their own front.

The evening of the 2nd April found the 3rd Squadron in a farm some two miles up the road on the far side of the canal. No. 2 Troop were at once put on to the maintenance of about two miles of a particularly bad track through the woods. This route had to be kept open until a temporary road, constructed by No. 1 Troop, was ready for traffic.

The object of these routes was to reach the main Osnabrück road from the 591 Squadron Bailey bridge. Following a track, No. 1 Troop had to prepare about a mile and a half of roadway fit to take divisional traffic—a large portion of the road required the laying of Sommerfeld track to avoid the bogging down of vehicles.

Work during the next few days was a nightmare. The weather, so long in our favour, broke out into a prolonged downpour. The ceaseless stream of the vehicles of 8 Corps over the stretch of road being maintained by No. 2 Troop, soon turned it into a deep morass. The only material at hand was bundles of faggots, which we had to collect ourselves from all farms in the area. These woodland roads carried not the slightest metalling, they were merely sandy surfaces. We used two "Auto patrols," machines with great scraping

THE DORTMUND-EMS CROSSING 1ST-3RD APRIL, 1945



blades on them, to remove some of the mud. The scraping was not enough however, and after a time we found ourselves manhandling every vehicle through. This was simply "not on," and the O.C. allotted us some of the Sommerfeld track being supplied to No. 1 Troop, and we had to attempt laying it whilst traffic continued to pour past.

The volume of traffic was intense at this time since the large city of Osnabrück lay a few miles ahead. The Royal Marine Commando Brigade was being rushed through to go into this large objective. My name and number were taken by one officious individual during one of the periods at which I was, of necessity, holding up the flow of traffic. So it went on through the night of the second and all day on the third. During the night of the third, half the troop rested whilst the other half carried on. Franklin and I split the night between us.

Our biggest worry was with civilian cars which were coming through with every unit. We were ruthless with any car which became bogged. The occupants were asked to transfer to other vehicles as quickly as possible, then a group of sappers would heave the car into the ditch. Later we were able to salvage a couple of good cars for the squadron !

We were very thankful to be relieved of this task on the afternoon of the 4th April. Some army sappers took over from us. By this time we had been left so far behind by the advance that we didn't care very much, all we wanted was sleep. Squadron, Brigade, Division and even Corps, were all ahead of us. Harbouring in a farm for the night, we moved off at 0600 hrs. on the 5th April. Moving some sixty miles up the divisional axis, all we had to do was follow the "Pegasus" signs nailed to trees by the provost. The signs marked the route all the way from the Rhine to the Baltic.

Crossing the Weser-Ems Canal we eventually found Squadron H.Q. in the 3rd Brigade area of Nordhamer, a hamlet to the north-west of Minden, some five miles south of the river now obstructing the progress of the 2nd British Army.

Resting until the evening of the 6th April, we were then called upon to assist in the construction of a Bailey pontoon bridge across the Weser at Petershagen. We really did very little there, but it was nice to be present at a big job once again. The bridge, built by Corps Sappers, was nearly complete before we arrived. The bridge commander was very glad to see us for all that, since his chaps were dead tired and there was a lot of work to be done on approaches and anchorages. No. 2 Troop got down to it and, liberally supplied with brick rubble from tippr trucks, had a good approach to the bridge completed by 0130 hrs. on the 7th ; it then rejoined squadron.

The Petershagen bridge was of great importance and the site had been contested by the enemy on the 5th and 6th. After their headlong flight back from the Rhine to the Dortmund-Ems and other canals, the Weser was the next natural obstacle behind which the Wermacht could hope to call a halt and attempt to reorganize. The speed of our advance depended largely on the scope and extent of the enemy's demolitions. Sometimes we were able to move a whole day in convoy across many small rivers, canals and railways, with not a demolition to be seen. Then we would run into a complete demolition belt such as existed along the Weser.

Higher up the river at Minden on our right, the Americans were having a stiff time in crossing. All the heavy road bridges in the city were blown. The U.S. engineers had to put a heavy assault pontoon bridge across, in the country well above the town at a most difficult site. We were in the area a week later and crossed their bridge.

From Osnabrück, the 2nd Army struck out towards Hanover, 6th Division was on the flank and did not go into either place.

Crossing the Petershagen bridge at 1630 hrs. on the 7th, the squadron moved up to the new location at Mesmerode. Here we had a little trouble since a large dump of excellent brandy was discovered. The bottles were all marked " Reservé pour la Luftwaffe en Finlande." We managed to obtain four cases.

At Mesmerode there were numbers of Frenchmen, mainly prisoners of war, some of whom had been four years in Germany. Doing farm work, they were in quite fair condition, but had obviously been regarded as slaves. Here, as on other farms, I saw the cages in which these slave workers were kept. Usually just a loft with wooden bunks in tiers crammed into it, the whole surrounded by a high wire fence. Always when on the move, we met streams of French and Russian prisoners and slave workers, all attempting to walk to the Rhine. This occurred despite our repeated warnings to them to " stay put." The horde of displaced persons could not be permitted to choke the already much overworked Rhine bridges. The task of collecting them in camps and sorting them out in the Rhineland, must have been gigantic. By the time they had moved a hundred miles or more, most of their ill-assorted transport was out of commission, their food exhausted and their condition very wretched indeed.

Unauthorized Transport

A great encumbrance under bad road conditions, but a luxury once good road surfaces were encountered, a vast assortment of non-military vehicles followed the advance across Germany. No. 2 Troop did good work by producing serviceable vehicles whenever required.

Soon after crossing the Rhine, the Troop rendered serviceable a 10-ton German army truck, which was found abandoned and loaded with 88 mm. shells. This vehicle was taken over by Rosie as extremely suitable for Squadron H.Q. cooking and rations. Despite this set-back, the Troop soon collected two good trailers of the caravan type extensively used by the enemy. These became troop cookhouse and rations store respectively. A light Opel of about 10 h.p. was presented to the Rev. Ken Childs, Chaplain to the Divisional Engineers.

From time to time higher authority would issue orders for the handing in to military goverment of all unauthorized transport, but we managed to retain several useful items in lieu of army vehicles rendered unserviceable.

On the night of 7th April, Driver Thompson of No. 2 Troop drove his jeep straight into the side of a Churchill tank near Petershagen. Such behaviour was not conducive to vehicle roadworthiness and the jeep was a write-off. We were thus short of a vehicle for some time until No. 1 Troop handed over to us—unwillingly—a 2½ litre Mercedes-Benz saloon. Sapper Wyatt became the proud driver of this beautifully smooth-running machine. Unfortunately the tyres were in very poor condition and although Wyatt mended puncture after puncture, I was eventually forced to hand the vehicle in to " Civil Affairs," since it was more nuisance than it was worth.

The last car deserving of mention was the brand new B.M.W. acquired by the O.C. and used right until the end of the campaign. Ownership of this car made him the envy of many of the more senior commanders in the division.

Bridge Reconnaissance

During the static period until the evening of the 9th, we produced recce reports on the demolitions along the Weser-Elbe canal, some twenty miles from our area. It was strange to be running around in a jeep doing recces of bridges, just as one would have done in training at home. The demolitions were most effective, and since the canal was full and had very high banks, with a gap of well over one hundred feet, it would have been a formidable obstacle if defended. One did not see many people and never a sign of other British troops. The locals kept out of our way when we were at work, and since the weather was warm and sunny, the task was a very pleasant one.

A long move over good roads through very nice countryside to Negenborn north of Hanover, took place on 10th April. Hanover, a mere shell of its former self, had fallen to the 2nd Army as we rested at Mesmerode. Many of us had no opportunity of seeing the bomb damage in Hanover, nor later in Hamburg—both had to be seen to be believed.

Stopping for a day at Negenborn, the squadron produced engineer stores' recces of the area. We then received news that we were to have the honour of building a folding boat bridge across the River Elbe, the last great obstacle to the army. As yet, we were many miles south of this great river and there was time to get in some training.

It seems strange to note that in the midst of a swiftly moving campaign, units have time to take a week off to train. This was so all through the B.L.A. operations. Nearly all big engineering tasks had much training put into them.

We were disappointed at being sent back, it had been so exhilarating at the front of the advance. Back we went on the 12th April, however, right back to the Weser, following the 8 Corps " down " route which was marked by a " top hat " sign all the way.

Our destination was a site a few miles up river from Petershagen, some seven miles below Minden. To reach it we followed the down route to a Bailey pontoon bridge well below Petershagen, thence to the Bailey in Petershagen itself, which was now the " up " route, and then along the river to a small village near our bridging site.

Bridging

On 13th April we built a 340-ft. bridge across the Weser. A grand day of hard work for all ranks. The current was very swift in the centre of the river, but we managed to complete the bridge in the end. The following day we stripped the bridge and reloaded it on to lorries. That afternoon we were able to go into Minden, where we saw the American pontoon bridge mentioned previously. There were a number of light factories in Minden, many of which we investigated. The most interesting one was filled with small woodworking machines and light timber of all descriptions. We wandered around for some time before deciding that it was an aircraft factory. The planes were of the light reconnaissance type similar to our " Auster."

Advancing Again—Belsen

Leaving the Weser once again in the early hours of the 15th April, we made a long move to rejoin the division in the area of Celle. A lovely part of Germany, densely wooded over large areas. Upon arrival we heard rumours

of the horrors discovered in Belsen camp, and were told that a certain large area near by was out of bounds. A week later a Sapper Major had tea with us, after spending a week in this camp helping to keep things going. He told us a long vivid tale filled with unimaginable horrors. The chief fact which he impressed upon us was that over 6,000 more people would die in Belsen despite anything we could do, simply because their starvation had reached such an advanced stage. He also gave us some unofficial descriptions of the treatment being meted out to Joseph Kramer, the camp chief, and to the S.S. guards. The guards were still retained there because there was no one to replace them for a time.

On the 16th April the squadron moved again, this time to a wooded area south-west of Uelzen. The weather remained really lovely and it was a pleasure to sleep out in those woods. No. 2 Troop were given the task of improving a sand road leading to Divisional H.Q., also of strengthening and repairing a timber bridge at the near-by village of Stadensen. The day before, a vicious battle had been fought in this village, which had been occupied by elements of the Divisional Recce Regiment. They were attacked by several S.P. guns and other heavy armour, and wiped out. As I scoured the village for suitable timber to repair the bridge, I had ample opportunity fo viewing the grisly aftermath of this action. The one gladdening feature was the sight of two S.P. guns "killed" after penetrating to the heart of the village. Here also, another Hun atrocity was revealed in the discovery of a ditch containing the bodies of several women and children as well as men. These, I believe, were Russian slaves who had taken their freedom prematurely.

I was called out in the middle of the night and told that the troop would be supporting the advance of the 3rd Brigade early next day. The object was an encircling move to the east and north of Uelsen, to clear villages and to cut off the retreat of German troops known to be in the city. Following the usual plan, I pushed off into the night with a jeep recce party to take my place in the brigade "O" group. We were a long way from Brigade Headquarters and arrived after the commander had left to move up to the start line. We followed up, and arrived half an hour before the brigade was due to start advancing.

The troop did little but follow up with the main body of the leading battalion for the rest of the day. Up at the command post with the leading troops, we had a grandstand view of the day's action.

In front went the tanks with parachute infantry on their backs. They moved steadily through a succession of villages about two miles apart. Each village held a few enemy troops, who fled after putting up a token resistance. As these wretches moved out over the open fields, the Churchills "went to town" against them with mortars and Besa machine guns. The command post was right up with the tanks ; it consisted of, the commander, pillion riding on a motor cycle, his jeep and the H.Q. Signals officer, Captain "Geoff" Hart, in a wireless jeep. They were followed closely by the Sapper jeep which, in theory, was also in touch by wireless with Squadron H.Q. We usually found, however, that beyond a range of two to three miles, we lost touch with the squadron altogether.

Crossing a stretch of open country beyond the village of Rasseau, we came under shell-fire from an S.P. gun in the next village. Opening out across a vast stretch of plough, our tanks put a salvo or two into the village and then we quickly closed in. The S.P. gun was found abandoned in the village.

Moving swiftly on to the next village, the tanks had to cross over a small river, under one of them the bridge being used collapsed. Fortunately I

found a heavy concrete slab bridge only a few hundred yards away and a diversion was quickly formed. Here the Brigade Commander called a halt early in the afternoon, since the troops following up had been on foot for many hours. 3rd Brigade H.Q. was established in Rassau, with two battalions forward, completely closing the remaining routes northward from Uelzen. As I was about to return to the troop, I was informed that the Brigade Commander intended to send out fighting patrols that night, to kill off any enemy attempting to filter out of the city. He required two sapper parties to accompany the patrols, in order to effect road blocks. Returning to the troop I sent out Franklin with one party and Corporal McDuff with another —each sapper party was a section strong. Both sections had a very pleasant night in the real guerilla style. They established road blocks in the area of Emmendorf and from them killed four Germans, captured seventy-five and destroyed several vehicles. They rejoined us and the squadron in woods south of Bollensen at midday on the 18th April.

On the 18th, No. 2 Troop moved up to Rassau and was followed by the squadron later the same day. The encircling move on Uelzen took place just in time to prevent the Germans consolidating a defensive position. Mines were being brought up in quantity and we discovered a large dump. The 19th was passed pleasantly in destroying this dump of Tellermines. The method used was to place them, half a dozen at a time, in a slit trench with a charge of plastic.

German forces retreating before us had now crossed the Elbe, and the division had a good rest whilst 2nd British Army moved up in preparation for the crossing of this great river.

On the 19th and 20th we rested and sorted ourselves out. Sunday the 21st, was marked by a combined Divisional Engineer church parade, which was held in a large new barn and conducted by the Rev. Childs.

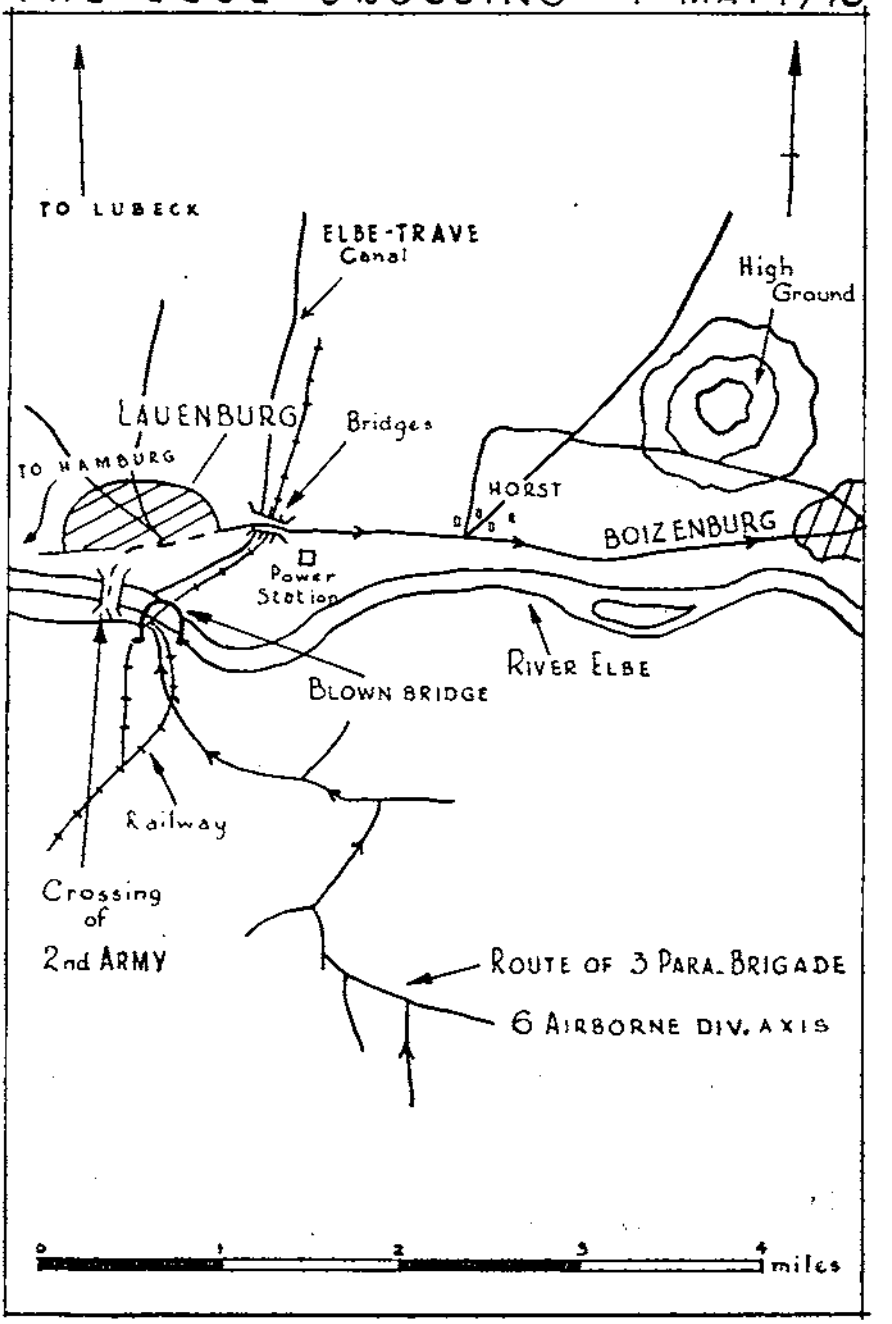
Jack Inman, at this time and throughout most of our spell in Germany, worked as a field engineer at H.Q. R.E. One day he and the Padre were ambushed on a side road; they narrowly escaped capture or death, only by abandoning the Padre's latest car.

The 23rd April saw the squadron move to Seedorf, once again in support of the 3rd Brigade. Here we stayed until the crossing of the Elbe on the 30th. The week in Seedorf was not wasted by any means. Stores and vehicles were overhauled and prepared for the last mad dash over Germany. Engineer recce of a vast area was completed, including the examination of an ammunition dump in the Münster area. A grand football match was played against 591 Squadron, which we won, 9–5. The Ulster Squadron retaliated by winning the next game, 4–2.

The Crossing of the Elbe

6th Airborne Division took no part in the assault crossing of the Elbe. This crossing was made at Lauenburg by Commandos of the Royal Marine Special Service Brigade. The first wave went across at 0200 hrs. on 29th April. The 6th Division stood by to cross as soon as it could after bridges had been constructed by corps troops. The Commando assault was a spectacular success and an important bridge to the east of Lauenburg was captured intact. This bridge was prepared for demolition with heavy shells. No. 2 Troop assisted the Commando sappers to remove these shells. Later we learned that Rosie and Peter Dixon had been the first to reach this bridge and recce it, Rosie also brought in a large bunch of prisoners from Horst.

THE ELBE CROSSING 1st MAY 1945



3rd Para. Brigade crossed the river by a folding boat bridge early on the 30th and relieved the Commandos to the east of the town. The plan for the day's operations was as follows :—

1st Canadian Battalion to cross first and relieve the Commandos on the bridge over the Elbe–Trave canal to the east of the town. The 9th Battalion was to pass through and occupy some heights to the east, four miles from Lauenburg, and a mile due north of the main road which we should all be using. Afterwards the brigade was to occupy Boizenburg.

Traffic was very dense over the crossings at Lauenburg and since the 15th Scottish Division, who were to move due north, had priority over us, the majority of our vehicles were held up most of the day. During the afternoon, 3rd Brigade headquarters was established at a small power station on the eastern side of the Elbe–Trave canal, beside the important bridges. Attention was focused on the village of Horst, about a mile east along the road. A few German troops were in the village and there were no signs of white flags. The Brigadier was determined to avoid casualties and intended to shell any village which did not surrender after due warning. The gunners had an O.P. with a wireless jeep on the spot. It was fascinating to hear the request for fire go over this " blower," and within a minute or two to hear the boom of the supporting 25-pr. guns. The shells then came over, droning and whining; we saw every burst of this crashing salvo. One salvo was sufficient to cause a host of white flags to appear in the village. Half an hour later we were in full cry down the road through Horst. The following copies of messages I sent back to the the O.C. and to Lieutenant Franklin, give a good picture of the situation.

To O.C. 3rd Para. Squadron R.E.
From 2 Troop.
Sitrep. at 012000 B.
Am with command post on west edge of Horst which is now occupied by 9th Battalion. Advance continuing to brigade objective (high ground to north). Rations have been delivered by Corporal Cronin. Things going well."

To Lieut. Franklin
From 2 Troop. 012045 B.
Frank—I am at Horst and there is a crater at 924350. Bring up full troop, mend crater and then follow up. I hope to get troop billet in Boizenburg. I must have a D.R. to contact you, so send Thorne back to me.
Sgt. Poole is now trying to get prisoners to mend the crater but no progress.
I have compressor here and it will wait at crater for you. It has our rations on it.
See you tonight.
Best. Johnny."

Both messages are dated " 01 " which meant the first day of the month. I must have been a little hazy over my dates. These messages were actually written at between eight and eight-thirty on the evening of 30th April.

The troop arrived on the scene in time to fill in the crater. I left them at Horst and accompanied the brigade when it moved on to Boizenburg. We were not settled in the town until well after midnight. The house selected was unsuitable for Brigade H.Q. so a move was planned for the first thing in

the morning. Early next day brigade moved into a pleasant area on the central square of the town. I spent the early part of the morning feverishly hunting for billets for the squadron.

It was clear to us all that the war was coming to an end and we should very quickly finish our advance. The Russians had reached Berlin, the Americans had swamped the Ruhr and we had "swanned" over most of north-western Germany.

On the morning of 1st May, the squadron moved up to the outskirts of Boizenburg, where some good billets were occupied. No. 2 Troop cleared some smashed vehicles off the road and then joined the squadron. During the afternoon an intensive engineer recce of the town's resources was accomplished. One question in particular had to be answered—could we get the railway working and produce a train? Sergeant Poole was our locomotive expert and it was chiefly due to his efforts that we were able to get an engine into working order by the morning of the 2nd. All locomotives in the district had been well "shot up" by allied aircraft.

A grand plan was afoot, the broad outline of which was as follows:—Since the Russians were making such good progress down the Baltic coast and had already reached the limit of their advance as decided by the combined staffs of the Big Three, our division was to make an all out dash for Wismar on the Baltic, to reach it before the Russians. It was hoped that the 6th Airlanding Brigade could make this last dash in a surprise move by rail, while the rest of the division swept up over the roads.

Early on 2nd May, No. 2 Troop were put on to the work of repairing a crater in the railway about two miles beyond Boizenburg. Meanwhile, the railway train, "Poole's Pride," was getting up steam. As the troop were repairing the railway, I walked up the line to the first bridge over a river and found it well and truly prepared for demolition. A few sappers were given the task of removing the charges and throwing them into the water. We had been working as hard as we could go for an hour and a half, when a small aircraft was seen flying down the line towards us. It circled several times and we saw someone waving to us from it. After a time it flew away, and half an hour later we received a message by despatch rider to the effect that work was to cease. Bev. Holloway had been flying in the aircraft and had made a recce of the line ahead. He had found two demolished bridges along the line, so division abandoned the rail scheme.

My orders were to follow up the division as quickly as possible. The advance had begun two hours before, so we were now in a "rear area." Fuming with the frustration of having worked so hard and being left behind, we got on to the road and began to follow the divisional axis as fast as we could. We had travelled about twenty miles when Jack Inman appeared on a motor cycle. He brought a message direct from the C.R.E. Our new orders were to stop at a small bridge in order to strengthen it so that it would take the mass of transport which was on the way up. Our chances of getting to Wismar quickly, were now absolutely finished. Reluctantly we gave up hopes of being "in at the kill" when 3rd Brigade met the Russians, and we set to work at the bridge. Local timber supplies were very good and without difficulty we strengthened the trestles of the bridge and improved the decking. After a meal we pushed on; in all the task had taken four hours.

Six hours behind the spearhead of the advance, we had difficulty in making any progress at all. The roads were choked with German soldiers, most of them on foot, but a few in vehicles or riding on horse-drawn transport. Mingled with the unending column of troops were civilians, country people with all their belongings piled on carts.

We managed to cover about fifteen miles in the hour. Sergeant Poole rode ahead of the column on a motor cycle, tooting his horn and waving his arm to clear the road. After a time we began to realize that the cause of this debacle was the Russian advance. Countless thousands of Germans were fleeing before the Red Army; they wished to be made prisoners by the British or Americans. They anticipated that the Russians would administer occupied territory with the whip and cudgel in the same manner as they themselves had administered Russian territory. As darkness began to fall I decided to give up the effort for that day, and sent recce parties on ahead to scout for accommodation for the troop. We eventually pulled off the road into a crowded farm at a small village north of Schwerin. All the outbuildings were filled with sullen, despondent German soldiers and civilians. We obtained what rest we could amongst our vehicles in the farmyard.

We were on the road again next morning as early as we could and made good progress. The further north we went the less crowded became the route, until at one spot we saw the incredible sight of two large German convoys halted nose to nose. At this point the Germans in retreat before the Russians had met those fleeing from us. One can imagine what their feelings were when they realized that it was no use going any further.

It was a glorious day as we swept on to Wismar. At the outskirts of the town we met a long column of marching German soldiery. This column differed from all those we had seen, in that the men were marching in step and were being conducted by some parachutists. It seemed that we were already introducing some organization to the chaotic scene. A large camp for prisoners was being established well outside the town.

So ended the "great swan" across northern Europe, during which we witnessed the collapse of the Nazi Empire.

We spent the next fortnight in clearing up the mess. Every roadside for miles around Wismar was littered with German arms and ammunition of every description. The sappers were given the task of destroying it all, each squadron was given a vast area to search and clear. Another task was the provision of water supply to the vast camps for displaced persons and prisoners, which were established.

We were now able to get some relaxation from our strenous work during the advance. The favourite pastime was yachting, and quite a fleet of small craft was collected in Wismar docks.

Several high-ranking members of the division soon possessed their own yachts. The more adventurous members sailed their craft across the Baltic to Copenhagen, where they were handed to the Navy, who eventually shipped many of the yachts back home. The C.R.E. sailed his yacht over with Bev Holloway as a member of the crew.

Wismar

On our second day at Wismar the O.C. disappeared in his smart 2½ litre B.M.W. driven by Lance-Corporal Fitzgerald. He returned at tea-time carrying a large weighty sack which was carefully emptied on to the floor of the mess. The contents of the sack included some half a dozen good cameras and dozens of Lugers and other automatics. Apparently Rosie and gone up to an airfield on the way to Lübeck and had taken the surrender of the garrison.

A story of the occupation of Wismar concerned Tony Wade. He was first into the billet which the O.C. selected as squadron location. It was a large warehouse block on the harbour front. In a room upstairs Tony found an

imposing assembly of harbour officials, one of whom was foolish enough to reach for his revolver. One shot from Tony's Sten sealed the matter and there was no more trouble.

The Russians reached Wismar two hours after 3rd Brigade had firmly established itself in the town. They left the town and erected a barricade some two miles out. Past the barricade only liaison officers and released prisoners of war of both sides were allowed to move. Very soon a strict non-fraternization ban was imposed between us and the Russian soldiers. It was feared that they would compare their miserable lot with ours. Some of our fellows met a Russian tank crew before the ban was imposed. The crew were insistent on offering hospitality and our chaps had to eat some Red Army rations. The poor bottle of German wine they were able to cope with, but not the black bread and pork fat which was the only food the Russians had.

We passed a very quiet V.E. day on 8th May. The N.A.A.F.I. had not caught up with us and we were extremely short of liquid refreshment. The division organized two big functions whilst we were in Wismar. The first was an impressive thanksgiving service, held on 6th May. The other was a victory parade in which representatives of most units took part. The parade took place on V.E. day; General Bols took the salute in the market square of the town. The tanks of the 6th Guards Tank Brigade, which had advanced with us from the Rhine, played a big part in the proceedings. The armoured column was followed by a marching column of parachutists and glider troops. A Scottish band was loaned for the occasion by another formation.

Field-Marshal Montgomery came to Wismar to meet Marshal Rokosovsky of the Red Army, at 6th Airborne Divisional Headquarters.

Despite the interesting events which took place in Wismar, our work and our yachting, time began to hang very heavily. We missed very much the old life of swift movement, of days and nights spent in the forests of northern Germany, of chasing the enemy in ceaseless endeavour to defeat him in battle. Much of the zest had gone out of life now that there was no enemy left to chase. Non-fraternization with the Germans became an awful bore even during that short time. The weather was very hot and since this was the German Riviera, the women soon appeared in all the scanty apparel of the holiday resort. All felt the absence of the wives and girl friends at home. We were very thankful when news arrived that we were to return home at once. One felt very sympathetic towards the occupation troops who had to remain in Germany under the non-fraternization ban.

The 16th May was spent in packing our stores and generally preparing to move. The plan was that the bulk of the division would fly home from the airfield at Lüneburg while the remainder moved with the vehicles all the way back to Ostend or Calais by road. Needless to say, I was the officer selected to bring home the transport of 3rd Parachute Squadron.

On 17th May, the Divisional Engineers left Wismar with all their transport and moved to a harbouring area in the woods beside Lüneburg airfield. The Elbe was crossed by a Bailey pontoon bridge which had been constructed since we had passed that way.

On the 18th the majority of personnel flew home and the engineer vehicle convoy set off down the long road to the English Channel. The convoy was commanded by Major Sandy Rutherford, O.C. of 249 Company. He headed the column while I, as the next senior officer, brought up the tail a mile or two behind. We accomplished the trip in five stages, the fifth stage ending at the transit camp in Ostend. In many ways we had the best bargain since we were able to see many of the wonders of the 21st Army Group *en route*. The road was easy to follow since we followed the main "down" route of

the army group supply line the whole way. It was marked for the best part of the way by the familiar " top hat " sign.

The bridges across the Rhine presented a most impressive spectacle. We crossed a Bailey pontoon bridge at Rees and saw the Bailey bridge on piles which the engineers of the 50th Division were constructing to take a railway across the river.

We stayed in Ostend for three days, waiting for ships to take us home. On the third night we moved to Calais where we went straight aboard L.C.Ts. and were carried to Dover.

EPILOGUE

During the months of May and June, 1945, the structure of 6th Airborne Divisional Engineers underwent great changes. The Parachure Squadrons were renamed as Airborne Squadrons, the Field Park Company became an Airborne Park Squadron, and the Field Company became a holding unit for, the Divisional Engineers. The Airborne Squadrons were composed of half parachutist and half glider personnel. 591 Squadron joined the 1st Airborne Division in Norway. It took with it most of the personnel from the 6th Divisional Engineers whose age and service groups were 27 or under. Regular soldiers and those with higher age groups, went to the Far East with 3rd Airborne Squadron. Major J. C. A. Roseveare, D.S.O., left the division; his place was taken by Major (now Lieut.-Colonel) P. N. M. Moore, D.S.O. M.C.

249 Airborne Field Company was disbanded in 1946. 286 Airborne Park Squadron moved to Palestine with the division in 1945. 3rd Airborne Squadron took part in operation " Zipper " with 5th Para. Brigade, in September, 1945. " Zipper " was the reoccupation of Malaya and Singapore.

After three months in Singapore, 3rd Squadron moved to Batavia with the Brigade and assisted the Dutch in the vast problem which faced them in Java. The squadron moved on again after four months, ending up in Palestine. It returned to England in February, 1947, as part of the 2nd Para. Brigade.

It remains for 3rd Airborne Squadron and 286 Airborne Park Squadron to uphold the record of the original 6th Airborne Divisional Engineers. Good luck and " Go To It."

RAFTING AND BOATING

By Colonel L. R. E. Fayle, D.S.O., O.B.E.

RAFTING and boating were required in the assault phase of many river crossings in N.W. Europe during the campaign of 1944–45. Some of these rivers were wide or swift or both, and consequently several Army and G.H.Q. Troops formations were specially trained to attain a higher standard of watermanship than, unfortunately, is met as a general rule in the Corps. As I was lucky enough to command one of these formations—15 (Kent) G.H.Q. Troops Engineers—during training and throughout the campaign, the experience gained may be worth committing to paper.

Training—Northern Ireland

The story really starts in March, 1943, in Northern Ireland on a day when the Army Commander, accompanied by the Chief Engineer, was inspecting my companies on training. One of the units was rafting a Valentine tank across a lake some 150 yds. wide on one of the early Class 40 rafts—70 ft. of Bailey on six Mark V pontoon piers. The method used was composite :—a party of men were hauling the raft across by means of a cable while the crew assisted them by working two propulsion units. The result was pretty horrible : I am not sure if the Army Commander appreciated how bad it was, for he said nothing, but the Chief Engineer was a yachtsman and I saw a glint in his eye. As we drove on to the next site the general asked me what sort of training I wanted to give my companies next, as they had covered a good deal of ground in the past year. I replied promptly, with a glance at the Chief Engineer, that they must get some additional training in watermanship. Consequently no difficulties were raised when a few weeks later I asked for permission to move the whole formation to the Quoile River, which runs into Strangford Lough near Downpatrick. The site was tidal with a 2-knot current and water gaps up to 200 yds. wide, so was ideal for teaching " intermediate " watermanship.

I gave a good deal of thought to the problem of rafting on wide rivers and decided that cables were not the answer. We must use 2 or 4 propulsion units on these big rafts. Yet somehow all crews I had seen hitherto had got such craft into the wildest gyrations. Thinking it out, the reason was not far to seek : with two propulsion units at, say, the two after corners of the raft, if one of these ran even slightly faster than the other the raft would tend to swing. I therefore decided to teach men to drive their units in the direction of the

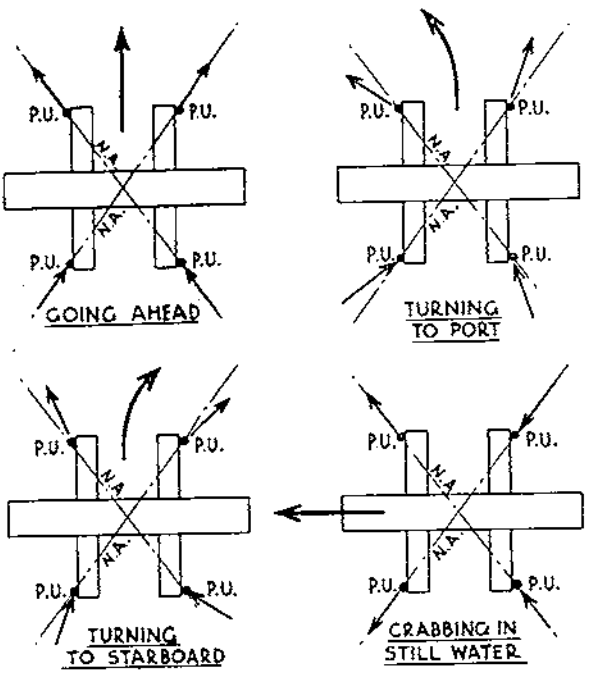
neutral axis, i.e., the line between the unit and the centre of the raft. If this line were kept to there would be no swing at all. For turning, the thrust of the propeller would be swung to left or right of the neutral axis as the case might be, the pulling units acting in the opposite sense to the pushing ones. To check the swing at the end of the turn, reverse helm would have to be put on before finally returning to neutral axis steering. Methods of "crabbing" were also worked out. (See Plate 1.) The raft commander would give all helm orders, prefacing each with a blast on a whistle, and giving them by simple signals very similar to those used in the old extended order drill.

I put these ideas out in the form of a detailed instruction to each company : I fancy they were not well received : most officers and N.C.Os. thought, I believe, that they were nonsense. So at the beginning of the training I said I would give a demonstration to show the neutral axis scheme, using *one* propulsion unit on a Class 40 raft and working it myself. All officers and N.C.Os. down to corporal would attend.

For the demonstration I was to take the raft away from a stone quay, round two buoys about 200 yds. apart and back to the quay. In boat and ship handling, most amateurs find they have "on" days when they manage everything very prettily, and "off" days when everything goes wrong ; mercifully this was one of my "on," days. We cast off and I pulled her away from the quay without a scrape, straight on each of the three legs of the course, rounding each buoy with little to spare and then back to the quay, stopping dead, with the end of the raft roadway only 2 or 3 in. from the quay. If I had tried a hundred times I could never have done it so well again. We tied up and I said to the spectators : "Now go and do likewise." This fortunate fluke turned the scale and scepticism on the theory vanished. Within a few days rafts began to be under control.

Early in this training the Chief Engineer visited the site and went out as a passenger in one of the rafts. Tide was ebbing and in mid-stream the raft ran at full speed on to a submerged rock. Only the raft crew was on site so there was nothing available to get her clear as the rock was surrounded by deep water and pushing her off was therefore impossible. A long wait resulted, making the C.E. late for another appointment, and the raft got clear on the rising tide with some damage to the pontoons. When I heard of this I arranged that all rafts should carry a boat so that "kedging off" should be possible. The only boats available were rubber recce boats, and company commanders protested that it was impossible to lay out a heavy pontoon anchor with these : so I had to give another demonstration myself, again to the officers and senior N.C.Os. It

PLATE I



N.A. = NEUTRAL AXIS

P.U. = PROPULSION UNIT

SMALL ARROWS INDICATE DIRECTION OF THRUST OF EACH PROPULSION UNIT.

LARGE ARROWS INDICATE DIRECTION OF MOTION OF RAFT.

CONTROL OF RAFTS

DIAGRAMS TO INDICATE STEERING METHODS

was, of course, quite easy. The anchor was suspended in the water, tied to the after thwart of the recce boat with a light line. I rowed away from the raft (against the current, to demonstrate how easy it was), the anchor cable being paid out to me from the raft. About 30 yds. from the raft I threw the buoy and buoy line overboard, cut the light line and down went the anchor. It worked perfectly and disappointed those who wanted to see the C.R.E. having a swim.

At the end of five weeks combined rafting, boating and Bailey pontoon training we held a formation regatta which included inter-company rafting competitions in Class 40 and smaller rafts, a "kedging off" competition, recce boat races, and pontoon sculling races. It was a great success and the Chief Engineer gave away the prizes. By that time we had some very effective raft crews.

I fear I have written much about this early training and have perhaps overstressed my own part in the affair; yet in my experience, to get enthusiasm for watermanship there must be a drive for it from the top. The popular moan that the equipment is no good and control impossible can be very quickly scotched if C.R.E. or company commander is prepared to demonstrate personally that with reasonable handling it will work well. No self-respecting junior officers or N.C.Os. will allow a senior officer to better them in one of their practical tasks for long, and so it proved with us: from now on there was a distinctly nautical flavour about the formation and the troops were inclined to throw a chest about it, which was exactly what was needed. "Messing about in boats" had become popular.

Training—Goole

In June, 1943, the formation went to Goole for three months' training and experiments in bridging and rafting on the River Ouse. The river there is brutal; 1,000 ft. wide at high water, with a 20-ft. tidal range at springs. The brown, soupy current runs at speeds up to 4½ knots, and there is even a miniature bore at certain times of the year with spring tides. Mud of the most tenacious nature is plentiful at low tides.

The first sight of the river rather appalled us all, but we had plenty of equipment and nothing could equal the training we got there. Besides small assault boats and F.B.E. rafts, we made up one or two Class 40 rafts—60 ft. of Bailey on 4-tripartite piers—and a couple of improvised Class 18 rafts which were merely 30-ft. floating bays of Bailey pontoon with an additional 10-ft. section cantilevered at each side, making 50 ft. of Bailey in all. We improvised causeways across the mud to allow rafting to go on at all states of the tide.

As far as boats were concerned we had Mk. III Assault boats and we trained in these, both paddling and using Seagull outboard

motors. Later we got the first stormboats powered with 50 h.p. Evenrude outboards. These required greater skill in handling so successive series of prospective helmsmen were sent to the E.B.E. at Christchurch to receive instruction. These in turn taught other helmsmen at Goole, and only those who had been passed out in a test at Christchurch or Goole were allowed to take charge of a stormboat.

Apart from the inherent difficulties of the river, things were not made easier by the river traffic, which included tugs with long tows of barges, but the value of the training was thereby increased : one simply could not afford to make mistakes. We had one Churchill and one Sherman tank and the raft crews could make three or four round trips across this 1,000-ft. river per hour after very little practice : with the strong flood tide against a fresh breeze, there was sometimes quite a popple on the water, but the heavy rafts, powered by four propulsion units, used to make the passage without difficulty even when waves were breaking over the decks of the pontoons. The initial training in Northern Ireland was proving its worth.

Apart from ordinary training with Class 18 Rafts carrying 3-ton lorries, we ran a bridging exercise to build an all-weather bridge across the river, and for this we ferried all our far bank lorries across on a Class 18 raft, two lorries at a time. Fifty-seven 3-tonners were ferried over and the empty lorries brought back, on this single raft, in under 12 hours : by this time it was a joy to watch the raft crews at work.

One of the great things which crews of both rafts and boats learned by experience of this river was to allow for current and to appreciate, for example, how a turn up-stream of an obstruction must be made well clear of it. Early in the training a fully laden Mk. III Assault boat, powered with a Seagull motor, proceeding down-stream tried to turn against the current just above a pontoon bridge. The helmsman allowed too little room and the craft was swept broadside on and jammed under the bows of the pontoons of the bridge. Luckily nothing serious happened in spite of a 3-knot current. The boat partly filled but the crew got out on to the piers of the bridge and the craft was extricated with some difficulty. It had been a horrid moment and the incident was witnessed by so many officers and men of the formation that the lesson went home.

By the end of our training, in September, 1943, I had made up my mind that if the formation were called upon to operate stormboats and rafts, I would use one field company (583) on boats and the other two (582 and 584) on rafts. While each company could do *either* boats or rafts, I found that each had developed a particular forte.

Further Training

From September, 1943, to February, 1944, the formation continued training in Co. Durham and later in Scotland. During this period I could devote very little of the companies' time to bridging and rafting, but I did not want the crews to lose their skill, while some changes of personnel meant that new blood had to be infused with the boating virus; moreover night rafting had so far been neglected. We therefore built a Class 18 raft on the River Wear near Durham and each platoon was given a refresher course with this in the late autumn, including night work. By night the same signals were used as by day but the raft commander carried a torch with a light shield and an arrow-shaped window to give the same signals as by day. This worked very well. One company ran a special trip for each platoon. The raft set off in the morning down-stream some 15 miles to Sunderland, arriving there at about 2 p.m. to the astonishment of the deep sea shipping in the port. During the afternoon the crew were given "shore leave" in relays, and at dusk the raft set off up the river again, to arrive at the mooring site late at night, after a round trip of 30 miles.

65 Field Company joined us from the Middle East in January, 1944, when we were in Scotland. This company had had little experience in watermanship and bridging, so training in these was started on the River Forth. Before they were able to become very proficient, however, we were moved to the South of England for preparation for a beach rôle in Normandy and this beach work (which involved a lot of boating) claimed all our activities till the end of July, 1944, when the formation started to work on normal Sapper tasks; by that time, however, 65 Field Company had left us, so the brevity of their training in rafting and boating did not affect us in our later tasks.

By the time we went to Normandy in June, 1944, the state of training in watermanship of the permanent field companies of the formation was such that:—

583 Field Company could produce eighteen first-class stormboat crews per platoon.

582 and 584 Field Companies could produce two first-class raft crews and a third crew nearly as good, per platoon.

The raft crews were by this time so skilled that they were able to depart considerably from the original drill which I had laid down. The system was generally the same but each crew had developed their own idiosyncrasies, all founded on a sound groundwork. The leaven of skilled men was so great moreover that newcomers to the formation picked up the system incredibly quickly.

Operations—The Seine

While the formation were "road bashing" in the Caumont-Vire area in early August, 1944, we had been selected, amongst others, for the Seine assault. We were therefore ordered to give small parties a watermanship refresher on the Caen canal. Stormboats were available, and also the Class 9 Close Support Rafts which we had not seen before: these were excellent rafts and became very popular, and in a week or two all the raft crews were at the top of their form while some additional stormboat helmsmen had been trained. By now I had definitely decided to use 583 Field Company on stormboats and the other two—582 and 584—on rafts. As it turned out I was able to stick to this arrangement throughout the campaign.

I had been called to various meetings by C.E. Second Army to give my ideas on the equipment and personnel needed for the assault and felt sure that the formation would be certain of a place in the operation. However, as the Falaise battle progressed it became probable that the enemy had expended most of his strength to the west of the Seine and that the crossing would be against light opposition. At a new conference at Second Army I heard the new plan: in the event of a "scramble" crossing, which was regarded as probable, my formation was not to be involved. If a set piece crossing were necessary it would be done by 3 British Infantry Division and we should operate the rafts and storm boats.

Accordingly we moved south of Vire and, on a large pond, started to train with 3 Division. We had already married up our rafts and stormboats to their crews, so that the latter could really know them and keep them in trim until the operation, and now our job was to get to know our opposite numbers in the division and to train the infantry in carrying the stormboats to the water and in driving on and off the rafts. We had put in one day's intensive training when I received orders thate w were going under command of 30 Corps, and was told to report to the Chief Engineer at once.

The C.E. told me that 30 Corps were to cross the Seine at Vernon, and 43 Division were to do the assault. Not much opposition was expected and I was to provide 16 stormboats and their crews as well as two Class 9 rafts and crews to go under C.R.E. 43 Division for the assault. It was a bitter disappointment to me to lose command of my troops in their first assault crossing, but we were to build a Class 40 bridge later and I could be at the river during the assault—so as to find a site for our bridge—and consequently should see something of them. The unfortunate company commanders were left out of it.

The move to the Seine was to be done in three echelons. The main body of my formation was to go with the last of the three, but

my stormboat and raft parties (one platoon from 583 Field Company and two from 582) were of course to go with the leading echelon and I managed to work my own recce party in as well.

The division was assaulting with one brigade up on a two-battalion front—8 stormboats (half platoon 583) and 1 Close Support raft (one platoon 582) were allotted to each assaulting battalion but the Divisonal Commander was pinning his faith on Dukws.

The leading troops of the division reached Vernon on the morning of Friday, 25th August. The enemy were holding the north bank and the town was overlooked by the steep hillside rising close behind the river and the crossing was well covered by enemy M.G. posts. The attack was very quickly mounted : the assault was to go in at 7.15 p.m. in stormboats, under cover of smoke, our bombardment starting, I think, at 7 p.m. with 10 minutes of H.E., followed by H.E. and smoke.

I was able to go down to the river a bit before the start and talk to the stormboat crews with their boats in hiding behind some houses, about 100 yds. from the river. They were in very good heart, but they did not know their opposite numbers in the infantry (for we had trained with 3 Division) and there had been no chance of trying the infantry in stormboat carrying. In fact, carrying the craft only 100 yds. proved difficult for men unused to it.

Only two boats started in the first wave on each battalion front, and the result of too hasty reconnaissance was unfortunate. On the right, the boats grounded on a shoal in mid-stream and when stopped were very badly shot up by Spandau fire, the boats being smashed and practically all the occupants becoming casualties. Lieutenant Bellamy, in command of the 583 Field Company platoon, was in one of the leading boats but was able, though slightly wounded, to swim back and reorganize the remaining boats to cross on a better line. On the left, the leading boats got over without loss, but the infantry were landed on an island which had been thought, wrongly, to be a peninsula, and this mistake was not rectified for some time.

Small parties got across the river in the boats before dusk, but were pinned down by M.G. fire until nightfall, when stormboating was resumed and a good hold on the far bank obtained. The Dukws were not a success as Dukws (the banks being impossible), but one of them, used virtually as a boat, succeeded in ferrying the best part of a battalion across the river.

The rafts were held back until well after dusk, but building started at about 10 p.m. Under intermittent M.G. fire this was not easy and each raft took some three hours to build, accomplished not without casualties. These rafts, powered with four propulsion units, were used a little during the night and again on the following morning (26th August) but though in brisk periods four or five round trips per hour were made by each raft, only a few vehicles were sent over

in this way, as the divisional plan was to use the F.B.E. bridge which 43 Division R.E. were building, and which they opened on the evening of 26th August.

On 26th August in the afternoon, I was ordered to get a Class 40 raft going for the early hours of the following day, as the Divisional Commander wanted to clean up the bridgehead with armour. Material was available for a Type B. Bailey raft, and I sent for a platoon of 584 Field Company. Meanwhile I was given a reasonable building site to the west of the town, Vernon being still a bit uncomfortable. M.G. fire had finally stopped but the enemy were mortaring the place intermittently. By 11 p.m. a party from 43 Division R.E. were off-loading the pontoons at the site when the platoon from 584 Field Company arrived (having gate-crashed through the American L. of C.) and took over. Building of the raft was not completed till dawn when we sent a bulldozer across to prepare the far bank approach. This got bogged and the site had to be changed—twice—consequently it was not until 10 a.m. that the first tank got across. Thereafter rafting went ahead rapidly in spite of an oblique crossing over ¼ mile wide. (See Photo No. 1.) By 8.30 p.m. thirty-two tanks had been ferried across—in 10½ hours —or over three round trips per hour. We then closed down the ferry as 7 Army Troops had just opened their Class 40 bridge.

This crossing was a valuable experience. We learned :—

(*a*) It is very important to train with the units which are to be ferried in one's boats and rafts. Complete mutual confidence must be obtained.

(*b*) Infantry must be trained, with their sapper crews, to carry stormboats to the water. A carry of over 100 yds. is not practicable.

(*c*) In an opposed crossing, stormboats, if used at all, should be employed on a large scale—at least 20 per battalion.

(*d*) The line for a stormboat crossing must be carefully reconnoitred. Shoal water and islands must be given a very wide berth as direction can be lost in smoke. Tactical considerations must not outweigh these requirements.

(*e*) Raft sites, even for tracked vehicles, must be chosen for their approaches, particularly on the far bank.

(*f*) The marrying of stormboat and raft crews to their craft before the operation is invaluable.

(*g*) It takes at least three hours to build a Close Support raft under fire in the dark.

Nijmegen

The operation "Market Garden," September, 1944, in which one British and two American airborne divisions were to drop in the Arnhem, Nijmegen and Eindhoven areas and be linked up by

30 Corps pushing up from Belgium gave us another water task. While it was hoped to seize the bridges over the Maas, the Waal and the Neder Rijn intact, an enormous sapper effort was laid on for rafting and bridging in case the permanent bridges were blown. Once more I was involved in the planning and the formation were booked for the Waal under 1 Canadian A.G.R.E. Once again the formation were married up to boats and rafts, but in the end nothing happened. Nijmegen road and railway bridges were captured intact and, instead, we took over their maintenance. In addition we had the tasks of building a boom with improvised local materials, of running raft and stormboat ferries, and of repairing roads on the " island " between Nijmegen and Arnhem. Our six weeks in that rather uncomfortable area, while in no way connected with assault crossings, taught us much more about wide rivers. The Waal at Nijmegen is about 1,000 to 1,200 ft. wide and the current runs at $2\frac{1}{2}$ to 4 knots. Building booms with improvised materials—logs, empty drums, Sommerfeld track, S.W.R. and miscellaneous anchors in such a river is a thankless task. No anchor available stood the strain and as the boom was extended the anchors dragged. In the end, after German frogmen had damaged both permanent bridges, I was allowed to abandon the original design of a boom right across the river and to build two horseshoe shaped booms protecting the main piers of the road bridge. (See Photo No. 2.) We should never have achieved the little we did without the help of a Dutch steam tug which had enough power to hold the boom sections against the current while anchoring, but this we had to man with our own troops as the Dutch crew, being civilians, rather naturally were not keen to show themselves to the east of Nijmegen road bridge which was overlooked by the enemy. This boom building took a steady toll of the formation as we were shelled fairly constantly. On our worst day—2nd October—we had 36 casualties. Later the Navy built booms across the river, but even the sailors found the task a very difficult one in spite of having special equipment, and their finished boom carried away more than once. My own opinion of booms, after my Nijmegen experience, and strengthened by subsequent work, is that in a wide and fast river, booms are not only wasteful in manpower, but are a greater source of danger to floating bridges they are " protecting " than the worst the enemy can do.

Rafting was more pleasant. We ran several ferries with Class 9 close support rafts and a stormboat ferry, but all to the west of the main bridges. For our road work on the " island " we were able to save much time in turn-round for tippers by ferrying these across to avoid long detours of one-way traffic. Another Class 9 ferry was used almost daily by the G.O.C. 30 Corps, General Horrocks, who used to go over in his jeep. He christened this particular raft " Mary Ann of Poplar " and the various crews used to vie with one another to cut

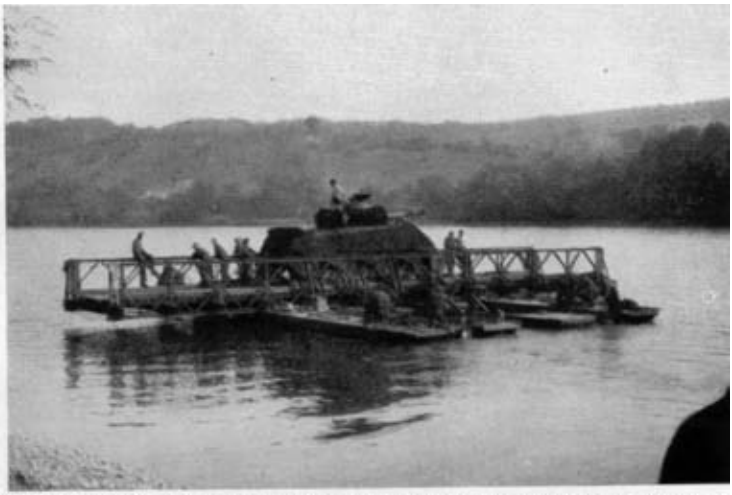


Photo 1.—Rafting a Sherman tank across the Seine at Vernon on Class 40 Bailey raft 27th August, 1944.

Photo 2.—The main road bridge over the Waal at Nijmegen, showing the horsesho booms protecting the main piers.

Rafting And Boating 1,2

down the time of crossing. The record was 2 min. 30 sec. from time of driving on to time of driving off—satisfactory time for a crossing of 1,100 ft. with the river running 3 knots.

In preparation for the Rhine crossing, we tried various methods of getting stormboats to the water over a 1,000 yd. carry, but it was 59 G.H.Q. Troops who evolved the technique—boats carried on improvised sledges towed by Lloyd carriers—which we used when we finally crossed the river. The Waal was very like the Rhine where we assaulted eventually and our stay at Nijmegen gave us invaluable experience.

The Maas

Early in 1945 we were involved in the planning of various assault crossings of the Maas north of Venlo. Again we got our stormboat crews in practice and the planning was useful to keep my company commanders and me "assault-crossing-minded": but the operations all fell through and we remained "road bashing" and bridging.

The Rhine–Xanten

The crossing of the Rhine at Xanten by 15 (Scottish) Division has already been admirably described by Colonel Foster in the *R.E. Journal*: in this account, therefore, I do not propose to describe the whole Engineer organization for the operation but merely to deal with the part which our formation played in that very successful crossing. A few points must, however, be recapitulated. 12 Corps was allotted the crossing at Xanten and the assault was to be undertaken by 15 Division, which was attacking with two brigades up. 52 (Lowland) Division were holding the home bank. 15 (Kent) G.H.Q. Troops (like all other Engineer troops under command of 11 A.G.R.E.) were placed in support of the right assaulting brigade (44 Lowland) which was attacking with two battalions up. The two leading battalions were to cross in L.V.Ts. and our tasks on the brigade front were:—

(*a*) Operation of stormboats (including the ferrying of the follow-up battalion of 44 Infantry Brigade).
(*b*) Operation of Close Support rafts.
(*c*) Preparation of tracks to raft and stormboat sites on each side of the river, including mine clearance on the far bank. Our responsibility extended from flood-bank to flood-bank, but not beyond.
(*d*) Cutting through flood-banks to allow passage for L.V.Ts.

As soon as Xanten had been captured, I accompanied Commander 44 Infantry Brigade on two reconnaissances of the river line. The Rhine at Xanten resembles the Waal below Nijemgen. The river is 1,000–1,400 ft. wide with groynes on either side forming ideal harbours for boat and raft sites in slack water. The river banks

were sandy and gently sloping. On our side the winter flood-banks were 700 yds. from the river proper, on the far side about the same : the flood plain was exposed to view, so a long carry of equipment was obviously necessary since the "hides" had to be behind the high flood-banks. The weather was fine and the flood plain was in ideal shape for taking vehicles with the minimum of track making.

Rehearsals for the operation took place at Berg on the Maas. These were invaluable, as though the river was very unlike the Rhine the whole organization of bank and crossing control was tried out and weak points rectified. Moreover we really got to know our opposite numbers in 44 Brigade, and they in turn gained confidence in our stormboats and rafts. At the same time we married the craft up to their crews. The stormboats became particular babies and I allowed the crews to name them and paint the names chosen on the boats.

For the operation I was given one field company from 15 (Scottish) Division and another from 52 (Lowland) Division, as well as a detachment from a Mechanical Equipment Platoon. The tasks were as follows :—

202 Fd. Coy. from 52 (L.) Div. with Det. Mech. Equipt. Pl.—making tracks from flood-bank to river on home bank, also cutting flood-banks—including a minor bank close to the river—for the L.V.Ts.

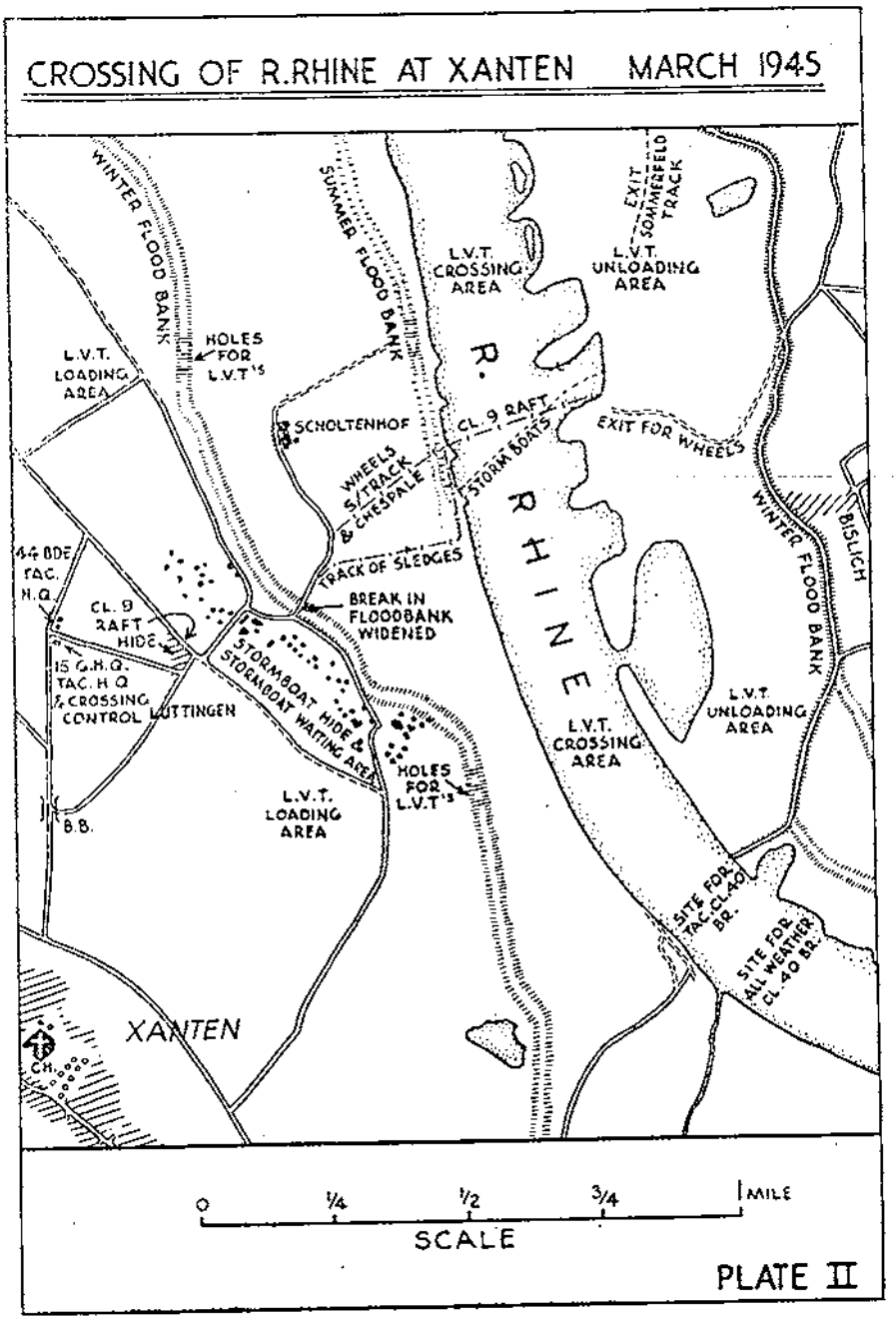
583 Fd. Coy.—operation of stormboats.

582 and 584 Fd. Coys.—building and operation of Close Support rafts.

279 Fd. Coy. from 15 (S.) Div.—mine clearance and tracks on far bank from raft sites to flood-bank—on completion to revert to C.R.E. 15 (S,) Div.

297 Fd. Pk. Coy.—to provide detachments on river bank for maintenance of engines and repair of boats.

I had a total of 50 stormboats and 60 outboard engines, of which we kept 14 boats and 20 engines in reserve in the concentration area. Six Close Support rafts were provided, 4 for operation with 2 in reserve, and each of these was powered with 4 propulsion units. I had 1,000 spare shear pins made by the Field Park Company. This enabled each propulsion unit man to have a pocketful with him, as well as 100 per cent spare in the Field Park. The stormboats and rafts (except the reserves) were to be off-loaded behind the flood-banks during the three nights prior to the operation and camouflaged. Thence the rafts, each in four portions, and each portion on a sledge, were to be towed forward by half-tracks provided by 15 Division Recce Regiment. The stormboats, with their outboard motors fitted, and half a dozen auxiliary paddles in each boat, were mounted on improvised sledges of the 59 G.H.Q. Troops design, to be towed to the water's edge by Lloyd carriers provided by 157


CROSSING OF R.RHINE AT XANTEN MARCH 1945
WINTER FLOOD BANK
SUMMER FLOOD BANK
EXIT SOMMERFELD TRACK
L.V.T. CROSSING AREA
L.V.T. UNLOADING AREA
HOLES FOR L.V.T's
L.V.T. LOADING AREA
SCHOLTENHOF
CL. 9 RAFT
STORM BOATS
EXIT FOR WHEELS
WHEELS S/TRACK & CHESPALE
R. RHINE
WINTER FLOOD BANK
BISLICH
44 BDE TAC. H.Q.
TRACK OF SLEDGES
CL. 9 RAFT HIDE
BREAK IN FLOODBANK WIDENED
15 G.H.Q. TAC. H.Q. & CROSSING CONTROL
STORMBOAT HIDE & STORMBOAT WAITING AREA
L.V.T. UNLOADING AREA
L.V.T. CROSSING AREA
HOLES FOR L.V.T's
L.V.T. LOADING AREA
B.B.
SITE FOR TAC. CL.40 BR.
SITE FOR ALL WEATHER CL. 40 BR.
XANTEN
CH.
0 1/4 1/2 3/4 MILE
SCALE
PLATE II

Brigade of 52 Division, who also provided auxiliary infantry carrying parties in case the sledges broke up—this, however, did not occur.

"H" hour was fixed for 0200 hrs. on 24th March, at which time the L.V.Ts. were to enter the water. Stormboats were to be towed from their hides at "H" hour and their first job was to take over 279 Field Company whose task was mine clearance and track making on the far bank. They were to be ready to take the follow-up battalion of 44 Infantry Brigade at "H+45 min." The rafts were to be towed forward from the flood bank as soon as the home bank was free of enemy M.G. fire and they were to be in operation by first light.

In the planning of the operation, our rafts were scheduled to take over a total of 80 vehicles in the first 24 hours—mainly half-tracks and other vehicles too heavy for L.V.Ts. I was rather horrified at this figure, saying that it was absurdly low and that we could deal with at least three times as many, but was told that anything extra we could take over would be regarded as a welcome bonus.

I was asked if we wished to run our ferries on wires across the river. I declined, as I regarded—and still regard—wires across a wide and swift river as a menace, and I was happy to use the reliable propulsion units available.

The reconnaissances I was able to make before the operation, in company with the Brigade Commander and the C.O. of the L.V.T. Regiment were very useful. We were able to get some way across the flood plain in daylight and mutual agreement reached on ferry sites and L.V.T. and stormboat crossing sites was satisfactory to all concerned. Better sites could not have been picked. Later my own field company commanders did a night reconnaissance to this river bank. They were unfortunate as they were seen and mortared: two out of three were wounded and so missed the operation, but the information they brought back was of value.

Before the operation the amount of liaison and co-ordination required was considerable even down to my level. But everything was thought of, and 11 A.G.R.E., under whose command we were, were a most efficient team. The rafts and boats were all placed in their "hides" to schedule, and on 23rd March I moved my H.Q. into a cottage behind the winter flood-bank, just alongside Brigade H.Q. The troops dug in alongside their craft in the "hides" and the stage was set.

The preliminary bombardment was impressive, starting at 10 p.m., and for four hours we were treated to a really magnificent firework display, the bass accompaniment being provided by a heavy Lancaster raid on Wesel, a few miles away. The troops were all in good heart, and indeed the enemy's reply was only a little mortaring in our area. Meanwhile under 202 Field Company, six dozers successfully cut four openings for L.V.Ts. in the winter flood-banks.

Before 2 a.m. the L.V.Ts. laden with the assault troops, were on their way up from the rear and at 2 a.m., when they entered the water, the first twenty-five stormboats set out for the river bank in tow of Lloyd carriers. By 2.20 a.m. the boats were in the water and 583 Field Company were ferrying across the first troops, 279 Field Company for the far bank work, together with the raft recce parties from 582 and 584 Companies. There had been no hitch in towing the boats on the improvised sledges and the carriers returned for the remaining craft. By 2.55 a.m. the whole of 279 Company was across and the follow-up battalion of 44 Brigade was starting to go over. By now the Field Park maintenance parties on the bank had their hands full, as the stormboat engines were giving trouble as usual, so that at any one time there were rarely more than 8 boats in action. While they worked, however, they did well, taking an infantry section at a time, and by dawn most of the follow-up brigade of the division had crossed the river, partly in the stormboats and partly in the L.V.Ts.

At 2.30 a.m. O.C. 584 Field Company was at the river bank and reported that conditions were suitable for raft building. I got permission to start from the Brigadier and ordered the rafts forward, and they were on their way by 2.45 a.m. They had suffered rather more than the stormboats in their "hides." Only one of the latter craft had been put out of action, but several of the raft pontoons had been holed by splinters. Towage to the river by half-tracks proceeded smoothly, but damage hitherto unobserved was found when building commenced. This delayed construction, and it was not till 6.30 a.m.—just after first light—that the first two rafts were completed and rafting started, first with two airborne dozers which we were sending over for 42 Assault Regiment—who were scheduled for Class 50/60 rafts further down-stream, following with two D.4's of our own for improving the raft exits. Meanwhile 279 Field Company had been doing good work on the far bank tracks and had cleared the very few mines encountered in the area. They completed their job by 11 a.m. and reverted to their own C.R.E. On the home bank 202 Field Company were improving the raft approach by adding Chespale and Sommerfeld track, and throughout they kept these approaches in good shape.

When rafting started just before sunrise the river was an unforgettable sight. We were crossing the great Rhine—the assault crossing which had been every Sapper's dream since the beginning of the war—and things were going unbelievably well : all the years of planning, experimenting and training were bearing fruit. Away on each flank L.V.Ts. were waddling in, crossing, climbing out, off-loading and returning in endless succession. D.D. tanks, looking monstrous on the banks, were plunging in and wandering across apparently helplessly but none the less effectively : the rafts, with

their curious loads, looked purposeful as they made the passage with a smother of foam at their bows, while crossing and recrossing their track yet never impeding them were the stormboat flotilla, eastbound, laden with infantry, making a lot of fuss at 7 knots, or flying back light at 18 knots or more.

Stormboating died down to a trickle by 9 a.m., though occasionally there was renewed activity as some unit was sent forward to cross in these craft: their return passage was often made with a complement of prisoners. (See Photo No. 3.)

Rafting however was on the up grade. As already mentioned, we could start with two rafts only, but the Field Park detachment worked hard on repairing damaged pontoons so a third raft was in service by midday; the fourth raft of the originals was beyond repair, but I ordered up one of the two reserve rafts at 7 a.m. and the other later, so that by the evening of 24th March we had five rafts afloat. Next day 11 A.G.R.E. procured us yet another making six in all.

Six rafts on paper—but not in practice! The most common loads were scout cars, half-tracks, 3 tonners and 15 cwts. (the last were loaded two per raft). The half-tracks were considerably over Class 9 and when under way at full speed with this heavy load the bows of the rafts were pushed under water. (See Photo No. 4.) Consequently every few trips the rafts had to be pumped out, so at any one time we never had more than four rafts working, while the average was about three. Shear-pin breakages were frequent (mainly through running the engines flat out), but with plenty of spares to hand this rarely put a unit out of action for more than a minute or two. Once the rafts were built the two operating Field Companies worked in platoon shifts, each platoon doing 4 hours on, twice in 24 hours, and manning two rafts.

After dawn on 24th March there was no enemy interference on the river bank, bar a very short, and harmless (though unpleasantly close) burst of shelling of the raft site at about 11 a.m. and minor air attacks the following night. The raft crews were doing magnificently and Bank Control had to be pressed for more vehicles for rafting: they responded joyfully, for until the early hours of 25th March there was no bridge at all across the river and then only a Class 9 F.B.E. which cannot take great speed or density of traffic. The first tactical Class 40 bridge was opened on the evening of 25th March, but rafting was continuous until 2 a.m. on 26th March, after which the bridges were able to handle all the traffic. We took seven more vehicles after that time and closed down at noon on 26th March, when we set to work on an all-weather Class 40 bridge.

A table is given showing how rafting progressed at the ferry site from the time of opening—6.30 a.m. on 24th March—till traffic tailed off at 2 a.m. on 26th March. During this period of 43½ hours 630 vehicles (excluding trailers and motor cycles) were rafted east-

Photo 3.—Stormboat on the Rhine (Xanten) disembarking prisoners, 24th March, 1945. Note the name and number painted on the boat.

Photo 4.—Crossing the Rhine, 24th March, 1945, at Xanten ; the bow of a Close Support raft immersed by heavy weight of half-track being rafted : the propulsion unit is practically under water.

Rafting And Boating 3,4

Photo 5.—Class 9 rafting at Xanten. A raft leaving the east bank with a truck as load. An empty raft returning at full speed on the left.

Photo 6.—On the east bank of the Rhine. A 3-tonner about to disembark from a Class 9 raft and another laden raft coming in to berth.

Rafting And Boating 5,6

wards, and a number of vehicles and prisoners brought back. This represents approximately 570 round trips shared between six rafts, but the average number of rafts *working* throughout the time works out at just over three, and the average number of rafts on site during the period works out at 4.7 Thus the rafts were out of action about one-third of the time they were on site, and when in action each raft averaged 4.7 vehicles or 4.3 round trips per hour. As the round trip was just over half a mile, and loading of prisoners for the return trip was sometimes slow, this seems a very creditable performance. I wonder if better continuous rafting has ever been accomplished : it was certainly a joy to watch (See Photos Nos. 5 and 6.). One German officer returning as a prisoner, on disembarking, said to the raft commander : "Splendid watermanship !"—a pleasant unsolicited testimonial. One must mention, however, that weather was kind, the approaches stood up with a minimum of maintenance, enemy interference was practically nil once the first rafts were built, and morale was high, raised still further by the sight of the inspiring fly-in of 6 Airborne Division over our heads on the morning of 24th March. At night, artificial moonlight allowed us to continue with undiminished speed. At Xanten, indeed, everything went to plan or better : our friends 30 Corps at Rees were not so lucky, as it was they who came up against the tough opposition.

The Rhine ended our assault crossings : we hoped to be in at the Elbe, but 30 Corps took us, and we went to Bremen instead, where our water activities were confined to building a barge bridge.

Conclusion

This account has been written with the object of stimulating intelligent interest in watermanship in boats and rafts, and to point out that a high standard can be achieved with thoughtful training. Some murmurers may think that because we had concentrated on watermanship we were a specialized formation : I would here point out that in all other R.E. tasks in the field we were fully trained, and though by far the most interesting tasks we had during the campaign were connected with water I do not think the formation fell down on other jobs which we had to do at various times. While agreeing that the time spent on watermanship training was considerable, I believe we could have achieved 70 per cent of our Rhine rafting performance after our six-weeks' initial training in Northern Ireland in 1943.

It seems to me that far too much time in rafting training is spent in *building* rafts, and cutting down building times to purely fictitious figures in exercise conditions. Building rafts under fire at night in an operation is a slow business anyway and bears no relation to training times. Surely it is more important to operate the raft smartly when it is built ? Four round trips an hour per raft over a

1,000-ft. river is easy to well trained crews, and possible even under fire, yet I have seen a crew from an otherwise efficient Field Company take half an hour over a single passage of a 400-ft. river in a Close Support raft in peaceful conditions.

One last point, on what I would call engineer discipline. I always insisted in my formation that to tackle an engineer task unintelligently or to finish one off sloppily, was not merely inefficient ; it was bad discipline and was treated as such. This applied specially to work on the water. Rafts and boats had to be kept neat, and handled and stowed in a seamanlike manner. This system worked right down to the bottom of the formation, and a man who handled a boat or raft badly was an object of ridicule to his fellows, and of shame to himself. Consequently lapses were rare and this as much as anything kept the standard high. For myself, I could not wish to have commanded better troops in war.

PROGRESS OF CLASS 9 RAFTING. LUTTINGEN (XANTEN), RIVER RHINE. 582 AND 584 FD. COYS. R.E.

Date	*Time*	*No. of rafts in action*	*Cumulative total of vehs. rafted*	*Vehs. rafted per hr. in each period*
24th Mar.	0630	2	Nil	—
	0800	2	14	9·3
	1000	2	36	11.0
	1200	3	64	14.0
	1400	3	108	22.0
	1600	4	131	11.5
	1800	4	155	12.0
	2000	3	202	23.5
	2200	3	234	16.0
	2400	3	264	15.0
25th Mar.	0200	3	285	10.5
	0600	3	335	12.5
	0800	3	371	18.0
	1000	4	420	24.5
	1200	3	464	22.0
	1400	4	497	16.5
	1600	4	521	12.0
	1800	3	555	17.0
	2000	3	584	14.5
	2200	2	596	6.0
	2400	2	611	7.5
26th Mar.	0200	4	630	9.5

ORGANIZATION OF AIRFIELD CONSTRUCTION FOR WAR

By COLONEL A. G. WYATT, C.B.E.

" *Myself when young did eagerly frequent*
Doctor and Saint and heard great argument
About it and about; but ever more
Came out by the same door as in I went."
(*Omar Khayam—Stanza 27.*)

Field Service Regulations, Vol. I. 1939.
Chapter XIII, Sect. 87, Para. 6.

" *The preparation of the surface of the aerodromes and the provision of aeroplane hangars is the duty of the Air Force, but the necessary labour and material will be provided from Army sources.*"
Para. 7: " *All works services for the Air Force will be carried out by the Army.*"

THUS, summarily, was the question of Airfield Construction dismissed in the pre-war " bible " of the Army, yet from these two sentences there sprang a wealth of argument, discussion and sometimes acrimony in nearly every theatre of war before methods were evolved which would satisfy the various interested parties. By the end of the war general agreement on the responsibilities between the Air Force and the Army engineers had been reached, but complete unanimity of thought was still lacking and the exact machinery for accomplishing the tasks still varied in the different theatres.

With the advent of peace, so called, the Army has ceased to be responsible for construction of airfields. Although combined Air Ministry and War Office research and planning into the problems of airfield construction continues, there is, in the writer's opinion, a danger that by the time the next war is upon us we may have lost the thread of previous thought on the practical aspects of the problem and once again we may be left to flounder through the welter of old arguments and heresies.

The writer, who had experience in organizing airfield construction in several theatres during the late war, proposes to try and trace through, as briefly as possible, how the airfield construction organization grew up in those theatres in which he had experience, referring on the way to some of the major growing pains which were encountered, and to finish by trying to establish a firm advance base from which we may take off next time.

To begin with, let us analyse a little more closely the wording of the *Field Service Regulations*' directive quoted above.

Taking the first sentence, it would appear that the intention was for the R.A.F. to be responsible for the specification and direction of all the works required on airfield surfacing, the Army merely supplying labour and stores. Here was cause for dissension straight away. Whilst agreeing that the R.A.F. were and must be responsible for defining the size of airfields and other matters pertaining to the operational necessities of aircraft, were they in fact to define the purely engineering specifications such as thickness and type of material required on runways? Were they to have a separate force of military engineers entirely under their control and direction, or were they merely to act as supervisors and checkers of the work carried out by the military? Finally, how much say were they to have on the allocation and control of engineer stores?

The second para. quoted, on the other hand, seemed to be a straightforward statement, but few people realized at the time what it involved!

France and the Battle of Britain

Let us now see how the Army set about solving the question from their point of view.

The War Office, realizing their responsibility for airfield construction but failing entirely to realize the scope and scale involved, decided that they must have some specialist officers for airfield work on the eventual outbreak of war. In consultation with the Air Ministry, it was agreed that these officers should be provided from the Air Ministry Works Dept., which was then an entirely civil department in the Air Ministry. The officers earmarked from the Air Ministry Works Department attended an initial course of one month's duration at the S.M.E. Chatham and subsequently were attached to R.E. Field Companies during manœuvres for a fortnight's training. On the outbreak of war these officers were mobilized into the Corps of Royal Engineers and allocated as Deputy Assistant Directors of Works (Air) to the Engineer-in-Chief and the Director of Works Expeditionary Forces.

On arrival in France it was apparent almost at once that the amount of work involved on airfields for the Air Component and

Air Striking Forces was far beyond anything envisaged in peace-time, and that the existing organization was quite unable to cope. Neither the staff nor the number of troops necessary to carry out the work were available. It was therefore decided to appoint a Chief Engineer to each of the two Air Forces to work under the direction of the Engineer-in-Chief, Expeditionary Force and to give each a force of engineers sufficient for the work entailed. A large number of hastily recruited and quite untrained General Construction companies R.E., and some Pioneer companies were then raised and dispatched piecemeal to France, where they were loosely banded together under various Cs.R.E. Works (Airfields). One C.R.E. might have a dozen or more airfields under his control, with anything from one to four or more companies per airfield. In the latter case the senior Company Commander would be appointed O.C. Airfield Construction for that particular field.

In the general rush of the moment the organization of these two engineer set-ups was somewhat sketchy, and no clear directive was issued as to their responsibilities. Differences soon arose as to the chain of command, *vis-à-vis* the Engineer-in-Chief, the Chief Engineers (Air), A.O.Cs. Air Component and Air Striking Force, A.O.C.-in-C., the Air Ministry and the War Office.

The R.A.F. General Duty Officer had not been trained to think in terms of works in war-time and had been accustomed to long-established bases, with all the luxuries of peace-time barracks, hangarage, workshops, concrete runways or first-class grass airfields, etc. As a result it was difficult to control their somewhat ambitious demands for airfields and camps in France. This, coupled with their interpretation of "direction of the works," made them feel that they could not get a fair deal from the Army Engineers unless labour and provision of resources were in their entire control.

To add to the complications, there suddenly appeared in France a small cadre of Air Ministry Works Officers in R.A.F. uniform, working directly under the orders of the Air Ministry. On Training airfields in the L. of C. these officers proceeded to enter into competition with the Army for the services of various contractors, at a time when all the civilian resources in France were being tapped to the utmost by the D. of W. for the furtherance of priority works as laid down by the C.-in-C. Considerable chaos ensued. These officers, divorced as they were from all aspects of the operational picture, were quite unable to realize the extent of the chaos they caused, and even when the Germans were nearly on top of them they were still advising the A.O.C. against the use of these newly sown airfields by our aircraft for fear of spoiling the next year's turf.

In spite of much controversy between the Air Force and the Army, and even between the Engineers themselves, a very large

number of airfields both forward and at the Base, were constructed in those early months—but with much wasted talent and effort. Unfortunately, many of the newly-constructed fields were used for the first time by German aircraft.

After the evacuation of France, and during the period of the Battle of Britain, some of the units that had been employed on airfields were put on aerodrome maintenance in the U.K. to help A.M.W.D. civilian gangs make good the damage done by enemy air raids. Here they did excellent work, since, being disciplined labour, they were perhaps in a better state to carry out effective repairs during and between attacks than normal civilian gangs who were not always too reliable.

The remaining units were formed into Airfield Construction Divisions under Cs.R.E. for the urgent construction of new airfields in the U.K. These divisions were responsible for the surfacing of the airfields only, the buildings, etc., being the responsibility of the Air Ministry Works Dept. through the agency of civilian contractors. An Airfield Construction Division at this time was a very fluid affair, consisting of an indeterminate number of General Construction, Artisan Works, Road Construction, Quarrying and Pioneer companies. In the writer's division there were at one time as many as twenty-four companies of all sorts. Most of the engineer units were over-subscribed with skilled tradesmen, for whom there was no suitable work, with the result that many excellent tradesmen were being misused.

Realizing the wastefulness of employing highly-skilled labour on what were virtually mere labourers' tasks on airfield maintenance, the E.-in-C. (War Office) decided, after the Battle of Britain, to put those units employed on maintenance tasks to more useful work on army camps, etc., which by now had become a question of high priority. He proposed to substitute for them units of a lower trade category, and a conference was held at the War Office in the latter half of 1940 with Air Ministry representatives to discuss ways and means of implementing the scheme and how best to exercise control over these forces. The Air Ministry, however, tended to distrust the permanence of any labour force so formed, feeling that they might be called off at short notice to other tasks which the Army considered more important, and they decided instead to form their own Maintenance Works Squadrons in R.A.F. uniforms for the purpose.

In 1941, the ever-increasing demand for Army Camps and engineering works of all sorts in the U.K., coupled with the necessity of finding reinforcements for overseas, forced the E.-in-C. to reconsider the use of the mass of highly-skilled tradesmen employed on airfield construction as well, and by the end of 1941 it was decided to with-

draw these units also, and to hand over all airfield maintenance and construction in the U.K. to the Air Ministry. Thus, after approximately two years of war, in the U.K. at any rate, we were more or less back where we started, with the Air Ministry responsible for airfields at home, but now raising their own forces for the purpose, and no Army airfield organization to send on an overseas expedition.

At this point it might be as well to review the major snags that had been encountered up to date.

1. Failure of adequate liaison pre-war between the Air Ministry and the War Office, leading to lack of planning for what was required in the way of airfield works on the outbreak of war. As a result, the Army Engineers were not in a position to carry out the tasks demanded and had to make an *ad hoc* arrangement in the theatre of war with all its inevitable teething troubles.

2. Excessive demands by the Air Force based on peace-time conceptions of airfields which, when they could not be implemented, led the Air Force to believe that the Army was not giving them a fair deal.

3. Lack of study and understanding by the Engineers of the problem of rapidly-constructed airfields, with the result that efforts were wasted in constructing peace-time standards of runways.

4. Misunderstanding by the Air Ministry regarding the necessity of keeping the Commanders in the field *au fait* with their plans, again leading to acrimony between the Army and Air Force staffs.

5. Failure of Air Force Commanders in the field to understand the Engineer set-up, namely that the E.-in-C. was, in fact, advisor to both the C.-in-C. and the A.O.C.-in-C., leading to further mistrust of the loyalty of Army Engineers to the Air Force. This, again, could be attributed to pre-war lack of liaison between the two services, in particular as between the Air Force and the R.E.

North Africa

The position at the end of 1941 did not last long. Early in 1942, with planning for an overseas assault beginning to take shape, it became once more a matter of urgency to decide on how best to tackle the airfield problem. The lessons of the past were studied and it was realized that in any future campaign the number of airfields necessary and the rapidity with which they would have to be constructed would warrant the whole-time use of a certain number of engineer units. Some thought since 1940 had also been given to the problem of rapid surfacing of an airfield. Trials had been carried out by the Air Ministry in conjunction with the War Office as a result of which it was decided to use Sommerfeld Track, and production was put in hand on a large scale. It was still accepted by both the War Office and the Air Ministry that the R.E. would be responsible

for the execution of Air Force works for forward airfields in overseas theatres. In North Africa owing to the presence of the American Forces, base airfields were largely left to the U.S. Army Air Force engineers, though British airfield construction groups were at times also employed. Some argument again arose as to the control of the engineer units so employed, but with the appointment of a D.C.E. (Airfields) under C.E. (Army), and working at Army H.Q., it was generally hoped that this question might be considered settled. For some time the A.O.C.-in-C. Task Force tried to insist that the D.C.E. should be appointed as C.E., R.A.F., but he eventually seemed to realize that it would be necessary for the Chief Engineer of the force as a whole to be the advisor to both the G.O.C.-in-C. and the A.O.C.-in-C., since a separate C.E. R.A.F. would have very little real power. A further step to ensure that the Air Force got a fair deal was the attachment of an R.A.F. officer permanently to the staff of the D.C.E. (Airfields), with the intention that he should be in on all engineer planning, representing the R.A.F. point of view at all times and seeing that they got a fair share of whatever was available.

A trial organization for an Airfield Construction Group was also proposed and an exercise was carried out to test its efficacy, as a result of which certain modifications were made and about August, 1942, the first U.K. Airfield Construction Groups were born. Each group consisted of :—

C.R.E. H.Q.
1 Artisan Works Company.
1 Mech. Equipt. Section.
4 Pioneer Companies.
1 Bomb Disposal Section.

The lesson of using too many valuable tradesmen on airfield work had obviously been learned. One R.A.F. General Duty Officer was posted to each C.R.E. to advise him on the purely air-operational aspect of airfield layout and construction but with no power to influence engineer specifications. Combined planning between the Air Forces and the Army ensured that the Army engineers would not again be caught out on the scale of work involved.

In fact, it appeared that everybody really had learned some lessons from the past—though perhaps rather belatedly—as not much time was available before Operation " Torch," in November 1942, was upon us.

The new arrangement, in practice, worked reasonably well during the ensuing operations, but a few contretemps naturally occurred.

Early on the Sommerfeld Track proved useless on the clay and silt airfields of North Africa and, for a time, the air forces were more or less grounded during the rainy season on these airfields.

The American P.S.P., and other practical aids later evolved, were not yet available to us. The R.A.F. higher staff, failing to realize the engineering difficulties engendered by nature, thought that the Engineers were not giving them all the necessary support, and, with Air Ministry approval, a very well-known business-man, with two or three of his friends to advise him, suddenly arrived in North Africa dressed in R.A.F. uniform with the apparent intention, among other things, of putting the Engineers on the right track. Their solutions, however, were not such as either to solve the Engineers' problems or to fit in with the operational needs of the theatre and, after a great deal of argument and discussion it was agreed that the Engineers were perhaps best able to judge the facts for themselves.

With more experience and the advent of better weather, airfield construction improved and by the end of the campaign a very large number of airfields and R.A.F. camps had been satisfactorily constructed. Liaison between the Air Force and the Engineers in the theatre, at any rate at lower levels, was good. It was noticeable, however, that each time a change occurred in the higher ranks of the Air Force the old argument that engineers in khaki could not give really loyal service to the R.A.F. cropped up again, only to subside as experience proved otherwise.

The American Army, alongside the British, had a slightly different organization from ours for airfield construction. Whilst having the equivalent of our construction groups in their Aviation Engineer Battalions, their Chief Engineer and the whole of the Aviation Engineers were directly under the command of the Commanding General, Army Air Force, and had their own source of supply. The British Army criticism of this system was that it was wasteful of engineering effort and supplies, because in any theatre with a limit to resources the whole engineering effort must be kept fluid and ready to be put to maximum use according to the theatre's priorities.

However, the mere fact that there was an organization directly under the control of its own Air Force, regardless of the fact that the Air Force was itself controlled by the Army, caused the R.A.F. to cast longing eyes from time to time on such a system, especially whenever, due to lack of facilities, it was not always possible for the British Engineers to give them their full demands.

By the end of the campaign it was also discovered that the original set-up for the airfield construction group was not entirely satisfactory, and a new establishment was recommended, consisting of :—

C.R.E. H.Q., with attached R.A.F. Advisor.
2 Road Construction Companies including mechanical equipment plant.
2 Pioneer Companies.
1 Bomb Disposal Section.

and this organization, when finally approved, remained basically the same in the European and Middle East theatres for the rest of the war.

Looking at the mistakes made during this campaign compared with the earlier one it appeared that :—

1. Although an attempt had been made by the Army Engineers to study the problem of rapid airfield construction before operations commenced, this had not gone far enough and in practice the solution was not adequate.

2. Failure by the Air Force Commander and the Air Ministry to understand the rôle of the Chief Engineer led to mistrust and an attempt to set up their own engineering advisor, with resulting disputes and waste of time. Some of the fault for this must be laid at the Engineers' door in not effecting sufficiently adequate liaison.

On the other hand, planning between the two services had been good, the Engineers generally were able to compete with the work involved, and the general mistrust of khaki engineers by the Air Force was being overcome.

Middle East, Sicily and Italy

Since the beginning of the war the Engineers in the Middle East theatre had been faced with the same problems regarding airfield construction as at home, with the added complication that in Egypt, which had become an operational theatre, there was already existing, pre-war, an Air Ministry Works and Buildings organization directly responsible to the Air Ministry at home. The officers of this organization were given R.A.F. commissions on the outbreak of war. Methods had to be devised to integrate this Air Ministry Works organization with the Royal Engineers, and after a great deal of complicated and, at times, wearisome discussion, a *modus vivendi* was agreed whereby an Army Chief Engineer Aero was appointed, representing the Engineer-in-Chief M.E., but living at H.Q., R.A.F., Middle East, with a Chief Engineer R.A.F. (Ex-A.M.W.D.) more or less in parallel with him. The Chief Engineer R.A.F. was responsible for base and non-operational areas, working as much as possible in liaison with the Chief Engineer Aero, especially over the problem of stores in short supply. As can be imagined, this arrangement depended to a great extent on personalities and gave the A.O.C.-in-C. two Engineer Advisors. This was not a very satisfactory state of affairs, but it was made to work although creaking loudly at times.

Forward airfield construction was the responsibility of the Royal Engineers, and after various trials it was decided that it was necessary to have an organization in which the units were kept permanently on airfield construction, as previous attempts to farm out work to

any Engineer unit had led to difficulties over the time factor, as units inexperienced in the work were not able to complete airfields quickly enough. Eventually, an organization somewhat similar to the U.K. Airfield Construction Group was evolved, consisting of:—

C.R.E., H.Q.
3 D.C.R.E. Units.
2 General Construction Companies.
2 Mech. Equip. Sections.
2 Indian Pioneer Companies.
1 M.T. Company.

No R.A.F. Advisor was appointed to Chief Engineer's H.Q., as the Chief Engineer lived and worked with the R.A.F.

At C.R.E. level, an R.A.F. officer who might be any pilot-officer, was appointed as required and was not a permanent member of his staff. R.E. Units generally lived with the R.A.F. and close integration was secured. The D.Cs.R.E. took charge of all works and had allocated to them such units or portions of units as the work necessitated. In the desert, airfield construction was not as complicated as in other parts of the world and did not, therefore, require the same comparable effort.

Owing to this close integration with the R.A.F., very close liaison, understanding and friendship between the Desert Air Force and their Engineer units grew up in this campaign, but at Base and on higher staffs there was not always quite the same accord.

On completion of the North African campaign, planning began for the invasion of Sicily, and it was decided to amalgamate the Middle East and North African Airfield Construction Organizations, and also to bring in an Airfield Construction Group over the beaches direct from the U.K. This latter group was still organized on the same basis as the original groups which had gone to North Africa. It was not possible to get this variety of units together before the operations began, and the net result was that after landing, there were virtually three different organizations and three different schools of thought. The Middle East school, in which the tendency was to underrate the difficulties of airfield construction and supply of engineer stores in the new terrain and to doubt that any other engineers could have the same loyalties to the Desert Air Force as the old firm. This doubt was, of course, zealously supported by the D.A.F.

The North African school, which, whilst viewing the engineering task from a less parochial point of view, did perhaps tend to hold aloof from the close integration with the Air Force achieved in the Middle East, relying more on the R.A.F. Advisor as their link with Air H.Q.

Finally, the U.K. school, who were full of enthusiasm but lacking in up-to-date active service experience and with a tendency to consider that the airfield units were solely for use with the R.A.F.

The three organizations differed in considerable details of their make-up, and as soon as possible a regrouping of the various units had to be accomplished to bring them more into line with the organization proposed as a result of the North African campaign. All this had to be done during the stress of active operations and was not accomplished without some heart-burning, a certain amount of wasteful discussion and a reduction of effort. It also tended to re-open the controversy between the Air Force and the Engineers as to the ownership of the airfield construction groups.

By the end of the campaign the groups had more or less settled down, with the result that when the invasion of Italy took place we were at least free of some of the headaches encountered at the beginning of the Sicilian campaign. In Italy, however, there developed more and more a tendency for overlapping between the British and American airfield engineer effort. The American system of direct control of their Engineers by the Air Forces and their ability to draw direct on stores of engineer provision without reference to the Army Staffs caused at times considerable confusion on the British L. of C., and eventually it was decided to appoint a D.C.E. (Air) at Army Group level, with D.C.Es. (Air) or their near equivalent at Army level, with the intention that they should try and co-ordinate the work of the allied airfield engineers, or at any rate get advance information of the intentions of the American Air Force. At the same time the R.A.F. demanded that the R.A.F. officers with the D.C.Es. should be withdrawn and become Staff Officers at equivalent Air H.Q. This threw the onus more squarely on the Royal Engineers to keep effective liaison between them and the R.A.F., with the result that the D.C.E. Air moved over from Army Gp. H.Q. to Air H.Q., leaving a Staff Officer link at Army Group H.Q.

At construction group level, however, the R.A.F. decided to continue the North African system and appointed an R.A.F. officer as a permanent advisor to the C.R.E. on air operation technicalities, the Middle East system of deputing an advisor on a part-time basis having led to certain difficulties over continuity.

The above organization remained basically the same for the remainder of operations until the end of the war in Europe, and worked well.

Back in the Middle East, meantime, with the lifting of the threat of operations, the Air Ministry Works Dept. proceeded to take over more and more airfields and eventually took control of the entire lot.

What were the snags encountered in this phase?

1. On the War Office side, lateness in deciding on a suitable plan for the development of an airfield construction organization resulted in the haphazard growing up, in other theatres, of different organizations which eventually had to be welded into one under adverse circumstances.

2. The absence of any firm directive on the division of responsibility between the two Services for the provision of Works Services for the R.A.F. at Base caused continued confusion in any theatre where the two systems clashed.

3. Continued failure of the Air Force to trust the "brown job" engineers, but this again was partly attributable to the engineers failing to follow up their share of the liaison. At all lower levels liaison was excellent. It was on the higher staffs that doubts crept in.

India and S.E.A.C.

In India, Air Force works in peace always had been the responsibility of the E.-in-C. India, and a C.E. Air Force Works existed who had his office at Air H.Q., India. On the outbreak of war this officer was appointed Deputy E.-in-C. Air, India, and moved over to the E.-in-C's. office but retained a proportion of his staff working at Air H.Q. At Command levels D.C.Es.(Air) were also found. Although difficulties were encountered they were chiefly technical and there was never the same recurring mistrust by Air H.Q.India of the loyalty of the Engineers as occurred in other theatres, and liaison at all levels was excellent. An organization for forward airfield construction grew up on somewhat similar lines as in other theatres, with a mixture of skilled and unskilled units but varying in considerable detail from the U.K. and Middle East set-ups.

With the establishment of S.E.A.C. it was rightly decided to appoint a Deputy E.-in-C. Air to that command. A new Air Command other than Air H.Q., India was also formed, and once again the old arguments and discussions arose as to whether there should be a Deputy E.-in-C. Air, S.A.C.S.E.A.* or a C.E., A.C.S.E.A.,† and once again, reluctantly, the Air Force agreed to the Deputy. Bearing in mind past mistakes, and taking a leaf from India's book, a portion of the Deputy E.-in-C. Air's staff worked at Air Command, and gradually this arrangement settled down to the satisfaction of all parties. The question of the composition of the airfield construction groups was taken in hand with G.H.Q. India and alterations were made which brought them more into line with similar organizations elsewhere. A D.C.E. Air was appointed at Army level, who lived and worked with Tactical Air Force H.Q.

* Supreme Allied Commander South East Asia.
† Air Command South East Asia.

S.E.A.C. and A.C.S.E.A. then moved in 1944 from Delhi to Ceylon. In Ceylon there was a similar problem as had occurred in the Middle East, namely an established A.M.W.D. organization with its own Chief Engineer, the officers of which wore R.A.F. uniform. Once again methods had to be devised to try and integrate the two engineer organizations and, at first, the Middle East solution of dual partnership was tried out but, as was to be expected, was no more successful than in the Middle East, and arguments and misunderstandings continued.

In late 1944, the Deputy E.-in-C. Air and his staff moved over to live and work at Air Command, leaving only a small link with the E.-in-C.

At about this same time another organization began to raise its head to complicate the scene still further. In view of possible developments in the Pacific war against Japan it had been agreed on a high level at home that certain R.A.F. Airfield Construction Wings, which were a development out of the original maintenance works squadrons formed in 1941, and which had been employed in N.W. Europe and were now redundant, should proceed to the Far East for employment on "Tiger Force." With the cessation of hostilities against Japan it was decided to divert these wings to S.E.A.C. where they would come under the control of Air Command and be used for the initial rehabilitation of the Air Forces. Another Engineer Commander, R.A.F., now appeared on the scene, disclaiming any allegiance to either the C.E., A.M.W.D., or D.E.-in-C. Air. There were now three separate engineering advisors to the unfortunate A.O.C.-in-C. ! After a lot of head-scratching, dissension and reference back to the U.K., agreement was finally reached that the D.E.-in-C. Air was the sole advisor to the A.O.C.-in-C., and the respective spheres of responsibility of the other C.Es. were defined. This decision was largely reached owing to the confidence in the E.-in-C. that Air H.Q. had now developed ; a confidence helped to some extent by the fact that the D.E.-in-C. Air and his staff was a part of Air H.Q., and had established good liaison. Eventually, when the wings arrived in the theatre, a satisfactory chain of command having been established, they were able to fit into the picture without undue difficulties.

Once more looking at the snags, it was apparent that :—

(1) Continued lack of a firm directive on the sphere of responsibility for the provision of Works Services at Base as between the two Services still led to endless confusion in any theatre where the two systems clashed.

(2) Continued failure of R.A.F. Commanders to trust the loyalty of the Army Engineers until experience proved otherwise.

North West Europe

The writer had no personal experience of this theatre, but it might be as well to round off the above surveys of other theatres with a very brief glance at the general principles evolved for this campaign. By the time the invasion of Europe started there was, of course, a great deal of past experience to be drawn upon, and it was decided to adopt the method already proved satisfactory in other theatres, namely the control of forward airfield construction through a system of Deputy Engineers at the various formation levels and at S.H.A.E.F. In some cases these Deputies lived at Air H.Q. and in others at Army H.Q. Airfield Construction Groups were of standard pattern, as recommended after North Africa, but were augmented by R.A.F. Airfield Construction Wings which were under the control of the respective R.E. Commanders in whose areas they worked. One of these wings was used for a time on forward airfield construction, working with the Army Airfield Construction Groups and coming under the command of the respective A.G.R.E., and did excellent work, though they were primarily designed for Base and L. of C. work.

The Future

The above brief surveys of the growth of airfield construction show how, beginning with practically no conception of the size and scale of the work required for airfields, the engineers in each theatre developed the hard way, independently, solutions to fit the needs of the air forces, ending up eventually in each case with very similar answers. Running throughout each theatre, however, were certain definite faults which were common to all and which can be summarized as follows :—

1. Mistrust by the Air Force that Engineers in khaki could be really loyal to the boys in blue, leading to the necessity of Engineers continually building up goodwill with each change at Air Command.
2. Lack of co-ordination of the airfield engineer build-up in the various theatres.
3. Difficulties encountered with the A.M.W.D. organization in any theatre where already established.

In addition to the above were certain other faults which were not necessarily common to every theatre and which were generally rectified in due course, namely :—

(1) Failure by the Engineers to force the pace in liaison between them and the R.A.F.
(2) A belief by the Army that airfields can be satisfactorily constructed by any engineer unit, which, whilst basically

true, does not allow for the speed of construction, which can only be gained from constant practice.

It is an accepted fact nowadays that the adequate and timely provision of airfields is a vital requirement to air forces operating in the field in support of the Army. Although a vital requirement to the Air Force, the provision of airfields is an Army responsibility, and, therefore, demands the closest possible inter-Service co-operation. What then on the Engineer chain is the best way to achieve this co-operation? In the writer's opinion, by the end of the war we were well on the way to success in that we had found that a system of Deputies to the Chief Engineer at every level was the answer but there was one level at which we did not have this link and that was at the War Office. The result was lack of co-ordination and liaison at the fountain head, leading to the reiteration of the faults outlined above in every theatre.

There should be in any future war a Deputy Engineer-in-Chief (Air) at the War Office, as was the case in India. It is furthermore no use leaving this task to be filled by a junior Staff Officer as not only do the R.A.F. consider the provision of airfields so important, that it warrants a senior Engineer Officer, but also a junior officer cannot carry the necessary weight, bearing in mind that this officer has to represent the E.-in-C's. views not only to the Air Staff, but also to the Director General of the A.M.W.D.

In addition to the above there must similarly be D.E.-in-Cs. (Air) and/or D.C.Es. (Air) at all appropriate command levels in the various theatres. These deputies including the D.E.-in-C. (Air) at the W.O., must live and work at their corresponding Air H.Q. level, with a portion of their staff at the Army H.Q. acting as their link with the respective Chief Engineers.

Airfields for the new types of aircraft now contemplated are becoming a more and more complex subject. It is probable that even more airfields than were necessary in the last war may be required next time. It will, therefore, be more than ever essential to earmark a proportion of the Engineer force available as primarily airfield construction units. This is not to say that they cannot and must not be used for other engineer tasks, but the Air Force believe that they are entitled to some special consideration in this matter, and experience has proved that airfield construction units do in fact produce better airfields in quicker time than units not so accustomed to the work. All engineer units must be capable of tackling any task, but as there are certain units more trained for certain aspects of engineering so must we have units primarily trained and kept for airfield construction.

At present it is an accepted fact that there are two sources responsible for the construction and maintenance of airfields :—

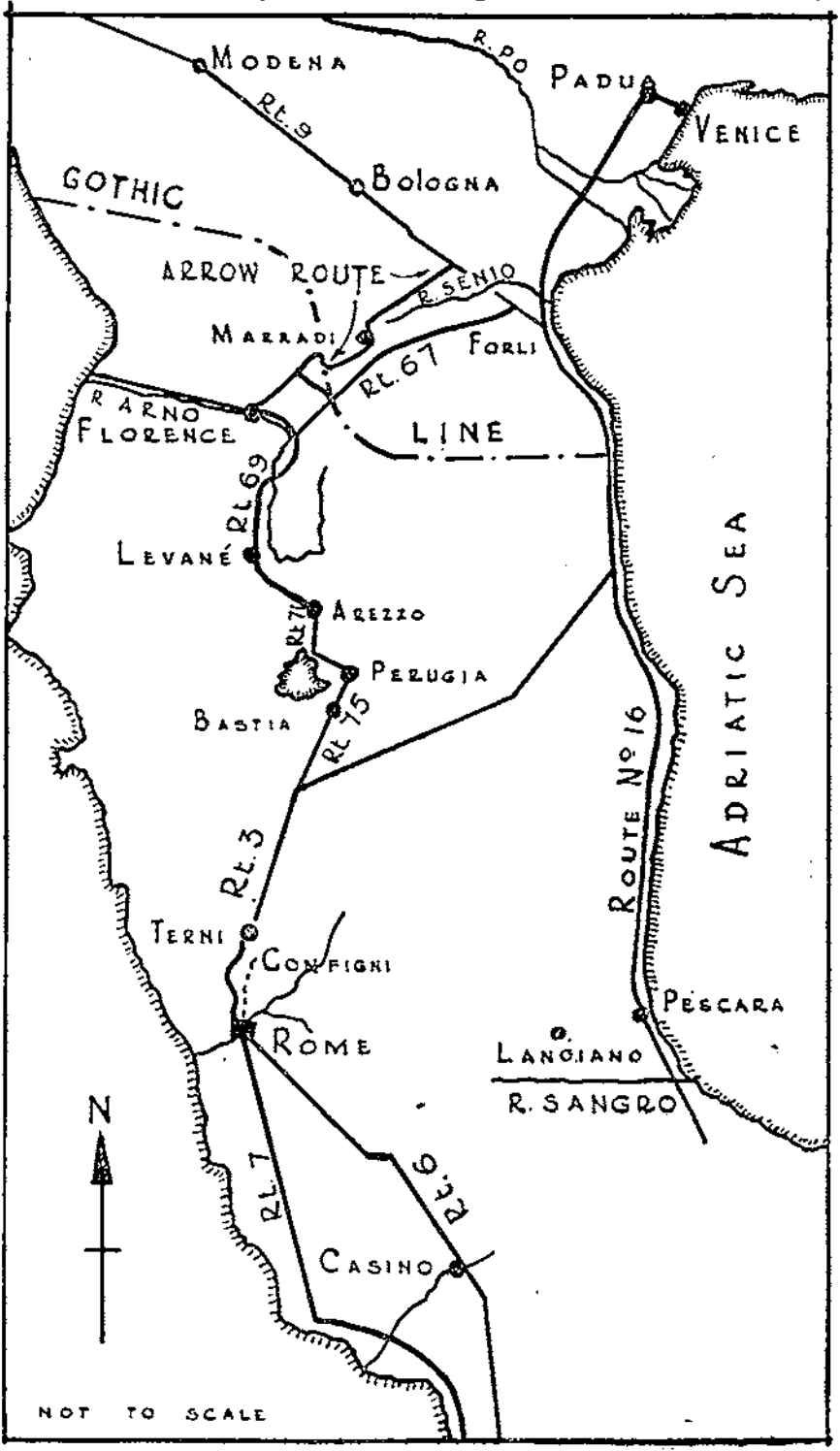
(*a*) The Army will be responsible for the construction and maintenance of all airfields and R.A.F. installations and works services for the Tactical Air Force, up to and including Light Bombers in the zone in which the Army is actively operating. The construction, conversion and maintenance of airfields for Transport Aircraft within this zone may be an Army responsibility.

(*b*) The R.A.F. will normally be responsible for the construction and maintenance of airfields, installations and works services for Heavy Bomber Aircraft; also for Transport Aircraft in zones other than referred to in sub-paragraph (*a*) above.

It is obvious that the above directive gives no cut and dried demarcation between the two services and, therefore, there is bound to be overlapping and consequent adjustments. If we wish to avoid friction in the future there must be clear a realization by both Services that in the theatre of operations there is one Engineer, and one only, who is ultimately responsible to the Commander, and that no Commander can have two separate Engineer Advisors.

As the R.A.F. Engineer Force, which is now an accepted fact, will be drawn from the same over-all national resources of manpower and equipment as the Army Engineer Force, it will be essential to ensure that both forces are balanced and not wasteful of either manpower or equipment, and this points once again to the necessity of the closest liaison between E.-in-C. War Office and the Director-General A.M.W.D., both in peace and war. It is therefore essential that during peace effective liaison is maintained at W.O. level, preferably by having a Staff Officer R.E. whose task it is to ensure that this is so, especially with the A.M.W.D. who are the sponsors of the R.A.F. engineer forces. Interchange of officers should be encouraged and every opportunity taken by any R.E. unit to bring the R.A.F. into their training schemes and to meet them socially.

SKETCH MAP OF CENTRAL ITALY



ROAD MAINTENANCE IN ITALY

By CAPTAIN D. C. BROWNING, R.E.

I WAS a platoon commander in an Indian field company during 1944 and early 1945. Initially this was an independent company, but latterly it was absorbed into No. 16 A.G.R.E. As we were not tied to a division, once a project was started we could usually complete the job before having to change location. The majority of work was concerned with the construction or maintenance of roads and bridges. And, as the varying types of ground from Rome to Venice, including plains, marshes and mountains, were covered in all kinds of weather, from snow and torrential rain to dusty drought, many points of general interest were noted.

TAR MACADAM ROADS

A tar macadam road was the first job encountered. This was just south of Rome on Route 6 where the traffic was running continuously both ways, nose to tail. As traffic could not be delayed it was impossible to rope off half the road and cut the potholes square. After experimenting with various methods it was eventually found best to cut an empty tar drum in half, place it on bricks and fill it a quarter full of tar. The half-drum was then heated by burning tar-soaked wood beneath it. As soon as the tar was sufficiently hot, small chippings were added and stirred up. The tar-coated chippings were then dug out of the drum and thrown into the potholes where they were rolled in by the traffic. The drum was then moved to the next bad patch and the same process repeated. On small groups of potholes a similar method was employed, using a bent piece of corrugated iron. These methods did not produce a perfect surface, but they prevented the potholes from enlarging.

WATERBOUND ROADS

Waterbound roads were more difficult to maintain. The first task was to get all water off the road as quickly as possible. On the plains this was done by clearing out all the channels in the verges with a minimum width of 18 in. Initially it was often found that there were deep ruts in the road surface, and so it was essential that the channels were cut so that they collected all the water out of these ruts. This was done by cutting small channels in the road surface, these were filled in later at the same time as the ruts were repaired. While these were being cut another party would be repairing potholes in the normal manner. They first dealt with all the bad patches, working systematically from one end of the sector to the other. In the mountains the problem of water on the road was far more acute owing to the gradients of the road. If

water was once permitted to run along the surface it would cut a groove several inches deep within a few hours. To counteract this, catchwater drains were put on the uphill side of the road and the channels improved. If the camber of the road was bad it was sometimes necessary to cut a groove out of the road surface in order to divert the water into the ditches. Another method, if sufficient chippings were available, was to make small humps extending the width of the road. This was the preferable method as it avoided damaging the road surface.

Ice Bound Roads

Ice bound roads brought their own troubles. As it was difficult for lorries to pass on icy roads, a "convoy system" was instituted. Normally the road was opened for four hours to north-bound traffic plus two hours to clear the route, then four hours to south-bound and another two hours to clear. This system enabled drivers to drive on the crown of the road, but in doing so the wheels of their trucks made two ruts with a solid ridge of ice between them. This ridge acted as a railway line which steered the truck. This meant that if a truck happened to be coming in the opposite direction (ambulances and maintenance engineers having permission to go against the convoys) the two trucks could not pass. It was necessary for them to stop about twenty yards apart so that a 2-ft. wide gap could be picked out of the ice ridge in front of each truck, thus enabling them to run their offside wheels on to the inner rut and so pass (usually ripping their canopies at the same time). If possible, drivers should be trained before winter that when driving on snow covered roads they should not follow in the tracks of the previous vehicle. If this practice is observed the ice-ridge is not formed and maintenance is made considerably easier. If, however, the ridge had already been formed the first essential was to remove it, leaving a flat ice surface. Potholes in this surface were usually repaired by ramming snow into them, this soon turned to ice, slightly below the level of the rest of the surface. A second layer of snow was then added to make a smooth surface. As most army trucks had four-wheel drive, and all trucks had chains, there was no trouble in driving on this surface at speeds up to 20 m.p.h. The road had too many sharp bends to go any faster, and so this surface was considered satisfactory. On Christmas day, 1944, an Indian division was moving over the "Arrow Route" pass. The hill at Road Post "B" was particularly steep and icy. Trucks were got to the top fairly easily, but the carriers could not make the grade. As soon as the drivers felt their tracks slipping they accelerated, this caused the carriers to side-slip. Eventually officers and N.C.Os. drove them to the top. When their tracks started to

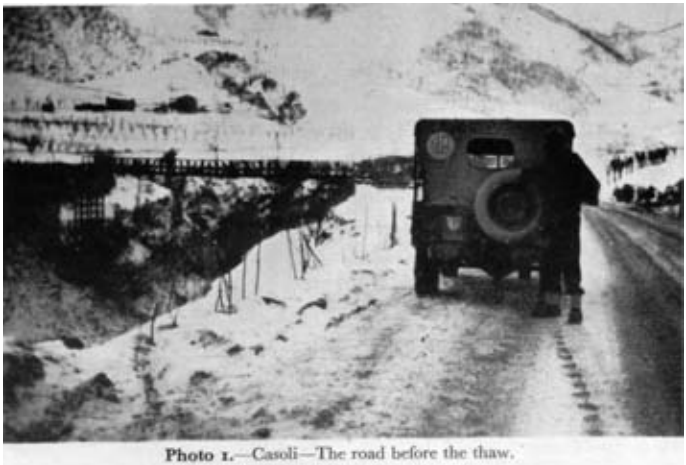


Photo 1.—Casoli—The road before the thaw.
Saul Bridge in background, length 260 ft.

Photo 2.—Casoli—The road after the thaw. Left half of road repaired by tipping rubble on to Sommerfeld track. Right half completely relaid later.

Road Matienance In Italy 1,2

Photo 3.—Montivarchi—Brick bridge built to replace a drum culvert. Temporary Irish bridge in foreground.

Photo 4.—Levané—Semi-permanent Bailey being launched. Brick casing for piers half completed.

Road Matienance In Italy 3,4

slip they decelerated and the Sappers threw chippings under the tracks which enabled them to get a better grip on the ice.

Once the thaw started the last snow and ice remaining on top of the road had to be removed, by pick and shovel if necessary, otherwise the water which formed soaked into the road foundations and left a quagmire. This happened very suddenly ; one evening there was a perfectly good road surface of ice, the following morning lorries were winching themselves through a sea of mud. When this happened all vehicles were kept to one side of the road while the other half was completely rebuilt from the foundations (see Photos 1 and 2).

Bulldozers

Bulldozers were used extensively to clear snow off the road. Size II (D.7) were used to remove the big rocks and snow drifts, which had slipped from higher up the mountain side. Size IV (D.4) and small snow-ploughs removed the remainder, leaving about 6 in. clear of the road surface. This 6-in. layer was left in order to prevent plant from damaging the road, and also to act as a wearing surface. Auto-Patrols were not much use for normal snow clearance as their blades were too long and only swept a small piece in the centre of the road (unless there was no camber). Their rubber tyres did not have much grip on ice and consequently they were used for the light jobs, such as removing small drifts that had piled up against retaining walls and in the gutters. The blade was angled to about 60 deg., so that the drift was pushed to the centre of the road for removal by bulldozers.

When plant was being used in snow conditions it was essential to take care to avoid cutting field telephone wires lying alongside the road. These were hard to see as the wires were usually under snow. If any wire was cut a jeep was immediately sent to collect a Signalman, in order that communications should be delayed as little as possible. Precautions also had to be taken when blasting in quarries, or when using " Beehives " to widen ditches in rocky sectors, and Signals personnel were warned in advance if wires were near essential blasting.

Replacing Culverts

While waiting for the advance on the Gothic Line the company was maintaining Route 75 near Arezzo. This was a good tar macadam road, but it contained numerous Bailey bridges over blown culverts. As it was realized that all Bailey equipment would be required during the attack, the company was detailed to replace all Baileys by permanent brick bridges (see Photo 3). These bridges were usually built by civilian contractors under the super-

vision of the platoon Sappers. In most cases the design of these bridges was supplied by the Italian Highways Dept. The smaller gaps did not have bridges over them, but consisted of a "40 gal. drum tube" which was covered by earth bulldozed up to the original road level. These had to be replaced as the surface was continually rutting and there was usually danger of flood water washing out the drums. Whenever possible the unit initially constructing culverts should try to find out the maximum flow of water likely during the winter months and to insert sufficient drums to cope with it. Short Bailey bridges were built over these drum culverts, so that a brick bridge (or culvert) could be built underneath without interrupting the traffic. The Baileys were built with raised endposts and long ramps in order to leave room for the bridge construction. The earth and drums were bulldozed out and the brick bridge built. When it was ready for surfacing the Bailey was slipped to one side, so that half of the new road could be surfaced. The Bailey was then slipped to the opposite side so that the surface could be completed, after which the Bailey was removed. In one instance where there were several craters close together a Bailey was towed, on rollers behind a Scammel, from one crater to the next. Actually this method did not save time as traffic was blocked during the whole of the interval during which the bridge was being towed.

On the minor roads there was not sufficient traffic to warrant the use of Bailey bridges over the smaller craters. In these cases Sappers with bulldozers eased the gradients by pushing the edges into the bottom of the craters. Then a rough surface of chippings, or on the worst spots Sommerfeld track, was laid down. All these dips had to be signposted well in advance, the signs being about 2 ft. by 3 ft. in size. The worst of these craters at Configni was preceded by the sign "*Caution 10 ft. Drop*", nor was this much of an exaggeration.

General Maintenance

The most important part of the road surface maintenance is to keep water off the road, mainly by repairing ditches and channels, but all the work done can be spoilt in ten minutes by a troop of guns leaving the road to enter a field. Either they would enter by a gate, in which case the weight of the guns would crush the drains, or else they just crashed through the hedge and filled in the ditch at the same time. Usually in the latter case the offending troops were made to repair the ditch, but they had not got sufficient skill to repair the drain. While the Sappers were excavating it to a cross section of about 2 ft. wide by about 2 ft. 6 in. deep, the Platoon blacksmith would be riveting a sheet of corrugated iron into a

tube about 1 ft. 6 in. in diameter. This was put into the bottom of the excavation, riveted side uppermost. Chippings were then rammed in hard all around it and for a foot on top. The surface was then completed by a layer of track. Before commencing to dig it was best to liaise with the O.C. of the troops occupying the field; this ensured that ration lorries etc. did not want to leave just as the hole had been made across his gateway.

There were several instances of rocks falling on to the road. Small rocks were broken into chippings, where they fell, by Italian labourers. The larger ones were broken up by explosives. In one instance a particularly large rock was demolished using six Hawkins mines, no other explosives being readily available. The chippings made from these rocks were used to repair the potholes that had been formed when the rocks fell.

One of the main worries was the supply of materials. This was especially bad on the plain, south of Florence. Tippers and 5-ton flat trucks had to go about 15 miles for bricks and cement, nor was the supply of sand much better. Surfacing materials for water-bound roads were also in short supply; bricks and rubble from bombed buildings were fairly plentiful, but they decomposed under the weight of army traffic, turning into dust or slush. In one case pebbles from the river were used. The supply was good and a dragline filled the tippers, but the stones were too smooth and jumped out of the potholes as fast as they were inserted. To overcome this a road construction company's crusher was set up, but this was not really satisfactory as the turn-round time of the tippers was considerably lengthened.

Once the hilly area was reached stone was plentiful. A large quarry of good stone was operated by the Field Park Company and each platoon also made smaller ones by blasting out the cliff face at the side of the road. Each platoon usually had four quarries with about a mile between each. This system eliminated long carries by the tippers. In time these quarries became quite big and were using plant obtained from the Corps Field Park. In an emergency rock was broken off the cliff near the job, this was not recommended, however, as the quality of the rock was usually bad.

Preparation for Winter

With the approach of winter 1944, the formation was faced with the job of preparing for snow. We were on "Arrow Route" north of Borgo San Lorenzo. The platoons were divided amongst the snow posts. Since most of the road had been constructed on the mountain side, with a sheer drop over one verge, it was obvious that in winter snow would slip down from the slope above and so block the road. Also the drivers of the bulldozers clearing the snow

would not be able to see the side and would be in danger of driving over the edge. To prevent this, 15-ft. poles were erected at the outer edge of the road at all corners. They were sunk about 3 ft. in the ground into a weak mix of concrete (this proved insufficient as several poles collapsed under the weight of the snow). They were painted with red and white bands, as it was found that black and white tended to merge with the background (the black being mistaken for rocks). Dumps of chippings were made at corners and steep parts of the road, and a 6-ft. pole was erected at each with a numbered board attached. This enabled the dump to be located under snow. A rough register, showing the quantity and type of stone available at each dump, was kept at Platoon H.Q. Signposts were erected at all dangerous corners and diversions, also at the forming-up and marshalling points for convoys. Where a railway bridge crossed the road, the Germans had usually demolished it so that one end rested on the abutment and the other on the opposite verge of the road, thus seriously restricting the head room for vehicles. It was necessary to paint the bottom chord of all these bridges white and show clearance heights on the web of the girder.

The ramps of Bailey bridges were made as flat as possible, either by lowering the bridge to make it flush with the road, or where this was not possible the length of the ramp was increased. Skin decking was renewed using small spikes instead of nails as the continual frost followed by thaw tended to loosen the planks. The local civilians were organized into gangs under Capo Squadras and were allotted definite sectors of the road to maintain and keep clear of snow. Tools, wheelbarrows etc. were dispersed along the road in the various labourers' houses, so that they were immediately available in case of road blockage.

Diversions

Diversions were built where it was impossible to repair the road or bridges. On the level this was a fairly simple matter once mines had been removed. In the mountains, however, it was more difficult, on one side of the road was a sheer drop and on the other the hill-side rose steeply. This often necessitated blasting a new road out of the hill-side. If a railway line ran alongside the road it was sometimes possible to tear up the track and to use the ballast as a diversionary road ; as a very temporary measure rubble could be tipped between the rails, but this slowed traffic too much to be of any use behind divisional area. In one diversion, at Marradi, the road was taken through a railway tunnel which the Field Park Company lit with its electric lighting set. A further diversion was built where a railway and road bridge had been too badly damaged to repair or replace within a reasonable time. Initially a ramped

down slope was bulldozed at a gradient of about 1 in 10, which after each shower of rain proved too slippery for the average truck. This resulted in a bad bottle-neck as they had to be winched up one at a time by the R.E.M.E. Scammel. To improve this surface, stones were removed from the near-by railway embankment and laid, flat side down, on the outer half of the diversion. Chippings were placed on the rough upper side to provide a level surface. As the stones were laid higher up the slope their weight locked the lower ones firmly in position. When the outer half of the road was safe for traffic, with a guard rail and riband of 6-in. diameter spars fixed, a drain was cut into the rock on the inner edge of the slope. A number of rumble drains were also laid diagonally across the roadway running into the main inner side drain. The surface was cambered so that all water ran into this drain, as it had been found on earlier diversions, that if water was allowed to run over the outer edge the fill would be eroded away, and in the worst cases, undercut. The inner half of the roadway was now laid ; the finished diversion taking two-way traffic without difficulty.

Bailey Bridges

No special points arose when erecting Bailey bridges during the summer months except it was brought home to us very forcibly that, although a gap may only contain a small stream in summer it may be a raging torrent in winter. Local inhabitants can often give details of the maximum winter water levels, which can normally be confirmed by scour marks. Two bridges, at Levané, were washed away overnight on 6th September, 1944. A high level (semi-permanent) Bailey was built to replace them (see Photo 4). The piers were of the vertical Bailey panel type, but they were surrounded by a brick shuttering into which was poured a weak concrete. The river later came up and lifted the decking, but these specially constructed piers held.

Under snow, Bailey maintenance was considerably more difficult than usual. In the mountain sectors there was seldom much room between the edge of the gap and the mountain side, as the road and river between them usually took up the whole width of the valley, crossing each other every mile or so. This caused bridge bank-seats to be set nearer the edge than is normally taught. To make matters worse the continually alternating frost and thaw wore the edge away and so daily checks had to be made that each bridge was still safe. The north bank seat of " Goliath " bridge (Class 12) sagged dangerously after one thaw. The maximum straight approach on this side was about 23 ft. and so it was impossible to add a further bay of normal construction to the bridge. After jacking up the north end of the bridge one panel was added to each

girder and grillage inserted under their bottom chords. The bridge was then jacked down so that all the weight was taken by these grillages, thus moving the effective centre of the bank-seat 5 ft. back. The top chord, end vertical and upper half of the centre vertical were then cut off with plastic explosive, thus leaving room for lorries to start their turn while still on the original ramp (see Plate 1).

It was necessary to sweep all snow off Bailey decking, after each fall, before any vehicles were allowed to cross, otherwise the bridge would turn into an ice rink and lorries would jam diagonally across the roadway with their bumpers between two panels. Normal maintenance of nuts and decking was carried out, but if special checks were not made pier bracing nut maintenance was apt to be "forgotten" during the cold spells.

Occasionally the unit was told to dismantle the Bailey bridges that were no longer in use and to transport them to forward bridge dumps, the round trip usually taking about three days. On one of these trips I was in charge of fourteen trucks taking equipment from Terni to Arezzo area. On arrival at the forward end of the run there was trouble finding the dump. The dump where we had unloaded the trip before was full and we were told to go to a new dump about 6 miles away. On reaching it the O.C. said that they were to be a spare part depot and not a Bailey dump. After several other false instructions the dump was eventually found to be still unformed, as we were to be their first load. They had not thought of putting up a signboard indicating the site. When lorries from a different area are known to be bringing up supplies etc. dumps should be signposted immediately the site is selected, if necessary stating on the notice "OPENING ON :——." A further difficulty experienced was obtaining petrol. The forward petrol point at Bastia only supplied full Jerricans on receipt of empty ones; nor did they allow convoys to fill up their tanks. As the convoy required 460 gal. each refuelling, there were not enough empty cans available to fill up all the trucks in one go. The method that we normally employed was to park the convoy in a near-by field where the midday or evening meal was prepared. Meanwhile the stores truck driver collected all the empty cans which he exchanged for full ones at the petrol point, these were poured into the trucks' tanks. This process had to be repeated three times in order to fill the tanks and have all reserve cans full.

Mines

We found very little unusual in the way of enemy mine laying. One "S" mine was found buried in a pile of road metalling left behind by the Germans. A dead mule blocking up a ditch and drain

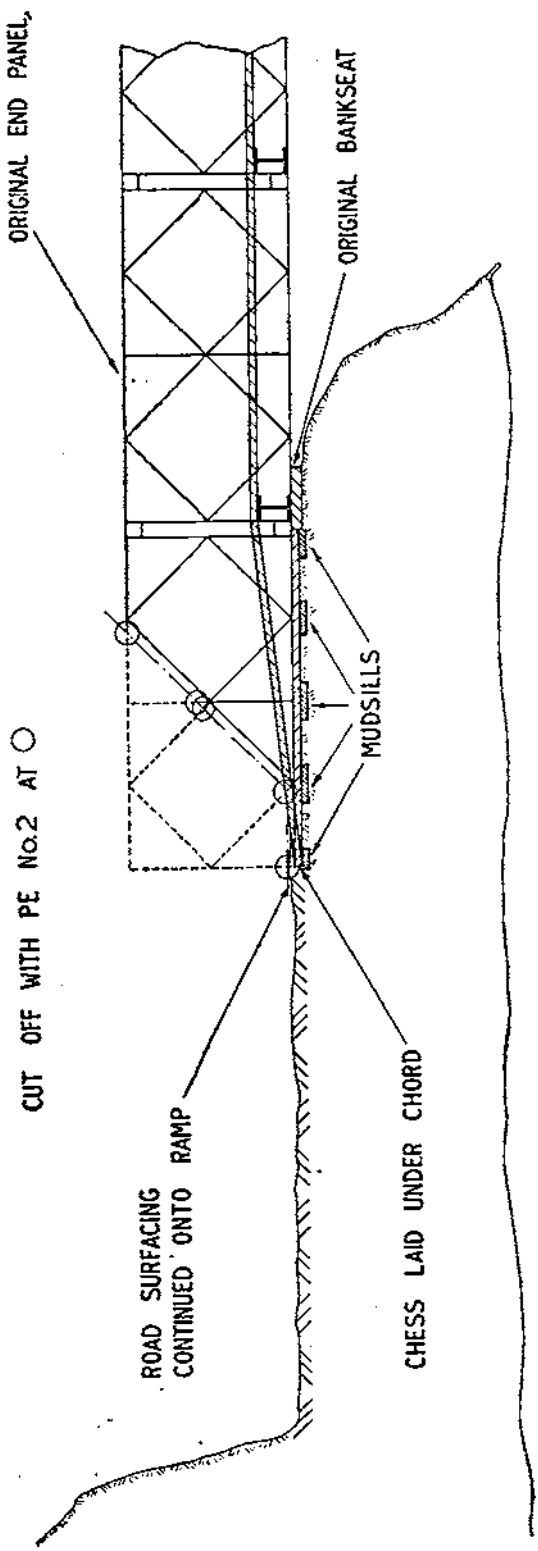

ORIGINAL END PANEL,
ORIGINAL BANKSEAT
CUT OFF WITH PE No.2 AT ○
MUDSILLS
ROAD SURFACING CONTINUED ONTO RAMP
CHESS LAID UNDER CHORD

PLATE 1

was also found to be booby trapped. "Schu" mines which had been covered by snow for several months had become very dangerous owing to the ZZ 42 Igniter pins having nearly rusted through. Several mines exploded through this each day.

Labour

The labour available was of two kinds, civilian and military. The civilians were given the routine jobs to do, and a definite length of road to maintain. The military were given any special work, such as rebuilding walls or Bailey bridge maintenance. In the mountains one section of the platoon was continually employed as a "Flying Squad." They started at one end of the sector each morning and checked the road through to the other end. They carried with them picks, shovels and wheelbarrows containing explosives. Their job was to remove any small rocks, etc., that had fallen on to the road, and to clear the channels in order to prevent water from running down the centre of the road. They were not allowed to spend more than fifteen minutes on any job ; if they saw that it would take longer than this they informed the civilian gang, in whose sector it was, and then reported to Platoon H.Q., from where, if necessary, a special squad could be dispatched. If water were allowed to run on the surface (through a ditch having become blocked or some other cause) there would be a deep rut within eight hours, and so it was essential that the whole road was inspected once, and if possible twice, a day. At Platoon H.Q. there was always a winch lorry standing by, containing picks, shovels, sledge-hammers, wheelbarrows, explosives and a stretcher, ready to go out to any emergency without any delay.

Civilian labour was divided into three kinds : (*a*) Cantoneeri, (*b*) Contractors and (*c*) Locally recruited labour. The first were the peace-time road workers and were good at repairing brick bridges, and maintaining culverts etc. They could not realize, however, that roads carrying army loads required more maintenance than they received in peace-time. They would sprinkle the road with the small stones that had been thrown to the edge by the traffic, instead of using the chippings provided.

Contractors were employed when a brick bridge was to be constructed in order to replace a temporary Bailey. They gave an estimate of the cost, and if this was approved by the finance branch they were told to go ahead and were given a completion date. They were usually supplied with materials from army sources, but they found and paid their own labourers.

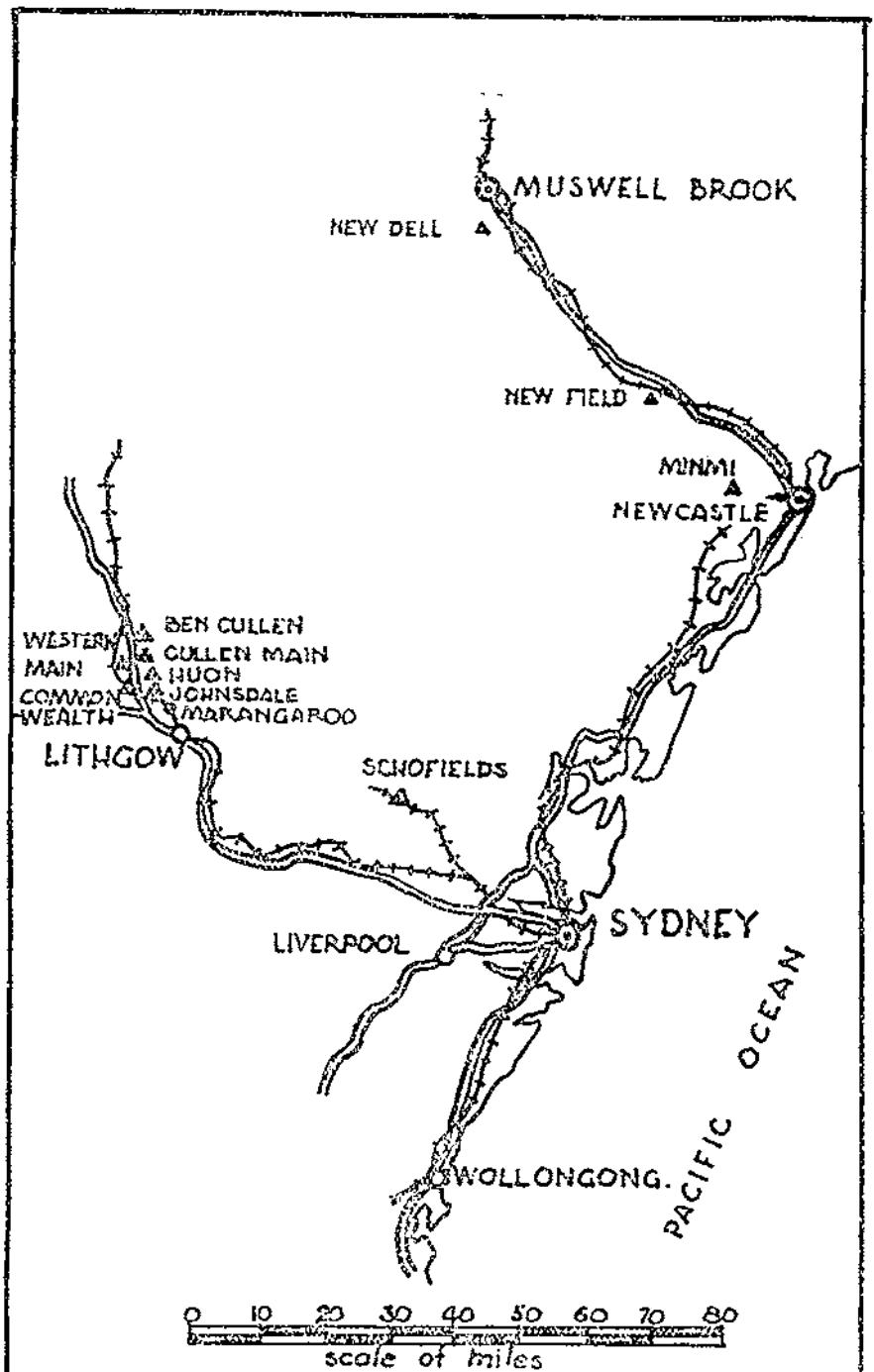
Locally recruited labour was employed directly by the company. Time-keeping rolls, pay sheets etc., all had to be maintained by the Platoon Commander. The Platoon Clerk was at Company H.Q.,

and as often as not unobtainable owing to snow, and so the Platoon Officer had to enter up 600 time sheets each evening when he returned to his billet, usually by a hurricane lamp. These civilians were all paid at different rates according to their trades, and they also got overtime for more than eight hours and for Sunday work ; it was an endless job. They were also issued with one loaf of bread for every six men each day. These had to be ordered two days ahead and came up with the rations. The day on which the bread was ordered was possibly fine, whereas the day on which it was delivered might be wet, with only half the workers turning out, thus making all calculations for the loaves ordered incorrect. One platoon even went so far as to supply them with hot soup in the really cold weather, but this was not very satisfactory as it was usually cold by the time it reached the individual sites.

Communications

Communications in the mountain sectors during winter were difficult. It was impossible for D.Rs. to ride on the ice and so all written messages had to go by jeep or truck. Nor was wireless communication very reliable as the waves were reflected off the mountains and became blurred. Whenever the platoon changed location it was necessary to experiment with various types of aerial, until the best one for that location was found. No fixed rules as to the direction or type of aerial could be determined. In one location it was impossible to hear a platoon 2 miles away, and it was necessary to use a platoon 25 miles away as a relay station (this state persisted the whole time that we were in that location). There was also some difficulty when the net had both Indian and British operators on duty at the same time. Although their procedure was identical the different intonations caused the words " Say again, over " to be repeated too often for efficient operational working. Eventually the C.R.E. to Companies' net was manned by all British operators and the Company to Platoons' net was manned by all Indian operators.

Generally it was found that the essential principle in all road maintenance problems, especially with waterbound or earth surfaces was the disposal of water (*a*) off the road into the ditches and (*b*) out of the ditches, well clear of the road, into a stream or down the hillside where it could not run back and undercut the road foundations.



MAP A : SHEWING MAIN COAL FIELDS IN NEW SOUTH WALES

THE EMPLOYMENT OF THE ROYAL AUSTRALIAN ENGINEERS IN "OPERATION EXCAVATE"

By LIEUT.-COLONEL M. F. BROGAN, O.B.E., ROYAL AUSTRALIAN ENGINEERS

INTRODUCTION

POLITICAL and industrial history was made in Australia on 2nd August, 1949, when the Australian Regular Army was called upon to meet a nation-wide emergency brought about by a coal strike, which after six weeks had almost brought secondary industries and transportation services to a standstill and had put hundreds of thousands of workers out of employment. Negotiations between arbitration tribunals and trade unions had reached an impasse (several leaders of workers movements had been fined heavily for contempt of court) and the unprecedented calling up of the Regular Army for industrial service seemed the only possible measure in the circumstances which had developed.

COAL SOURCES

Coal is mined in all states of Australia, but the main sources of supply are in seams in New South Wales roughly between Newcastle and Muswellbrook in the north and Wollongong in the south and extending westward to Lithgow (*vide* Map A), i.e., covering a total area of 1,600 square miles. The bulk of Australia's annual production of 15 million tons of black coal is won in this area, which is the more important also because of the varieties of coal included in the output, viz., gas coal, boiler coal and coking coal. It was in this area that the operations described herein took place.

The principal method of mining coal in Australia, as elsewhere, is still underground, but during the war, extensive development in open cut mining had taken place, and with the simultaneous advances of earth-moving equipment it would appear that even more rapid and spectacular progress in this field can be expected in the future (dollars for equipment permitting).

From the R.A.E. point of view, open cut working seemed more "on" than underground mining, particularly with regard to the greater security measures and higher degree of skill necessary in the latter method. Consequently the principle of being diverted from normal training into open cut mines caused no rush for panic stations when first announced, although it was realized at the outset that logistical limitations would probably preclude the building of that essential stockpile of coal which, as far as fuel was concerned, was going to mean freedom from want for the community.

R.A.E. Resources and Plans

The G.O.C. Eastern Command, in whose area were situated the main coal measures and the larger concentrations of the Regular Army, was appointed G.O.C "Operation Excavate" and established his H.Q. at Sydney on 12th July, 1949. He appointed the author, from C.O., S.M.E. (Liverpool), to be C.R.E. Mines, with instructions that the only R.A.E. personnel available for the task were the students and staff of S.M.E., 1 Field Squadron R.A.E. (S.M.E.) and 7 Field Squadron R.A.E., which was then committed to important work in Central Australia in connexion with the Long Range Weapons Project but which, it was anticipated, would be flown to Sydney by R.A.A.F. if required.

At this stage it was envisaged that only one open cut mine (Muswellbrook) would be worked by the Army. Accordingly an establishment was prepared and planning proceeded on this data and it was decided it was just possible to do this task on a multiple shift (24-hours) working, utilizing all R.A.E. personnel (250) and equipment available.

However, on 15th July, 1949, the Joint Coal Board advised that the production of the minimum quantities of coal required for the maintenance of immediate essential services (43,000 tons per week) necessitated the continuous operation of ten open cuts, viz., Muswellbrook, New Dell, Newfield and Minmi on the northern fields and Ben Bullen, Cullen Mains, Western Main, Huon, Commonwealth and Johnsdale on the western fields. In addition, it was forecast by the J.C.B., that for maintenance of ultimate essential services the Army had to produce 71,700 tons per week after, say, four weeks operations. The personnel required for this commitment were 1,050 "at the face" including excavator operators, tractor drivers, shot firers, drillers, gantrymen, labourers and truck drivers. This total represented about four times the R.A.E. personnel available locally (and in Central Australia) and therefore something drastic in the way of reorganization and training had to be done quickly in order to start work at midnight 1st August which was the "H" hour fixed by the Commonwealth Government as the last chance for the miners to resume.

The only apparently redeeming feature of this otherwise melancholy intelligence from the Joint Coal Board was that Army equipment would not be required as there was plenty of workable plant *in situ* and Army excavators were too small anyhow. However, during the first hour of operations the R.A.E. completely disproved both of these notions.

The position was examined on the night of 15th/16th July, when it was found that the main personnel deficiencies were in the trade groups of operators tractor, operators excavator and shot firers. In addition a large number of M.T. drivers would require conversion

to diesel tippers of 7- to 20-ton payloads, which are the normal load carriers used in open cut mining and which were to be impressed for this operation.

It was submitted to the G.O.C. on 16th July that to attain the output required it would be necessary to :—

(*a*) Use the complete R.A.E. resources of operators engineer plant in Australia.

(*b*) Utilize the services of 2 Airfield Construction Squadron, R.A.A.F., which at that stage was in Central Australia.

(*c*) Convert 180 drivers of all arms to diesel vehicles before 2nd August.

(*d*) Train :—

(i) 107 tractor operators
(ii) 67 excavator operators } before 2nd August
(iii) 85 shot firers

The above plan was accepted and whilst (*a*) and (*b*) were being negotiated on the higher plane, the R.A.E. training portion was implemented from 17th July.

Training for "Operation Excavate"

Normally the S.M.E. is the only centre in Australia for the training of tractor (dozer) and excavator operators, and as it had been taking twelve weeks to train six students at a time in these trades, the task of producing the numbers required in a fortnight seemed rather formidable.

However, a plan for training was evolved whereby the output could be stepped up by a little decentralizing. This scheme aimed at training initially :—

(*a*) 24 tractor operators per week at S.M.E.

(*b*) 24 excavator operators per week at S.M.E.

(*c*) 24 tractor operators per week by C.E. Southern Command (Victoria)

(*d*) 12 tractor operators per week by O.C. 7 Field Squadron, (Central Australia)

(*e*) 25 shot firers per week at S.M.E.

The training programme was accelerated by S.M.E. increasing its intakes after 20th July to such an extent that the complete training liability had been discharged by 1st August. This entailed night training of operators which was effected under electric light and movement lights. (The latter searchlights proved invaluable later on during the operation and the J.C.B. are now buying up obsolete army searchlights for use during night shifts in open cuts).

The operators produced by the above methods lacked a high degree of skill and maintenance knowledge, which was not unexpected. Some of the earlier breakdowns of equipment on the coalfields were undoubtedly caused by insufficient training but it is generally conceded that the over-all results justified the means.

Shot firers were trained in the S.M.E. quarry, and quickly became skilled in the operation of compressor equipment and the handling of explosives. The different nature of the equipment (e.g., electric and horizontal drills) and the commercial types of explosives used in the open cuts presented no difficulties.

All the required technical personnel were ready by " D " day, but it was considered that normal wastage must be offset by some training scheme and accordingly the S.M.E. Mobile Wing, organized to train twelve tractor operators, six excavator operators and six shot firers per week, moved to New Dell with the main body. Students were fed into this unit from all sources and it was found possible to combine training with the useful work of removing overburden for two of the three shifts worked per day.

Whilst not claiming that the R.A.E. training carried out for this operation was in complete agreement with the tenets of *Good Instruction Part I* or that it was adequate, it is significant that :—

(*a*) no accident occurred to personnel during operations, and
(*b*) the output of coal was a record, and each soldier miner produced more per shift than the " professional " miner had ever done.

R.A.E. Organization for Operation

It was found in the main that normal organization sufficed for the control of coal winning. Under the C.R.E. Mines there were appointed two D.Cs.R.E. Mines, one for the northern fields and one for the western fields. Each D.C.R.E. controlled a number of mining troops, allocated one per open cut, so that there were four such troops in the north and six in the west.

The mining troops (each commanded by a Captain, R.A.E.) varied in organization from mine to mine and were based on the normal allocation of civilian personnel to them. The following organization for Commonwealth Mining Troop R.A.E., may be cited as typical :—

O.C. (Captain R.A.E.)
3 Shift officers (Captains or Lieutenants, R.A.E.)
14 Excavator operators (for 5 excavators)
14 Excavator oilers
18 Tractor drivers (for 6 tractors)
18 Drillers (for 3 drilling rigs)
4 Shot Firers
4 Shot Firers, Assistants
30 Truck Drivers, Overburden
20 Truck Drivers, Coal
8 Labourers
8 Gantry Crew
8 Fitters

Photo 2.—General view showing the first and second seams at Muswellbrook being worked.

The Employ Of the Royal Austrailan Engineers In Operation Excavate 2

Photo 3.—Close-up of Minmi. No. 1 cut, showing draglines removing overburden and face shovel removing coal.

The Employ Of the Royal Austrailan Engineers In Operation Excavate 3

Photo 4.—Students of S.M.E. Mobile Wing at New Dell returning advanced overburden to worked out cut prior to exposing new cut.

The Employ Of the Royal Austrailan Engineers In Operation Excavate 4

It was found expedient to make 2 A.C.S., R.A.A.F., completely responsible for one mine (Ben Bullen) rather than integrate R.A.A.F. personnel amongst the R.A.E. mining troops.

In addition to the above organization, a Garrison Engineer with about twelve tradesmen was supplied to each of the main base camps at Muswellbrook (north) and Marangaroo (west).

It was originally considered that some active opposition would be offered by the miners to the Army's occupation of the mines and protective troops were included on the Order of Battle with the object of relieving R.A.E. from this responsibility. However, when it became apparent before " D " day that no offensive action was contemplated by the strikers, the rôle of the protective troops was changed to that of administration. It was, therefore, a refreshing experience for sappers in operations to be supported by other arms in the proportion of two administrative " bodies " to one sapper. (It was found however that the clerical and financial reconciliations involved when the Army took over the functions of a Government Department rendered this proportion not excessively high).

The Operation

Prior to " D " day, limited engineer reconnaissances were carried out by respective D.Cs.R.E. in mufti and escorted by mine managers and salaried staff, who had not gone out on strike. Estimates were prepared of requirements of:—

(*a*) Petrol, oil and lubricants.
(*b*) Floodlighting stores (night shifts were hitherto unknown in the industry).
(*c*) Reserves of earth-moving and compressor equipments.
(*d*) Access road repairs.
(*e*) Major repairs to J.C.B. equipment.

These reconnaissance reports were distributed to troop commanders, who were at this period training and organizing their troops at S.M.E., Liverpool. The main conclusions drawn from the reports were that the information about the serviceability of the J.C.B. plant was extremely suspect and that the likelihood of winning quick coal from some of the mines was doubtful, owing to the large quantities of overburden required to be removed before the coal seams were exposed.

However, the R.A.E. were reasonably confident of carrying out their assignment and it was in this spirit that movement was carried out to the coalfields on 31st July, and deployment to open cuts completed by 1st August. 7 Field Squadron, R.A.E., and 2 A.C.S., R.A.A.F. were flown from Central Australia to Schofields near Sydney on 29th July, and 31st July, respectively.

The technique of open cut mining is relatively simple and the sequence is briefly as follows:—

(*a*) Geological survey and analysis of samples.
(*b*) Removal of overburden (soil or strata above coal seam) by excavators loading into Tippers, or by dozers, or dozers and carry-alls, preceded where necessary by blasting or rooting.
(*c*) Drilling and blasting of exposed seam of coal.
(*d*) Removal of shattered coal by excavators loading into tippers.
(*e*) Crushing of coal if necessary.
(*f*) Loading into rail trucks through grizzlies or gantries.

The method of operation depends to a large extent on the equipment available. The accent at present is on larger plant as it is found more economical in the long run. For instance, in New South Wales the removal of overburden, using the available excavators (up to 4½ cu. yd. dippers), had to be augmented by the use of tippers in order to remove the spoil from the site, whereas by using the larger dippers (up to 30 cu. yd.) and utilizing the " boarding-house reach " of their larger arms, spoil could be placed well clear of the coal without recourse to the intermediate operations (tipper loading, moving and unloading). Thus where the limit of economic working may be in the ratio of overburden depth to coal seam as 4 : 1 using small equipment, it may, in certain circumstances using larger equipment be possible to extend this ratio to 30 : 1. The J.C.B. have several of the larger types of shovel on order from U.S.A., with a view to reducing costs of working New South Wales open cuts, but again shortage of dollars for initial outlay may limit the extent to which this can be done.

Similarly with other types of plant. The aim is to use size 1 tractors, tournapulls, tournatrailers, 12-yd. carry-alls and so on. Smaller equipment has limited use in preparation of standings for excavators or trimming of faces for blasting or " biting."

The real finesse in working open cuts is in the proportionate allocation of effort to clearing overburden and winning coal to ensure that the latter process is continuous. It must be admitted that during this operation, we took the coal where we found it often at the expense of encroaching close to the overburden. Desperate measures for desperate times and no doubt we were cursed when the miners resumed.

It will be seen from the above sequence of operations that open cut working is quarrying and not " mining " in the usually understood sense, and the term can be accepted only as a euphemism coined for industrial purposes. This stretching of the imagination is carried to such an extent that a mining deputy is required by local colliery regulations to test and approve the air in open cuts before

operations can proceed! However, none were observed carrying canaries.

The occupation of the open cuts was carried out without incident and operations commenced at 0001 hrs., 2nd August. The honour of getting the first coal loaded into rail trucks went to the R.A.A.F. at Ben Bullen which had one loaded by 0006 hrs.

It was soon apparent that the plant at the mines was going to need nursing as most of it was in a bad state of repair due to :—

(*a*) long service
(*b*) lack of maintenance for five weeks (i.e., since the strike started)
(*c*) exposure to weather and in some cases flooding, and
(*d*) minor acts of sabotage.

It was equally obvious that the maintenance of the equipment provided was beyond the limited resources of the R.A.E.M.E. personnel available. These latter were provided roughly on the basis of six fitters engineer plant attached to each mining troop, plus a workshop of about twenty personnel at each of the northern and western fields. To make the task more difficult, the types of equipment (including steam and electrical driven) together with the makes and the sizes, were novel as far as the army was concerned, and conversion thereto by maintenance personnel would take time—more so than that required for the operators, who after a few minor mishaps were quite at home on the machines.

This serious situation was advised to the G.O.C. on "D" day, who immediately requested the J.C.B. to provide as soon as practicable :—

(*a*) 100 per cent spare excavators and
(*b*) 50 per cent spare tractors.

In addition, he approved the movement forward from S.M.E. (additional to that of the S.M.E. Mobile Wing) of army equipment to the extent of :—

(*a*) 4 Buckeye excavators, $\frac{3}{4}$ cu. yd.
(*b*) 2 Graders Cat. 12
(*c*) 2 Size 1 Dozers
(*d*) 2 Size 2 Dozers
(*e*) 4 Transporters
(*f*) Sundry equipment including compressors, lighting plants and trailer pumps.

This rapid remedial action spelled success, although the J.C.B. found considerable difficulty in complying with the request for about sixty items of plant. With the co-operation of the New South Wales Department of Main Roads (equipment and transporters) and New South Wales Railways (equipment and rail movement) the Board was well on the way to meeting this equipment commitment when operations ceased on 13th August.

Output figures of coal had been based on all equipments being operative simultaneously, but experience proved that the average serviceability over a period was 75 per cent. No allowance had been made for wet weather, but fortunately such an exigency held off for the duration of the operation.

Other difficulties encountered were :—

(*a*) Flooding of some of the Cullen Main open cuts and the unserviceability of the pumping equipment provided. This was overcome by :—
(i) moving forward "Jupiter" type pumps from S.M.E. and
(ii) obtaining assistance from local fire brigades.

(*b*) Difficulty of controlling operators spread over the largest cut at Muswellbrook. A control post was established and "walkie-talkie" sets used by troop commanders and shift foremen.

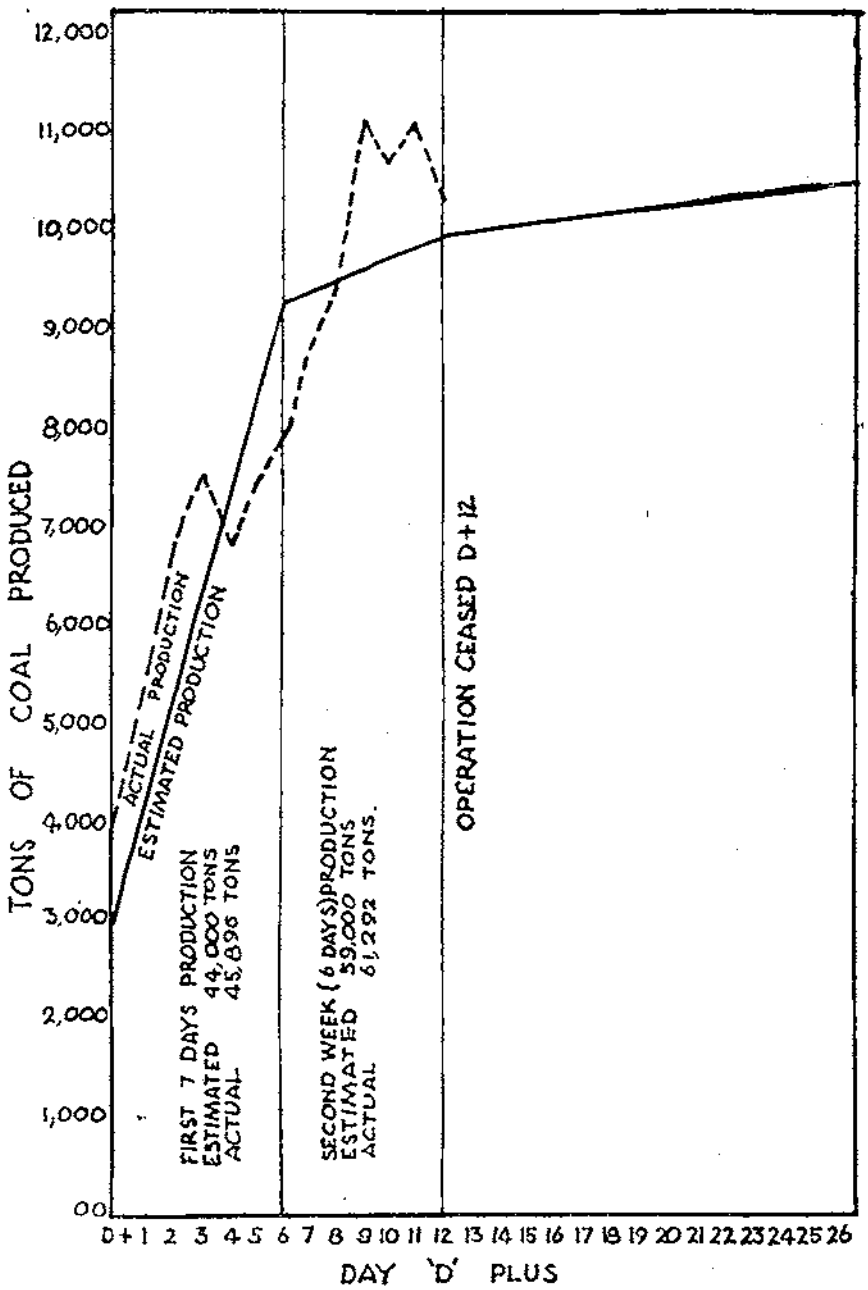
(*c*) Insufficient large tip trucks provided at Ben Bullen. Army 3-ton tippers were converted to larger payloads by extending the walls of their trays with timber to give 5 to 7 ton capacity, which was condoned for the short period involved.

(*d*) Time involved in vertically drilling through up to 30 ft. of sandstone overburden at Minmi. A horizontal drill with a 60 ft. auger was borrowed, the use of which reduced the time required by half.

(*e*) Large amount of overburden required to be moved (estimated time three weeks) at New Field. This open cut was abandoned on "D plus 1" and personnel diverted to New Dell and Minmi.

(*f*) Difficulty of diverting tippers, banking up at broken down excavators, to other sites where output exceeded cartage availability. This was particularly the case on the western fields where it was beaten by establishment of a R.A.E. control post at Marangaroo under a co-ordinator (Major A. F. L. Colson, R.E.) who was in wireless communication with all mining troops and the D.C.R.E. (rover set). This system was also used for transfer of earth-moving and drilling equipment as required. It was, however, not 100 per cent successful owing to technical difficulties on the signals side.

The two larger open cuts, i.e., Muswellbrook (north) and Commonwealth (west), had three and two seams of coal respectively which were worked simultaneously. At Commonwealth, which provided the coal for Bunnerong, the main power-house in Sydney, it was necessary from a steam-raising point of view to mix a "cocktail" of one load of the upper seam to two of the lower. However,



GRAPH SHEWING ACTUAL AND ESTIMATED PRODUCTION PER DAY ALL FIELDS

in the attempt to make output records and because the coal in the upper seam was easier won, human nature prevailed and the mixture was often railed in the reverse ratio. The clogging of the fire bars was accepted philosophically by the County Council on the "gift horse" principle following the period of blackouts which had become normal routine.

Outputs

Interest in the army's efforts on the coalfields was nation-wide, and it is safe to say that 90 per cent of the population wished us well. There were of course many pessimists who overtly sneered at the idea and some political factions which sincerely hoped the army would make a fool of itself in the venture.

The troops were keen to reach the target figures and, if humanly possible, to set new records. Both were achieved. The "scoreboard" kept in the operations room in Sydney was watched more intently than was any during a Test Match for the "Ashes" and the greeting of "What's the score?" assumed an equally national significance. Never before in the industry had 24-hour working proceeded and never had coal been won at the rate the army produced and dispatched it. In one day alone more than 5,000 tons were extracted from Muswellbrook, which exceeded the previous best by about 2,000 tons.

The accompanying graph shows the output of coal against the estimated production. It will be noted that the army were getting more than the minimum requirements of coal and were working up to full-scale production of 71,700 tons per week. This was realized by the strikers who capitulated and took over at midnight at the end of the thirteenth day's operation by the army.

At the conclusion of Operation "Excavate" the Commonwealth Government showed its appreciation of the Army's effort by awarding to all ranks who participated a gratuity of £15 and six days' leave. This plus the sense of satisfaction in a job well done amply repaid the effort and enthusiasm which had been displayed by all concerned in the closest approach to the real thing since 1945.

Some Lessons Learned

The following points have occurred to the writer in a retrospective analysis of the operation, but do not necessarily represent the official views of the Australian A.H.Q., nor of any other formation :—

(*a*) Key personnel such as shift engineers and N.C.Os. require as much rest and sleep as the men on the job, and the practice of working 20-hour periods day after day is commendable only as long as it is safe and conducive to increased progress. This was not the case after the second day's operation and this superman conception had to be suppressed.

(*b*) Intercommunication within R.A.E. units is not up to the standard required. All ranks still require further practice in tuning, netting and speaking R.T. clearly and in accordance with standard procedure.

(*c*) For big projects R.A.E. will require bigger tractors, excavators and tip trucks.
This would probably not be the case forward of Divisional H.Q., but Corps, L. of C. and Base units would appear to have a requirement for the larger sizes. High lift large bucket excavators would be advantageous in the construction of embankments for roads and railways.

(*d*) Whilst open cut mining cannot be considered a normal rôle for R.A.E., quarrying can, and it is suggested some form of mechanical horizontal auger drill (as used at Minmi) capable of drilling 60 ft. by 6 in. diameter, would be advantageous. The vertical drilling equipment used by R.A.E. Boring Platoons was satisfactory for the purposes used.

(*e*) Joint Coal Board experts consider that army explosives will be outmoded by others being developed, such as liquid oxygen. They also considered better blasting effect is obtained by staggered detonations (say at $\frac{1}{25}$ sec. interval) rather than simultaneous initiation of separate charges.

(*f*) For night working of plant, artificial moonlight was not sufficiently illuminating and direct play of the beam was too dazzling to the operators. The effective compromise was the directing of the beam horizontally over the operators supplemented by cabin, boom and headlights.

(*g*) The centralized control of M.T. (be it R.A.E. or R.A.A.S.C.) is an important factor in the success of a haulage project. The same applies to engineer plant in respect to earth moving.

(*h*) A mobile reserve of engineer plant on wheels (transporters) is a desirable asset on scattered working.

(*j*) A pool of "non-paying" engineer plant in quarrying or open cut mining is required to :—
(i) prepare access roads for M.T.
(ii) prepare standings for excavators
(iii) push soil into piles for removal by excavators, tournapulls, front end or bucket loaders.
(iv) assist bogged or labouring vehicles and plant.

Conclusion

Field Engineers in the Australian Regular Army are an innovation since World War II. "Operation Excavate" provided a test from which the R.A.E. emerged with the fullest justification of its *raison d'être* and an indication that its development is on sound lines.

THIS "WORKS" BUSINESS

By LIEUT.-COLONEL M. C. A. HENNIKER, D.S.O., O.B.E., M.C., R.E.

SO many officers with only field experience have asked me what "Works" in England are like that I am constrained to commit my reply to paper.

First I must say that after twenty-two years of service, without one day in "Works," I went to the post of C.R.E. (Works) Catterick District with some misgiving. I had not the slightest doubt that I could do the job, but I had a fear that I might in some way be defiled in the process: rather as a Brahmin might shrink from the post of Inspector of Sewers. I leave the job with regret, having enjoyed every day of it.

This leads to the attitude of mind you should adopt as a "Works" officer. (I propose to cease putting the word "Works" in quotation marks hereafter.) There are various ways in which you may look upon Works. You may look upon Works as engineering experience. If you do this you will probably be disappointed; for few Works jobs in England involve engineering problems of any complexity. You will probably have done bigger engineer projects abroad as part of your normal engineer work with the soldiery.

You should look upon Works in England in the same light as (say) an infantry officer looks upon an administrative staff appointment. An infantry lieut.-colonel in an A/Q appointment deals with all kinds of problems from the allotment of married quarters to the submission of recommendations for Birthday Honours. None of these, you may say, has much bearing on the command of infantry soldiers in the field. Yet if he is a sensible man he will regard his A/Q appointment as both interesting and profitable. A lieut.-colonel in the Corps should look upon a C.R.E. (Works) appointment in the same way. (*Mutatis mutandis* the same applies to a major or a captain.)

As C.R.E. Catterick I had to deal with endless problems which were not connected with either soldiering or engineering. At one end of the scale I had to organize a tour of the W.D. Sewage Works by the Mayor and Corporation of Richmond, who contemplated building one like it. At the other end I had to arrange a Christmas party for the 800 children of my W.D. employed civilians. Like the A/Q, I was supported by a staff capable of doing these things.

The next thing to point out is that in England the Works organization is *intrinsically* very efficient. I stress the word *intrinsically*. For reasons which I shall presently relate there is much that might be done to allow this efficiency to have its full effect upon the well-being of the army and the reputation of the R.E. Works Services. Perhaps I should give an example to explain what I mean. From the time a project of any size is conceived, to the time when work

begins, a delay of a year may well occur. This, of course, is quite shocking, but it is not the fault of the Works organization. On the other hand, when once a project is all "teed up" (of which more later) a C.R.E. Works can bring to bear upon it the immense civilian resources of the country. For instance I had 300 soldiers' married quarters and a hundred officers' married quarters all being built at once. Few regimental lieut.-colonels' organizations or resources could cope with that. Yet my Works organization took it in its stride.

The Works organization is made efficient by three factors. First, many of your staff are civilians who have been in the same posts for a long time. My A.C.R.E. (Administration) had been in the place for twenty-four years. When I said to him, "Who can build some steeplechase fences for the 17/21st Lancers?" he knew at once whom to recommend.

Secondly, your civilian Works staff all *like* their jobs. Being civilians they can leave their jobs if they do not like them. They are therefore all enthusiasts. Even the clerks, if you give them the slightest encouragement, will conjure up snow-storms of paper from a cloudless sky. By contrary, they all know how it can be avoided.

Finally, your office itself, not being mobile, is very efficient. My office had every gadget which the wit of my many predecessors could devise to enable the C.R.E. to work with speed, efficiency and comfort.

All these benefits accrued from one basic fact: continuity. You have continuity in Works in England, and it is a pleasure and a privilege to hold the helm of a ship which has weathered a thousand storms and which responds so quickly to the tiller. Of course it is no use being at the helm of a fine ship if she is in a land-locked sea; and there is no doubt that the Works "ship" is surrounded by shoals on many sides. But in one direction the captain can view the open sea. (Here we had better leave the metaphor before the ship founders.) There is a thing called Part III Funds.

Every year the Treasury allots sums of money for the upkeep and repair of existing W.D. property. This money is called Part III Funds. They trickle down the usual channels till in Catterick I found myself allotted £200,000 to spend on Maintenance. Over the spending of this I had undisputed authority. No one questioned my judgment as to how it was spent, provided it went on maintenance. With a population of 20,000 soldiers and a proportion of wives and families there were obviously many ways in which their lot might be improved by repairs to their homes, huts, and so on. It is always a lamentable thing to hear complaints. But when you have the power to put them right, it is a different matter. And £200,000 gives you a lot of power, particularly when you have an efficient staff burning to help you exercise it.

In the process of finding out how best to spend this money you make many contacts. The actual spending of it happens automatically because of the above-mentioned efficiency. All you have to do is to decide in plenty of time *how* to spend it. To decide this, you must visit C.Os., you must listen to their wives, you must consult your subordinates, you must watch the effects of sunshine and storm, and so on. You must perform the contortion of keeping your ear to the ground and at the same time scan the horizon. To do this you must get out and about. You are not tied to your office and everyone is pleased to see you. It is flattering and base, but none the less agreeable.

The work is thus enjoyable. There are also many interests. You meet all kinds of people of whose existence you scarcely dream in regimental life. Somewhere in a sulphurous cavern there lurks a monster known as The Command Secretary. In popular repute he is the personification of all that is vile. But as a Works C.R.E. you discover his function. His office is in effect a satellite of the War Office. The War Office is a Department of State, not a military H.Q., and for convenience it has sub-departments in each command. These sub-departments are each presided over by a Command Secretary, a Civil Servant who ranks as a major-general. The Command Secretary exercises in the provinces the financial control delegated by the Centre. This makes the Command Secretary a local nabob of some consequence. Building up harmonious relations between the Works Services and The Command Secretary is therefore important. As officers, we all profess to take an interest in people. It is the essence of man management to be interested in men. There is no need to restrict one's management to one's subordinates. There is undoubted charm in managing one's boss. And learning to manage the Command Secretary is comparable with taming a tiger. It is both interesting and entertaining.

Then there are the Trade Unions, and Civil Service Associations. Many of your subordinates belong to one or the other. In ordinary regimental life these gentry are outside your ken. It is quite extraordinary what a wrong impression the uninitiated have of them. A Trade Union boss is a man who from his earliest youth has shown skill in negotiation. He is a master at the council table. There must be times when his interests conflict with what the C.R.E. conceives to be the interests of the troops. A meeting must be convened and the C.R.E. by tact, firmness, cajolery, sincerity and all the other weapons in his armoury tries to get his way. There is a great sense of achievement when you win. And, because the Trade Union boss is a professional negotiator, he is the first to realize whom he is up against. The measure of help or obstruction you get from him is a direct measure of your own competence. No officer can deny the fascination in this. But, of course, you do not want to do it for too long.

You have dealings with the contractors who do most of your work. There is the official side wherein all the ancient customs of the sanctity of a contract are the pillars of English commercial life. This is mostly dealt with by the C.R.E's. surveyors, but there is interest in watching it and speculating how the various customs grew. There is also the unofficial side, seeing how contractors work : how this man does it all in his head, how that one makes notes, how another brings a bevy of underlings to a conference, how another plays a lone hand. All this is interesting.

Finally you have your own workmen. They are often excellent craftsmen and, at present, usually ex-service men. It is a pleasure to hear them talk about the war days. You get men who sailed in Russian Convoys, men who dropped at Arnhem, men who fought in the Desert and so on. I even had a man who had been personal clerk to the C.I.G.S. Their tales are such as story tellers dream of.

So much then for what is fun. There is, of course, the other side of the picture. I said the machine was *intrinsically* efficient and I hope I have shown how this comes about. But I said that much might be done to allow this efficiency to have its full effect. Why does it take so long to get work done? This is the question which must be answered.

The delays are of three kinds. First there is delay in deciding, at the correct level, to do the work at all. Primarily this is a "Q" matter. In theory the "Q" Staff decides what to do and the R.E. carry it out. Some of this delay might be avoided if the sappers at each level exerted more drive. There is a tendency for the sappers to sit back and say : "It is a 'Q' problem." This is an attitude which is in theory permissible, but which in practice is reprehensible. "Q" Staff Officers come and go, for it is only one side of military life. They have not the same opportunities to master these problems as the sappers have. Sappers at all levels should continually say, "Here is the problem ; here are the pros and cons ; we want to begin and you *must* decide something." Nor is this enough. The sapper should continually advise the "Q" Staff on what *is* the correct decision. I have often heard sappers say : "I can't get a decision from the staff on this." But I have often found that their efforts to get some decision would not bear close scrutiny. The R.E. have themselves to blame over a lot of these delays, and they too often shift the blame on to the staff. This would be less unbecoming in a civil servant than a soldier.

A corollary to this is that the sappers should be given a wider responsibility for the control of funds. I have pointed out that I had undisputed control of £200,000 worth of Part III Funds. But I could, under the existing regulations, only authorize new work up to £20. This is an anachronism. If a C.R.E. can be trusted to handle £200,000 of Part III Funds he should have authority to

spend more than £20 on a new work. If a C.R.E. had this authority the troops could more often have at once what is obviously necessary without having to reason with the staff in some distant H.Q.

Secondly, even when the decision has been made to undertake a project there is delay before work can start. There are two bottle-necks in the machinery. The first one is in the C.R.E's. drawing office. Work cannot be properly done unless good drawings are made first. It is clearly uneconomical to have always in a C.R.E's. office sufficient draughtsmen to tackle an outsize job. For everyday work I found my drawing office adequately staffed. But whenever a big project came, and we had several, the drawing office was swamped with work. Delay was inevitable and a way for avoiding it should be found.

The simplest suggestion for augmenting the capacity of a C.R.E's. drawing office is to allow the C.R.E. to farm out drawing work to civilian firms.

Something on these lines has already been done to widen the other bottle-neck in the machinery ; namely the surveyor's department.* A C.R.E's. staff includes adequate surveyors for normal times ; but when a big project presents itself they find themselves, like the draughtsmen, overloaded with work, and delay occurs. Regulations permit the C.R.E. to farm out surveyors' work to civilian firms ; and draughtsmen's work should be farmed out too.

A difficulty arises in this. You are only allowed to farm out specific jobs authorized by Command. At the present time civilian firms are busy too, and are not anxious to take on extra work. Civilian firms, however, must look ahead to bad times as well as good. If it were possible to make a term contract (i.e., a contract applicable over a term of years) with a civilian firm, or pay a retaining fee, for draughtsmen's and surveyors' work a different outlook would prevail. It would be like a Royal Mail contract with a shipping company. In good times it is a bonus ; in bad times it is an insurance. Firms who sniff contemptuously at the offer of a surveying job today would think twice before refusing a term contract or a retaining fee for it. It might just make the difference between solvency and ruin in bad times ahead.

Finally, there are many delays even after work has begun. The principal delay is that some items of equipment cannot be obtained from the makers in under a year or more. The C.R.E. can do something by foresight, but much is unavoidable. There is, however, one source of delay which deserves attention. Contractors can too easily plead excuses : shortage of labour is a favourite. The contract procedure should be screwed down so that the C.R.E. can more easily twist the tail of a slow contractor. To exact a forfeit from a

*For the benefit of those who do not know, it is the surveyors who frame all contract documents, which is a slow, laborious and essential job.

contractor is a matter of immense exertion. The contractor should be protected against an unscrupulous C.R.E., but he is at present armour-plated against all calibres.

There is one last aspect of Works which I should mention. It is "getting round the regulations." Many desirable projects in all parts of the globe have been executed in the past by evading the regulations. Long memories in Catterick could point to precedents set by officers who have since climbed to pinnacles of fame. It is probable that there has never been a C.R.E. in Works for a considerable time who has not had to bend the *Regulations for Engineer Services* to his (or his commander's) will. This is thoroughly bad. If a C.R.E. has to bend the regulations, his subordinates can hardly be blamed for breaking them. Consequently a C.R.E. has frequently to connive at contraventions of the rules for the general good, and sometimes even has to encourage such contraventions. The *Regulations* should, in fact, be rewritten.

First, however, it is necessary to agree upon what is desirable. No one is better placed for doing this than the Corps: for our officers have both experiences: that of the "user" and of the "provider." I suggest, with due respect, that the Corps is doing itself a bad turn by struggling along with the present *Regulations*. It is like swimming valiantly with a millstone round your neck. It would be better to produce a life-belt and say, "Let me wear this and I shall get somewhere." Then if everyone says the same thing the revised regulations will be approved, delays will be reduced, and His Majesty's business will be prosecuted with efficiency. Everyone will rejoice.

That brings me to the end of the story. Let me conclude as I began. Works are fun and they are interesting. The system is capable of improvement. To achieve this improvement should be an object of our united resolve. And the more officers with field experience who put their minds to it, the more likely are we to get an answer that satisfies the army.

Note by D.F.W.

"The regulations are in fact being rewritten at the present moment, but it is optimistic to hope that they will give Cs.R.E. a free hand on Part II funds (minor new works). These funds are scarce and they have many possible and strident claimants. Hence their exact use must be a matter for the staff.

"Regulations for R.E. Services, even when rewritten, cannot be expected to cover all possible exceptions. It will be a sad day when the Works Service is so book bound that it cannot find a way of doing desirable and economical things even when not covered by regulations."

THE MANHATTAN ENGINEER DISTRICT PIONEERS IN FISSION

By LIEUT.-COLONEL T. J. HAYES, U.S. ENGINEERS

(This article has been extracted from a talk given to a class at the School of Military Engineering by Lieut.-Colonel Thomas J. Hayes, Corps of Engineers, U.S. Army. Colonel Hayes served in England from January, 1946, until February, 1949, first as the American Engineer Liaison Officer, and later as American Assistant Military Attaché. This article covers the work of the U.S. Engineer Corps in the development of the atomic bomb. It does not cover the simultaneous work of the British and Canadians, which was so valuable.)

1. EVOLUTION

UNDER the Chief of Engineers of the U.S. Army are the Engineer Divisions and Districts, covering the entire area of the United States, whose joint responsibility are the Civil Works programme of the Corps. Undoubtedly the most famous of these Districts was the Manhattan Engineer District, organized in 1942, which developed the atomic bomb. But before discussing this, some of the background of the atomic project is necessary.

The famous letter from Professor Einstein to President Roosevelt in the Fall of 1939 is often regarded as the first step toward Hiroshima. Why was it written?

Early in January, 1939, two German scientists, Hahn and Strassmann, reported their success in splitting an atom of uranium. By the end of the month positive experimental confirmation had been reported by four different Universities in the United States. Calculations from binding energy data indicated that a great deal of energy must be released. Other implications were the production of radio-active atomic species and the possibility of a neutron chain reaction.

Tremendous interest was aroused and a number of sensational articles were published on nuclear "fission." From the first discovery of the large amounts of energy released by fission the idea of atomic power and atomic bombs was discussed. At that time American-born nuclear physicists were unaccustomed to the idea of using

their science for military purposes and hardly realized what needed to be done. Hence the early efforts in the United States, both at restricting publication and at getting government support, were stimulated largely by a small group of foreign-born physicists.

In March, 1939, only a few weeks after fission, they attempted without much success to interest the Navy Department. In July, Professor Einstein was brought into their counsels. That autumn the Einstein letter, the arguments of the interested scientists, and the outbreak of World War II convinced President Roosevelt of the desirability of encouraging work in the field. He appointed the "Advisory Committee on Uranium," with representatives of the Army Ordnance, Navy Ordnance, and Bureau of Standards. This committee recommended the procurement of 4 tons of graphite, 50 tons of uranium oxide and other materials costing some £1,500. Surely this was a humble start for a £500 million project.

By 1940 the picture had changed greatly. All the prerequisites to a serious attack on the problem of producing atomic bombs and controlling atomic power were at hand. It had been proved that mass and energy were equivalent. It had been proved that the neutrons initiating fission of uranium reproduced themselves in the process and that, therefore, a multiplying chain reaction might occur with explosive force ; and a number of methods for achieving a chain reaction had been suggested. Added stimulus had come from the report that a large section of the Kaiser Wilhelm Institute in Berlin had been set aside for research on uranium.

In June, 1940, the National Defence Research Committee (N.D.R.C.) was organized with Dr. Vannevar Bush as Chairman. The "Advisory Committee on Uranium" was reconstituted as a subcommittee of N.D.R.C., and later became the S-1 Section. Funds were supplied initially by the Army and Navy, but later by N.D.R.C. appropriations ; and N.D.R.C. made the contracts with the various research institutions. These amounted to some £75,000 by November, 1941.

Meanwhile there were stimuli from outside sources, both within and without the country. Interchange of information between the United States and Great Britain started in 1940. The British completely reviewed the subject in the spring of 1941 and this review was made available to Dr. Bush. He sent two American scientists to England in the autumn of 1941 for first-hand information on what was being done. The principal importance of this visit and other interchanges that year lay not in accurate scientific data but in general scientific impressions. Was an atomic bomb possible? The two scientists returned with a feeling of optimism and a sense of urgency.

A special committee appointed by the National Academy of

Sciences, after an impartial review of the subject of atomic power, atomic bombs, radio-active poisons, plutonium, *et al.*, announced in November, 1941, that it was thought that a "superlatively destructive" fission bomb could be produced in sufficient quantity within three or four years. The undertaking would be enormously expensive, but still in line with other war expenditures.

Dr. Bush felt it was the time to push the uranium project vigorously. Responsibility was transferred to the Office of Scientific Research and Development (O.S.R.D.) of which Dr. Bush was Director, and of which N.D.R.C. was a part. On 6th December, 1941, the proposed "all out" effort and the reorganization was announced.

The next day the Japs struck Pearl Harbour.

The top policy group, which consisted of the President, Vice-President, Secretary of War, Chief of Staff, Dr. Bush and Dr. Conant (his right-hand man and President of Harvard University), decided "that O.S.R.D. should press as fast as possible on the fundamental physics and on the engineering planning, and particularly on the construction of pilot plants." The presence of the Director of the Budget at the group's meeting on 16th December, 1941, indicated the new financial attitudes. It was decided that the Army should take over when full scale production was started, and that a technically trained army officer should be assigned to become familiar with the general nature of the uranium problem.

From January, 1942, until early summer the work was directed by Drs. Bush and Conant working with O.S.R.D. Successive reports by Dr. Bush showed increasing optimism and indicated that the time had come for Army construction of full-scale plants. In June, 1942, Drs. Bush and Conant submitted a report containing their appraisal of the status of development at that time. Basically this was as follows :—

(1) It was clear that an amount of U-235 or plutonium comprising a number of kilograms would be explosive, that such an explosion would be equivalent to several thousand tons of T.N.T., and that such an explosion could be caused to occur at the desired instant.

(2) It was clear that there were four methods of preparing the fissionable material and that all of these methods appeared feasible ; but it was not possible to state definitely that any given one of these was superior to the others.

(3) It was clear that production plants of considerable size could be designed and built.

(4) It seemed likely that, granted adequate funds and priorities, full-scale plant operation could be started soon enough to be of military significance.

This report, with recommendations by the Programme Chiefs and the Planning Board, was reviewed by Dr. Bush, Dr. Conant and General Styer (who was following the progress for General Marshall) Their comments were as follows :—

(1) If four separate methods all appeared to a highly competent scientific group to be capable of successful application, it appeared certain that the desired end result could be attained by the enemy, provided he had sufficient time.
(2) The programme, as proposed, obviously could not be carried out rapidly without interfering with other important matters, as regards both scientific personnel and critical materials. A choice had to be made between the military results which appeared attainable and the certain interference with other war activities.
(3) It was unsafe at that time, in view of the pioneering nature of the entire effort, to concentrate on only one means of obtaining the result.
(4) It therefore appeared best to proceed at once with those phases of the programme which interfered least with other important war activities. Work on other phases of the programme would proceed after questions of interference were resolved.

The over-all report was approved by the President on 17th June, 1942.

On 18th June, 1942, Colonel Marshal, Corps of Engineers, was instructed by the Chief of Engineers to form a new Engineer district to carry on special work (atomic bombs) assigned to it. This new organization was designated the Manhattan Engineer District (M.E.D.). The work with which it was concerned was labelled for security reasons the " D.S.M. Project " (Development of Substitute Materials).

On 17th September, 1942, the Secretary of War placed Brig.-General Groves of the Corps of Engineers in complete charge of all Army activities relating to the D.S.M. Project.

Where did M.E.D. fit into the organization charts of the Army and the War Department? Needless to say, under that name, it did not appear on many charts. Over General Groves was set a Military Policy Committee, on which General Groves was executive officer. The duties of this committee were to plan military policies relating to materials, research and development, production, strategy, and tactics, and to submit progress reports to an over-all policy group designated by the President.

The problem of rounding up the necessary Engineer officers for M.E.D. was tremendous. Colonel Marshal was given a wide choice

and his selections were given high priority. The District was organized rapidly and in the summer of 1942 was able to take over the procurement and engineering functions. However the period of joint O.S.R.D. and Army control continued through April, 1943, with the Army playing an increasingly important rôle as the industrial effort got fully under way. Finally, in May, 1943, the research and development contracts were transferred to the Corps of Engineers and the Army assumed complete control of the uranium project.

II. Scientific Problems*

A short review of the scientific problems facing M.E.D. seems pertinent here.

Uranium when bombarded by neutrons, is fissionable. The atom breaks into several unstable fragments, emits a few neutrons in the process, and releases an enormous amount of energy. This energy is a part of the binding energy which held together the nucleus of the atom (the unstable nuclei formed undergo subsequent radioactive decay by emission of electrons until stable nuclei are formed). This release is an "explosion." If a number of atoms can be made to explode at the same time the explosion would have great military value. If all the atoms in a kilogram of uranium underwent fission the energy released would be equivalent to the explosion of 20,000 tons of T.N.T.

The problem then is to obtain a chain reaction—to ensure that the neutrons emitted in the fission of one atom in turn cause the fission of other atoms, and so on. This is merely a question of probabilities. Neutrons produced in the fission process may :—

(1) Escape entirely from the uranium.
(2) Be captured by an impurity.
(3) Be captured by uranium in a process not causing fission.
(4) Be captured by uranium in a process causing fission.

The question of whether or not a chain reaction occurs depends on the results of the competition between these four processes. If the loss by the first three processes is less than the surplus produced by the fourth the chain reaction occurs : otherwise it does not.

Natural uranium occurs in three isotopes, U-234, U-235 and U-238, present to the extent (approximately) of 0.006, 0.7 and 99.3 per cent respectively. U-235 when bombarded by slow neutrons (whose speed has been slowed by a moderator such as carbon) has a much higher possibility of fission than do the other two isotopes. Since the amount of U-234 is small, the problem becomes one of separating it from the other two isotopes. Separation is difficult

* *Editor's Note.* While generally correct, certain details in this section may be open to possible criticism, and correspondence on them is not required.

since all three isotopes have the same chemical properties, In fact this separation was one of the two major lines of effort. Eventually the gaseous diffusion method was adopted at Oak Ridge. The uranium in gaseous form was diffused through porous barriers. Separation was possible since the diffusion rates of the two isotopes are slightly different because of the slight differences in mass.

A second problem was a moderator. It is not sufficient only to produce more neutrons by fission than are absorbed. The speed of the neutrons emitted must be controlled, for the probability both of fission capture and non-fission capture depends on this speed. The speed at which capture without fission is most probable is intermediate between the average speed of neutrons emitted in fission and the speed at which fission capture is most possible. Obviously the neutrons must be slowed down. The process is simply one of a moderator resulting in elastic collisions between the high speed particles emitted and the particles of the moderator practically at rest. For various reason the choice lay between hydrogen, deuterium, beryllium and carbon. Although heavy water or deuterium has been used, carbon proved the best moderator.

A third problem resulted from the radioactive materials previously noted. Radiations from these have deadly skin effects. It was found possible to extract these. This aroused serious consideration that the Germans might make surprise use of such radioactive poisons and defensive measures were planned.

It was early believed, and later proved, that capture of neutrons by U-238 would result in a new chemical element, U-239 or plutonium, which then could be chemically separated from uranium. It was found that plutonium also was fissionable and would support a chain reaction. It developed that plutonium, rather than U-235, was the main material to go into the atomic bomb.

III. Major Undertakings of M.E.D.

Probably the best known part of M.E.D. is Oak Ridge, Tennessee, which, since the first publicity on the atomic bomb and following a relaxation of some of the more stringent security regulations, has had a stream of visits from newspaper men, scientists, foreign dignitaries, and, in the summer of 1946, labour organizers. Admission is now under the Atomic Energy Commission and the degree of penetration into the inner sanctums depends on the purpose of the visit.

The so-called " Greatest Secret of the War "—what was going on at Oak Ridge from 1943 to the summer of 1945—was one of the triumphs of security. A city of 80,000 was created from a sparsely inhabited agricultural region over 25 miles from a major town. Giant plants were erected, fine roads built, vast quantities of materials transported, ultra-secret research carried on and yet only

the few initiated knew what it was all about. In fact most men who worked on the project from the beginning, many in responsible positions, had no idea of the ultimate goal.

The area near Clinton, Tennessee, originally was chosen for the programme. It would not disturb people, it was isolated, and most important it was near a large power supply (T.V.A.). Here was built the first plant both to serve as a pilot plant for chemical separation and to produce the initial supplies of plutonium required. Labour was assembled from all over the nation. Pay was good and the utmost was done to provide adequate housing, varied recreational facilities, transportation to near-by points, good food at reasonable prices, and educational facilities for children.

A number of installations were built. An experimental pile was set up to work out plutonium recovery methods and to produce some plutonium for further experiments. The pile started operation in November, 1943, and the first batch of slugs entered the separation plant, for separating and purifying the plutonium, six weeks later. A medical group worked on the effects of radioactive poisoning, and a large number of scientists used Clinton as a training and testing station for Hanford.

The Hanford Engineer Works was the second major undertaking. By the end of 1942 it was obvious another plant was needed for the manufacture of plutonium. Major requirements were isolation, 500,000 to 1,500,000 kilowatts of power, and a tremendous cooling system. A site near Hanford, Washington, on the Columbia River seemed almost ideal. The river has the finest supply of pure cold river water in the United States and would be suitable for cooling. The great Grand Coulee Dam with its hydro-electric plants of 2 million kilowatt capacity is on this river. And the river runs through a large area of sage-brush plains and barren hills. It was found possible to secure an area of nearly 1,000 sq. miles. Work began on the camp in April of 1943. At its peak the camp was a small city of 60,000. The first pile was started that June and two others were added later. They were successful beyond all expectations.

It was feared the heating of the Columbia River as it cooled the piles would effect fish life, but such has not proved the case to date.

The third major undertaking of M.E.D. and the most secret was the atomic bomb laboratory situated 30 miles from Santa Fe, New Mexico, and known as Los Alamos. The great open spaces were considered advantageous for proving grounds and few curious individuals were likely to be roaming around. As elsewhere construction began with almost nothing—in this case a few buildings of a former small boarding school. Los Alamos is now considered to have one of the finest of physics research laboratories. The laboratory

director, Dr. J. R. Oppenheimer, brought together one of the greatest collections of scientists the world has known. Assembling equipment was a herculean proposition, but it was accomplished within a few months and the laboratory was working by July, 1943. Security reasons have veiled much of the work done at Los Alamos but we all know that eventually a method of detonation of a highly successful bomb was produced which undoubtedly saved many more lives than it snuffed out.

IV. Conclusion

The wide scope of M.E.D. activities can barely be grasped. Dozens of universities from Massachusetts Institute of Technology to the University of California had contracts. One of the most important installations was the Metallurgical Laboratory at the University of Chicago. Here was set up the first pile. Columbia University was first in the field, but closed out its last activity some time ago. Uranium ore was obtained from Colorado, Canada, and the Belgian Congo. Many large corporations were needed to provide sufficient graphite for use as a moderator. At one time M.E.D. had branch offices at such widely scattered places as New York City, Chicago, Berkeley and Pasadena in California, Baltimore, Boston, Cleveland and Wilmington. The security service operating out of Oak Ridge provided couriers for special material, investigations for thousands of employees, and security checks on innumerable plants, laboratories, and offices.

M.E.D. brought together a great many of the ablest scientists not only in the United States but in the world. A scientist looks at things very differently from an Army man. He resents restrictions and rules. Many delicate situations had to be ironed out. A scientist believes his knowledge should be the world's, but in general, during the war, the scientists recognized the need for the utmost secrecy. Many scientists with and without reserve status were given important positions with M.E.D. Many of these technical experts have continued in the work.

Similarly many business men had to be brought into the picture. Arrangements were made to have them assist with their industrial experience, and their scientists and engineers assisted with their technical knowledge, all on a loan basis.

Why was the M.E.D. such a tremendous success? Probably because of one of the greatest combinations of teamwork known. The Corps of Engineers, through General Groves and those under him, was able to infuse into the minds of thousands of military men, business men, scientists, and workers the idea that they were creating something vast, of tremendous importance; without knowing the goal they gave their all. The U.S. Government backed the project

with money on a vast scale, and priorities second to none ; and gave officers authority and freedom of action such as has rarely been known in the Army. Anything to get the job done ! Good men were picked, then trusted to the limit. Morale was extraordinary. Yet none really knew the whole story of what was going on save a few at the top. And these few had to do much trusting themselves in the ability of scientists to overcome gigantic problems ; of business men to produce on an incredible scale ; and of the Corps of Engineers to build cities in what were wildernesses, to run them when built, and to co-ordinate the incredibly diverse activities of the greatest project of the war.

From the above it is obvious that the Atom Bomb was not specifically a Corps of Engineers assignment. While practically all military personnel assigned to the project initially were from the Corps of Engineers, the District Engineer in direct charge of the development was held accountable only to the Secretary of War. And the development of the Atom Bomb was under the direct supervision of the President of the United States. However, the proper operation of the Manhattan District was a responsibility of the Chief of Engineers.

Atomic energy will eventually be developed for the peace-time benefit of the whole nation and eventually for all mankind. Obviously this is not an Army function. So now control and research have passed to civilian hands, but with the Military consulted on any aspects affecting the security of the country. The Atomic Energy Commission has assumed many of the activities of the Manhattan Engineer District in co-operation with the Department of National Defence. The present head of A.E.C. is David E. Lillienthal, formerly head of T.V.A., who reports direct to the President.

MEMOIRS

MAJOR-GENERAL SIR WILLIAM A. LIDDELL, K.C.M.G., C.B.

WILLIAM ANDREW LIDDELL was the son of Mr. W. B. Liddell of Madras and was born on 26th December, 1865. He was educated at Clifton and the Royal Military Academy and was commissioned in the Royal Engineers on 9th December, 1884. Leaving Chatham he was posted to the 26th Field Company at Shorncliffe, but left for India in October, 1888, and was posted to the Bombay Sappers and Miners. He commanded No. 1 Company for over three years, taking part in the Zhob Valley expedition in 1890. In November, 1892, he was transferred to the Military Works Department at Rangoon and returned home in February, 1894, after being promoted Captain in 1893, and was posted as Division Officer at Gravesend. Returning to India at the end of 1895 he served in the M.W.D. Punjab and was Personal Assistant to the Superintending Engineer in 1899.

In 1900 he was appointed Assistant Secretary to the Military Department of the Government of India, which was then in charge of the reorganization of the Indian Army carried out by Lord Kitchener after the South African War. He was promoted Major in 1901 and in 1906 returned to Chatham for the "Wild East" Class. On its completion he returned to the Works Department (now known as the Military Works Services) and was Assistant C.R.E. at Dera Ismail Khan. He returned once more to England in 1908 occupying successively the posts of D.O. Liverpool and C.R.E. Dover, having been promoted Lieut.-Colonel in 1910.

Proceeding to France in 1914 he was attached to the office of the Brigadier-General R.E. at G.H.Q. in November, 1914, until appointed D.D. Works in 1915. He had been promoted Colonel in 1913, and was awarded the C.B. in 1916 for his services as D.D.W. In this post, under the supervision of the Engineer-in-Chief he was responsible for Works and Works Personnel in Army areas; this included Roads and Bridges, hutting, water supply, tramways, E. & M. Works, inundations, as well as the provision, co-ordination and design of Engineer Stores for all Army areas. His work was of the greatest value and gave full scope for his powers of administration and foresight. In April, 1916, he was appointed Deputy Engineer-in-Chief, G.H.Q. France, and it was largely due to his prevision that the large stocks of bridging were acquired, which proved of vital importance in the final advance. In December, 1917, he was transferred to the post of Chief Engineer, Third Army, which he held until February, 1919. During this period he took part in all the operations of the Third Army, the great German offensive of

March, 1918, and the final advance to victory. He had been promoted Major-General in June, 1918, and in 1919 was created a K.C.M.G. Among his foreign decorations were those of Officer of the Legion of Honour, Commander of the Order of the Crown of Belgium and the Belgian Croix de Guerre.

Returning home he was placed on half pay until appointed D.F.W. in succession to the late Sir Philip Twining. This office he held for four years, a period which covered much reorganization. During this period he played a leading part in the reorganization of the R.E. Officers' Widows Society and was Chairman of the Council for many years with the greatest advantage to the Society.

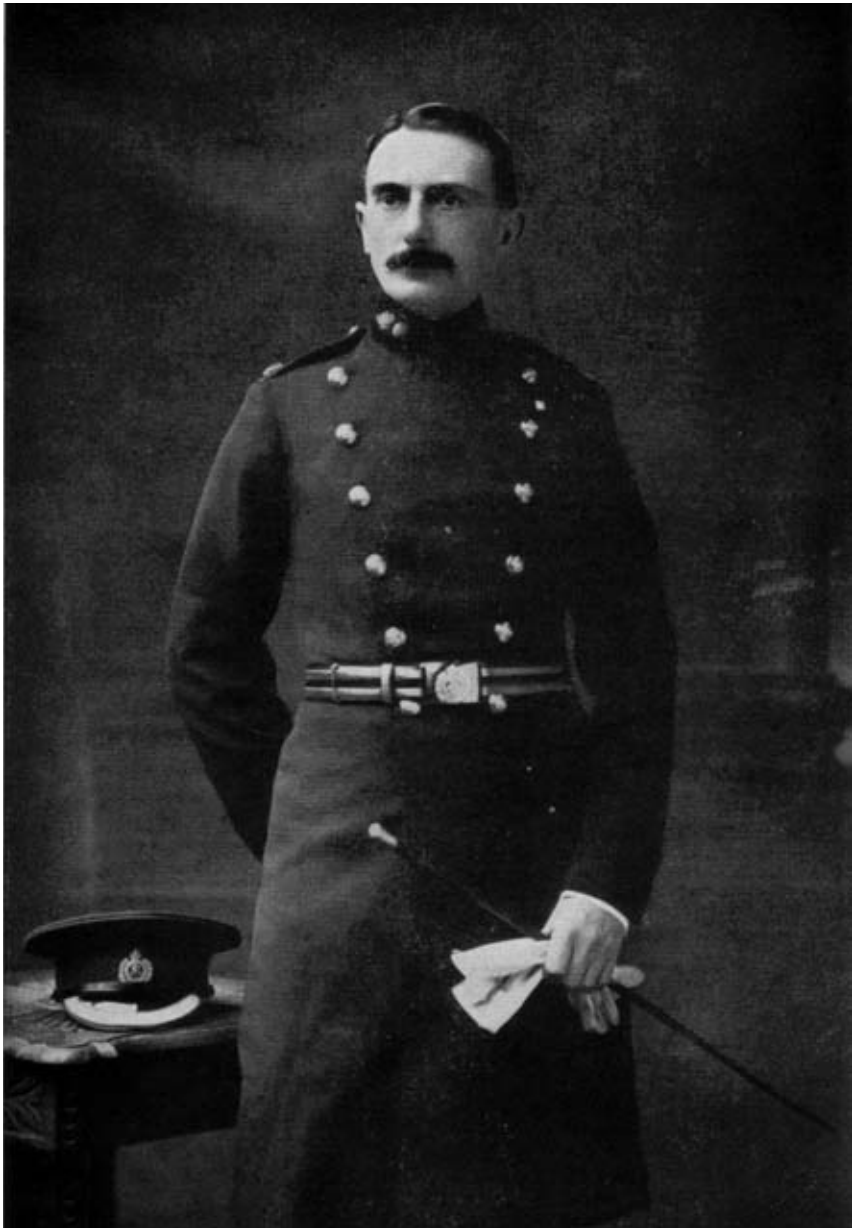
On retirement in 1924 he was appointed Director of Works and Buildings at the Air Ministry in succession to Sir Andrew Stuart ; another period of organization and reorganization under circumstances of great difficulty. This post he held for four years, retiring finally from public service in 1928.

In 1933 he was appointed a Colonel Commandant, R.E., until attaining the age of 70. He was married twice, first in 1894 to Miss Ada Lilian Livesey, who died in 1915 and by whom he had one daughter. Secondly in 1921 he married Helen Gladys, daughter of Mr. C. T. Murdoch and widow of Brigadier-General J. A. Tanner, who fell in the war. Liddell was an excellent man to serve under and he got the best out of his subordinates. He was of an equable temperament, sound judgment, great administrative ability and tactful in the handling of personnel ; always ready to listen to juniors and to see other points of view, his decisions were wise and gladly accepted. He died at Finchampstead on 17th November, 1949.

A friend writes : " May I on behalf of his friends, pay due tribute to Sir William Liddell ? To serve with him was an education and an example, for his ability was reinforced by a great capacity for work : a strict sense of duty made him always give of his best and expect it from others, and withal he was intensely human. It was during his long period in the Army Secretariat in India that his inherent aptitude for organization and administration burgeoned rapidly and bore full fruit later in the 1914 war, when he rose to high position in G.H.Q. in France. He was gifted with imagination and foresight, and thought big. Most of the major engineering conceptions, strategical or material, were due to his initiative : those of us who knew him well and could penetrate his modesty and dislike of advertisement fully realized how much our army in France owed to his prevision and successful provision. He was a most delightful companion and friend with an infectious sense of humour, and his interests were widespread—music and hunting were but two of his enthusiasms. He did constant acts of kindness to others, and seemed happiest of all when he was the courteous and charming host to so many of us in his own hospitable home."

H.B.

Major-General Sir William A. Liddell KCMG CB



Colonel A.M Henniker CBE

COLONEL A. M. HENNIKER, C.B.E.

COLONEL Alan Major Henniker, C.B.E., died at his home in Camberley on Monday, 11th April, 1949, at the age of 79.

The fourth son of the Rev. R. Henniker, he was born at South Charlton in Northumberland on 24th January, 1870. He was a scholar at St. Paul's School, and passed fourth into the R.M.A. Woolwich in 1887 on the strength of his Latin and Greek. His was the first intake to the Shop that was not allowed to take Classics as a subject for the final passing out examinations ; but he was not daunted by that. He applied himself to modern subjects with such success that he passed out second in Rooke's batch, to be commissioned on 15th February, 1889.

In April he joined the S.M.E. and began the usual Y.O. Course but missed doing Construction ; which is remarkable as later he became Chief Instructor in that school without ever having done a course there.

In the autumn of 1890 he and G. B. Macauley were selected as the first two R.E. officers to attend a Railway Traffic Course with the (then) L. & N.W. Railway. The course was an experimental one, and at its conclusion the two officers concerned were required to write a report on its value. They were commended for their report and one must still wonder at their early shrewdness in observing that " any military interference with the system of traffic management in war-time would result in chaos ; how traffic was moved must be left to the technical staff of the railway." They made various other recommendations which have in the main been adopted and survive today.

At the end of the course Henniker was posted to 10 Railway Company at Woolwich and served with it till November 1894. He was then due for foreign service and (to quote his own words) " having been trained in railway work and serving three years in a railway unit I was sent to a foreign station where there was no railway of any kind whatever."

The station was Bermuda. He served there till 1897 and was then transferred to Halifax N.S. He remained there till he was called away to the war in South Africa in 1899 in 31 Railway Company. In 1900 he became Railway Staff Officer and Traffic Manager to various sections of the railway system in South Africa.

At the end of October, 1900, he was promoted Captain and was appointed O.C. No. 2 Armoured Train. In his eighteen months of command he steamed over 30,000 miles. When the war was over 31 Railway Company was disbanded and Henniker became a D.O. (now known as G.E.) Canterbury.

In 1906 he was appointed Assistant Instructor in Construction at the S.M.E. and in 1908 he became Chief Instructor. During

this time he published a pamphlet describing "Procedure in the Works Services." He was officially commended by the Army Council for this valuable work and copies were thereafter given to all students in the School. Two years later, however, the Finance Member of the Army Council had it brought to his notice that the pamphlet "showed how a coach and four might be driven through the Regulations." He insisted that Henniker should be court martialled; but Haldane, the Secretary of State, saw the futility of censuring an officer for writing a pamphlet which the Army Council itself had commended; and the affair was allowed to drop.

In 1912 he was sent as D.O. Aldershot, where besides his ordinary work he was busy with more important things. He had been told of his mobilization appointment and was working also at the embarkation arrangements for the B.E.F.

When war was declared in 1914 he started the work for which he is best remembered—Transportation in the B.E.F. He arrived in France on 10th August, 1914, and played an important part in the assembly of the B.E.F. in its concentration areas in France. The smoothness of the arrangements, particularly in Southampton, were largely due to his foresight in peace-time.

He assisted in the negotiations with the French for transferring the base from Le Havre to the Atlantic seaboard in late August under the threat of the German advance.

In 1915 he became Assistant Director of Railways and in 1917 Assistant Director of Transportation. In both appointments he was the British Military Member of the International Railway Commission and it is probably here that he made his greatest contribution to the transportation arrangements in France. In 1918 he joined the British Military Mission to the Peace Conference. In 1919 under Sir James Edmonds he wrote the official history of Transportation on the Western Front.

After a period on half-pay (at his own request) he became Officer i/c Records in 1922 and retired in 1926. He was made C.B.E. in 1919 and was awarded the French Legion of Honour and both French and Belgian Croix de Guerre.

The qualities of method, industry and accuracy were the hallmark of all his work. By nature a friendly man with a keen sense of humour, he was always far too modest and self-effacing to get credit for all that he did. In his latter years he was stricken with arthritis and threatened with blindness. But he never complained. His gallantry remained till the end.

His family life was a very happy one. He married in 1902, Blanche Marie, daughter of the late James Gadsden, who survives him, together with his son Richard, who served in the Corps from 1940–46, and his daughter Nancy.

M.C.A.H.

BRIGADIER WILLIAM MARTIN BLAGDEN, O.B.E.

KNOWN as Willie to large numbers of the Corps and a wide cross-section of the Armoured Army, he was educated at Charterhouse and was commissioned from the Shop in January, 1919, in K. H. Tuson's Batch, the first batch after the 1914–18 war to do the full Y.O. Class at Chatham, where they were known as the No. 1 Junior Officers batch. He held a prize cadetship at the Shop, and, although resisting most forms of parade ground discipline, was a born Sapper. A burning desire to point out to the " horsey " defects in their mounts, to engine designers elementary faults in their engine designs, and to musicians defects in their music, made him a lively and entertaining companion, especially as his comments were difficult to withstand, and were delivered with a delightfully entertaining sharp wit.

His career as a specialist Sapper started with a searchlight course at Gosport in 1922 and later with a long electrical and mechanical course in 1926, after which he went to Singapore where amongst other duties he carried out much of the electrification of the new defences and the new military station at Changi.

At Singapore he became an instructor in the Flying Club. His history as one of the few to achieve, without much alarm, a spin in cloud during his " A " licence test, encouraged nervous members of the club

He became known to the Corps in general by a tour at the S.M.E. Chatham as Assistant Instructor at the E. & M. School from 1931–5. He was a brilliant, cheerful lecturer—one of the few who could hold the attention of young officers fresh from Cambridge. " The thing to remember about the gear pump is that it does NOT work like a mangle." Newly-commissioned young officers were somewhat surprised to see their instructor arrive carrying leather gloves and stick permanently fastened together by a thick rubber band, thus making the whole thing almost a jester's sceptre—his gesture of revolt against the parade ground—a revolt against military rule which also made him advise non-technical sappers to " grow adenoids and join the Cavalry."

In Tuson's batch he specialized in heated dialectics, thrusting home his points skilfully with the aid of dichotomy and Socratic technique, or considerable sharp personal abuse which delighted spectators. He was the best musician in the batch.

He became a most enthusiastic and courageous ski-runner and was elected a Q.1. judge of the Ski Club of Great Britain. He represented the " Downhill Only " Club of Wengen in races against the Kandahar Ski Club.

Although not qualified by a " z " course, he joined the Mechanical

Warfare Experimental Establishment at Farnborough in its early days and was particularly successful in assisting in and partially designing the Daimler Scout Car. His common sense and knowledge of what was possible in the engineering world made him invaluable at a time when many officers were full of ideas, but could not see which were impossible. He became a brevet Major in July, 1938, in recognition of his outstanding work in the mechanical warfare experimental world. During the recent war he was awarded an O.B.E. for his work on A.F.Vs.

His ability for leading the way in any engineering design, and his practical common sense gave him important posts in G.H.Q. Middle East during the recent war. He was Colonel A.F.V. (Tech.) directly under General McCreery. He exercised a most important influence on the design and performance of British tanks and vehicles generally, translating the harsh remarks of C.Os. in the field into constructive comments which designers could at once take up hopefully and successfully. At the time of his death he was in charge of wheeled vehicle design and development at the Fighting Vehicles Development Establishment, under the Ministry of Supply, after a long period as Deputy Director-General of Fighting Vehicle Development.

He obtained substantial awards for inventive contributions to mechanical vehicle design. "Mobiquity" is a word he invented; it is still in use in the fighting vehicle design world.

He was a first-class yachtsman—an original member of the Royal Ocean Racing Club and a member of their Technical Committee for many years. He navigated the *Ilex* when she won the Fastnet Race in 1926. His method as a skipper was cheerful, almost hilarious; and all cruises with him were rich with entertainment. He was an old skipper of the R.E.Y.C., dating from the days of *Fulmar* on her sail to Heligoland in 1921.

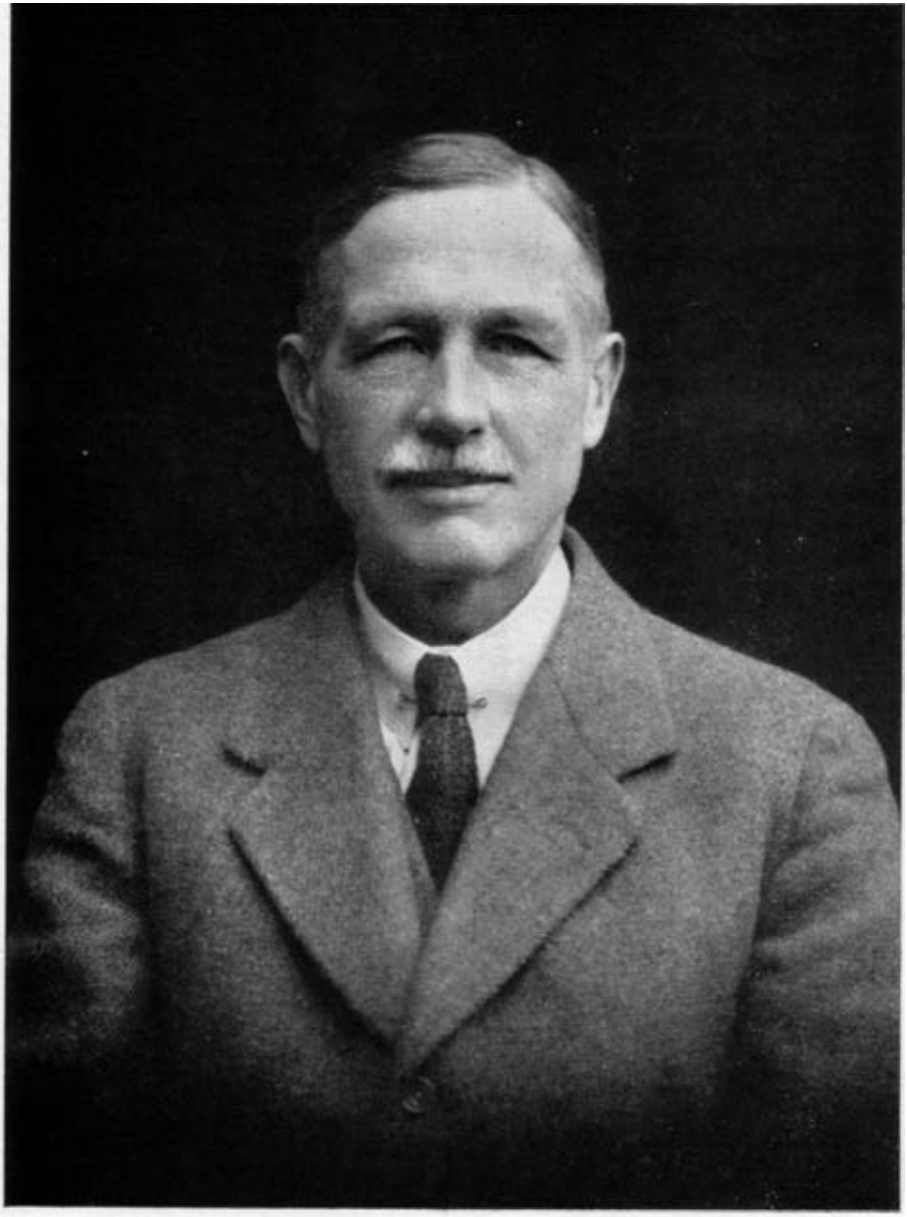
In November, 1948, he was promoted a substantive Brigadier.

By his death the Army and the Engineers have suffered a great loss. After the war a Senior Officer of the R.A.C. was heard to remark, "I don't know what we would have done without Willie."

He married Vourneen Hughes. They had two children—a daughter and a son, who is now at Charterhouse. The Corps and the Army are much the poorer for the unhappy motor accident on the 30th November, 1949, when near his home he received fatal injuries.

W.G.F.

Brigadier WM Blagden OBE



Colonel HC Agnew OBE

COLONEL H. C. AGNEW, O.B.E.

HERBERT CHARLES AGNEW was the second son of a well-known Writer to the Signet in Edinburgh. He was educated at Sedbergh, and went from there to Cooper's Hill ; and was commissioned into the R.E. in 1901.

From Chatham he went to India, and was posted to the Q.V.O. Madras S. & M., with which Corps he served continuously till 1923. He commanded No. 13 Company of the Corps in Mesopotamia from 1916 onwards, and on return to Bangalore, in 1919, was appointed Superintendent of Park.

Returning to England in 1923, he became, in turn A.C.R.E. Northumbrian Area, D.C.R.E. Re-construction Catterick, and C.R.E. York.

He was promoted full Colonel in November, 1930, but remained on half pay, until appointed Deputy Chief Engineer, Southern Command in May, 1932, where he remained until he retired in 1936. On the outbreak of war in 1939 Agnew took over the appointment of Chief Engineer, Northern Command, but owing to severe arthritis he was unable to carry on in this appointment. In spite of this he later joined the Home Guard and continued to serve with them in Scotland till they were disbanded. He was also Colonel Commandant of the Roxburgh, Selkirk and Berwickshire Army Cadet Force.

Herbert Agnew was first-class in every way ; as a regimental officer, as a mathematician and as an athlete ; excelling at polo, rugby and hockey.

While serving at Catterick, he was attacked by osteoarthritis in the hip-joints ; a trouble which slowly increased all the rest of his life. His determined and uncomplaining struggle with this disability was a source of admiration to all his friends.

On retirement, he settled near Jedburgh and entered fully into local life ; becoming, amongst other things, an elder of the Scots Kirk. He leaves a widow and two sons ; one in the Coldstream Guards and one an engineer apprentice on British Railways. The eldest son, David, was killed, flying, in the war.

All those who knew Herbert Agnew will mourn the loss of a very gallant gentleman.

C.W.B.

BRIGADIER D. A. HUTCHISON, O.B.E.

DAVID ALEXANDER HUTCHISON, who died in hospital on 21st November, 1949, was educated at Merchiston, whence he passed into Woolwich and got his commission in 1909. After a short spell of railway work at Longmoor he served in the Colonial Survey section in the Federated Malay States, where he acquired a good practical experience of survey in the field. After a short time in France in 1915, when he was unfortunately gassed and had to be sent home, he went to Chatham and then to the R.M.A. as a Cadet Company Officer.

In 1918 he joined the Geographical Section, War Office ; after which he became, in 1923, D.A.D. Survey, Constantinople. The following year he was posted as O.C. 36 Fortress Company in Sierra Leone, returning to the United Kingdom in 1925 when he was appointed to the Ordnance Survey, and served at Southampton for some five years, mainly in charge of large-scale drawing and reproduction. He did most useful research work in the treatment of paper, with the object of enabling erasures to be made without injuring the surface. That his methods were later superseded by others does not detract from the value of the work he did at the time. He was also a very useful wireless mechanic.

In 1931 he went to Maurtius as O.C.R.E. and O.C. Troops, and while there raised their first local defence force. In 1935 he was C.R.E. Wessex Area, and in 1937 he went to India as Chief Technical Examiner of Works, with the temporary rank of Brigadier. Although a similar appointment had been in existence at the War Office for several years, the appointment in India had only been started by his predecessor, and this, combined with the fact that Hutchison had not previously served in India, increased the difficulties which he ably overcame. He retired in November, 1944.

Hutchison in his youth was a Rugby forward of some distinction, getting his colours at the Shop and playing for the London Scottish F.C. Among his accomplishments he included water-colour painting and playing the bagpipes. In his professional work, a large proportion of which was devoted to survey, he had the characteristics of his race, being, if a little slow, very sure and thoroughly reliable. He was a most sociable and cheery person, and his untimely death, after a long illness which he bore with the greatest fortitude, will be greatly regretted by his many friends.

In 1913 he married Elsie Keane Winter, daughter of Brigadier-General S. H. Winter, C.B., C.M.G., by whom he is survived.

E.M.J.

BOOK REVIEWS

ROMMEL

By DESMOND YOUNG

(Published by Collins, St. James's Place, London. Price 12s. 6d.)

The Rommel legend was somewhat tarnished by Easter 1943—people had grown accustomed to the idea of " hitting him for six "—but Brigadier Desmond Young's book *Rommel* does something to revive it. He gives an account of Rommel's early life, his distinguished exploits in World War I, the dreary monotony of peace-time soldiering in German provincial towns between the wars, his work at the Infantry School and at the Staff College.

Until the advent of Hitler and the succession of German campaigns that he started, there was nothing particularly distinguished about the future Field-Marshal. His had been the orthodox military career of a good soldier, but in war there is a premium on men who can win battles, and Rommel happened to be one of them. Starting the war as a Major-General he was promoted Field-Marshal in June, 1942, at the age of 49.

Accounts of the battles in the desert and Rommel's work in Normandy are given to assess his title to greatness. No one will quarrel with the author's account of Rommel's courage, or personal leadership in battle, or his chivalry ; but some may think that to go much further is over-stating the case. The " Great Captain " has always been something of a diplomat and a statesman—even a politician—and Rommel was none of these things.

The author tells us of Rommel and his Chief of Staff destroying the infamous *Führerbefehl* of October, 1942, ordering the shooting of captured commandos and parachute troops. We see Rommel, until late on in the war, an ardent advocate of Hitler but contemptuous of his advisers ; and one cannot help wondering how much he knew of the concentration camps and other bestialities of the Third Reich. It seems odd that a general with tens of thousands of soldiers from all walks of life under his command could fail to be aware of the sudden arrests, the strange disappearances and other phenomena of a police state. No British commander could be so out of touch with contemporary life.

Perhaps for that reason Britain could never come to such a state that one of her most successful generals could be done to death as Rommel was. The author's account of this is horribly vivid. Indeed, except for a few rather pointless irrelevancies (such as one may see on page 41) the whole book is extraordinarily well put together and easily read.

In an appendix is a translation of some of Rommel's professional papers. Three things will strike the reader. First, Rommel's requirement of a tank (page 255) : " above all, manœuvrability, speed and a long range gun, for the side which has the more powerful gun has the longer arm and can the earlier engage the enemy. Weight of armour cannot make up for lack of gun power . . ." Here is a spotlight on his conception of tank fighting.

Secondly, Rommel criticizes the British " ultra-conservative structure of their army which was in no way suitable for war in the open desert, though excellent for fighting on fixed fronts . . ." and " . . . the British Command showed a marked slowness of reaction." Perhaps we have something to learn from this.

Finally the reader will note the extraordinary simplicity of Rommel's writing. Though one may not always agree with him there is never any doubt as to his meaning.

Taken all in all this is an excellent book about an interesting military character. It is well written, well got up, with a good index and photographs. It is very good value for twelve shillings and sixpence.

M.C.A.H.

Note.—

A quantity of first edition copies of *Rommel* has been set aside for Service Personnel and these may be obtained from Wilding & Son Ltd., Castle Street, Shrewsbury at 13s. post free. Orders will be treated in strict rotation until the special reservation is exhausted.

WAR DIARY: AN OVERALL WAR PICTURE 1939–45

By MAJOR F. A. L. DE GRUCHY

(Published by Gale & Polden Ltd., Aldershot. Price 7s. 6d.)

War Diary by Major Gruchy is a thin book of twelve chapters, each of which consists of two parts; a diary of events and a commentary upon them. The first chapter covers the period 1918–39. The last chapter covers the post-war period to July 1946; and the other ten chapters refer to the war itself.

The diary of events is convenient for reference and complete; though some would say that the Days of National Prayer might well have been included to show how they coincided with the various turning points of the war.

The commentary is good as far as it goes; but so many longer and more authoritative accounts have been published that this one is thrown into the shade. Few students, it is submitted, would turn to this book to evaluate the pros and cons of (say) our intervention in Greece in 1941. And, of course, some of the great controversial questions are barely mentioned.

The author tells us in the Foreword that he was a lecturer to the troops during the war; and readers may feel that some of his lecture notes have found their way, unaltered, into the book. The first fifteen lines on page 59 might provide a speaker with notes on the Battle of El Alamein; but they give an uninstructed reader a very wrong impression of the order of battle of the Eighth Army in that battle.

The author has a robust faith in the British Empire and is at pains to show the part played in the late war by United Kingdom and Imperial Troops.

M.C.A.H.

A SHORT STORY OF 21 ARMY GROUP

By HUGH DARBY AND MARCUS CUNLIFFE

(Published by Gale & Polden Ltd. Price 5s.)

In pubs and clubs where warriors assemble, arguments will commonly arise: Was Le Havre captured before Nijmegen? Was 15 Division in Cleeve before 43 Division? The ex-soldier of 21 Army Group is always the self-appointed advocate of his formation and Hugh Darby and Marcus Cunliffe's little book *A Short Story of 21 Army Group* will provide him with a good brief.

It is a well put together little book with plenty of photographs and maps. The pity is it only has a paper cover; but then five shillings will not buy much today. Of course it makes no pretence to being a book for the

serious student of war. It gives the facts, on the whole, accurately ; though there are some misprints (e.g., the Order of Battle of Second Army on page 62 includes 12 Corps twice over). It does not enter into the whys and wherefores of operations ; it merely states what happened.

This book is, therefore, a quick and easy reference book for the main events, written in a popular way and published at a low cost. And if you buy it expecting no more you will not be disappointed.

M.C.A.H.

ADAM TO ATOM

By DR. ROGER SHAW

(Published by The Society of American Military Engineers, Washington, D.C. Price $1.50.)

If you can imagine the Old Testament, in all its movement and philosophy, portrayed in a two-minute flash on the Movietone News, you can get an idea of *Adam to Atom* by Roger Shaw.

In this booklet of some sixty pages the author traces the history of warfare from David to the present day. He is sustained by the most admirable scholarship in a task which Hoffman Nickerson describes in a Foreword as difficult ; but which many people might call impossible.

The booklet is typically American. One feels oneself in the presence of a high-powered salesman, demonstrating with compelling force, a vacuum cleaner. The author goes at a terrific pace, bewildering the reader with erudition and salesmanship. One barely has time to smile at " P. Q. Varus " or " C. J. Caesar "; though " The First of Foot " may be surprised to see themselves as " Royal Scots No. 1 "—like a brand of whisky.

Occasionally the author pauses to give some detail of a particular battle : for instance Cannae gets two paragraphs, Rocroi four, and Jena two. These are, no doubt, in proportion to the general construction of the work, and from this the reader may judge the pace.

How should one place this booklet which, incidentally, is paper-backed ? Perhaps it would be fair to say this : The scholar, whose thought has been directed into general rather than military channels, may see how to apply his knowledge to the history of war. And the totally uninstructed, if he has a good memory, may learn some " talking points " with which to impress a not too inquiring listener.

M.C.A.H.

THE GOLDEN CARPET

By SOMERSET DE CHAIR

(Published by Faber & Faber Ltd., London. Price 7s. 6d.)

This book recounts the author's experiences as Brigade Intelligence Officer with " Kingcol," the Brigade Group which in 1941 crossed the desert from Palestine to the Tigris and captured Baghdad. It is a personal story rather than a military history, but it conveys the spirit and atmosphere of an operation which had heroic and romantic quality. The author, who is among other things a poet, captures the moments of spiritual elevation equally with those of mental and spiritual discomfort. His account is a little removed from the ordinary regimental soldier, but the pen-portraits of the rank and file who appear are vivid. It is

the officers, however, who stand out, sketched in a few clever strokes, with humour but not always politely, and on occasions with less than justice. He makes, too, critical comments on the " military mind," but the trouble may sometimes have been due not to too much " military mind " but to too little of it . . .

The author's military experience and acumen may be questioned but not his literary ability. He tells the story of the operations as they affected himself with considerable skill.

The references to engineer tasks are tantalizing. Due weight is given to the importance of those mentioned and also such account as is adequate for the general reader. As a Sapper, one would like to know more, but at any rate there is one sentence which warms the heart. It reads " General Clark explained to me that the campaign had hung on two threads—the two wire hawsers with which the columns had been ferried across the flooded waters of the Euphrates."

Glubb Pasha, the boy king Feisal II, and General Waterhouse were among those whom the author met personally, and there were also included sundry humbler folk and some curious intriguers. It was a strange mixture which he encountered, either in the obvious course of duty or else by virtue of his own enterprise, which led him to hob-nob with Arab chiefs and to probe into underground political plotting in Baghdad. Angels might sometimes have refrained from treading where he went in, but they would not then have had half so interesting, or useful, a time.

As literature this book is hardly in the same class as *The Seven Pillars of Wisdom*, but it carries the same caste-marks, while among accounts of battle experiences it should maintain a high place.

R.E.B.

OFFICIAL HISTORY OF THE GREAT WAR—ITALY, 1915–19

By BRIGADIER-GENERAL SIR JAMES E. EDMONDS, C.B., C.M.G., D.LITT., LATE R.E., AND MAJOR-GENERAL H. R. DAVIES, C.B.

(H.M. Stationery Office, 1949. Price 30s. 0d.)

The publication of this volume of the *Official History of World War I* marks the end of this great piece of research and literary work, co-ordinated by Brigadier-General Sir James Edmonds. Although some of the later volumes could not be published until many years after the events they record, the work is now complete and is not only an accurate but an extremely interesting history. It is very readable indeed. The Corps can be justly proud that its writing was entrusted to a sapper officer.

The volume on the Italian campaign lives up to the high standard of the others. It describes briefly the fighting in Italy up to the end of 1917, when the many costly Italian attacks on the Isonza were brought to a close by the defeat at Caporetto and the retreat to the Piave. It was then that both French and British divisions were sent to Italy, finally to take part in the victorious advances across the Piave and to Trent in the southern Alps. The rôle of the British troops in these battles has never been officially recorded, and was slurred over in the Italian history. We now have an unbiased story of their achievements and can appreciate how great was the moral and military assistance afforded by the allied troops and their commanders to a nation who had suffered a shattering defeat.

It was a British division that led the way into the Alps, and it was two British divisions (one of them commanded by Major-General H. F. Thuillier, late R.E.) who led the way across the Piave. The story of this crossing should be of great interest to engineer officers because, with the equipment available, it was certainly one of the most difficult ever undertaken by the British army, though the assistance given to our sappers by the skilful Italian *pontieri* must not be forgotten. Had the crossing not occurred at a time (October, 1918) when great battles were being fought in France, it would doubtless rank even more highly in the annals of the British Army. The story of this and other operations is very well told.

E.F.T.

REINFORCED CONCRETE

By PROFESSOR A. L. L. BAKER

(Published by Concrete Publications Ltd. Price 15s.)

This book is an important addition to the Publishers' "Concrete Series" books on reinforced concrete design and construction.

The author is the Professor of Concrete Technology at the Imperial College of Science in London, and appears to have a complete mastery of his subject. This book covers most aspects of reinforced concrete—theory, design and constructional procedure. It is, however, based on lectures given to students, and, as a consequence, the emphasis is on the principles and theory of design; it cannot be used easily as a reference book nor as a designers' handbook by anyone who is not already conversant with more advanced theory.

The opening chapter is largely devoted to a careful consideration of factors of safety. The author quite rightly emphasizes this subject throughout the book; a slavish adherence to "permissible stresses" often blinds the engineer to the true factor of safety in his designs, and the military engineer, who frequently has greater uncertainties to compete with than his civilian counterpart (but at the same time can take bigger risks), should be particularly knowledgeable on the subject.

About a third of the book is devoted to the theory of indeterminate structures, which occur frequently in R.C. design. Several alternative methods of analysing continuous beams, building frames and arches, are explained, and the author suggests that the reader should take his pick. He assumes a considerable previous knowledge of mathematics and theory of structures, but, even allowing for this, a lot of the work is not easy to follow. The subject is made more difficult by an academic preference for symbols rather than numbers, and, in consequence, the average engineer will be frightened into making his structures determinate; perhaps this would be no bad thing. The subject is completed with the theory of slabs and vaults and some useful work on the distribution of load on groups of piles.

Several chapters are then devoted to the ordinary theory of R.C. beams, slabs and columns, and the effects of creep, shrinkage and plastic yield. A number of design curves are included, but they are not as simple to use as those in the military concrete manual.

Thirty-two pages are devoted to the theory of prestressed concrete, in which a thorough analysis is made of the effects of "loss of prestress," tensile cracks and yield of the steel. The author demonstrates that, if both are calculated on the *ultimate* moment of resistance, a prestressed concrete beam is very little stronger than an ordinary R.C. beam of the

same size. It must be remembered, however, that a prestressed beam requires only about a quarter as much steel, since high tensile steel and stronger concrete are used, and there may be big savings due to dead load relief, greater shear resistance and unconventionally shaped beams.

The remainder of the book is devoted to design practice, drawing office work, estimating and construction procedure. The importance of aesthetic appeal and surface finish is emphasized, and a large number of excellent photographs illustrate the arguments in the text.

This is an excellent text-book for anyone who has frequently to design complicated concrete structures. It is not, however, recommended to the average engineer who does not wish to become a specialist in the subject.

M.E.T.

PRINCIPLES OF A NEW ENERGY MECHANICS

By Dr. Jacob Mandelker

(Published by The Philosophical Library, New York. Price $3.75.)

This book is a cheering one, even to those of us who have been brought up to understand a little about mechanics, and nothing much beyond. To us, the picture of the universe, current in the best circles a century or two ago, as composed of a multitude of atomic pellets, all obedient to the ordinary rules of mechanics and gravity according to Newton—this world-picture, I say, was a good, concrete, understandable notion which enabled us to feel that we had the universe where we wanted it. We were chilled by the later discovery that Einstein and his confederates had outmoded mechanics entirely, and replaced it by a strange dream-geometry in which nothing seemed to be dependable (save perhaps the velocity of light !), and in which our simple intuitive notions of unvarying length and mass, and even time itself, were disclosed as illusory and relative. No wonder that most of us have lost heart, and failed to come to grips with the mysteries of "Field Theory" and "Quantum and Wave-mechanics." And how depressing it is to think that nobody is able to form a true picture of the way God made His universe except a smattering of super-highbrow mathematical professors.

But Dr. Mandelker offers—if his work is substantiated—to give us back Mechanics as the basic study underlying natural phenomena. To be sure his work is built up on Relativity and the rest, and cannot be understood until one has mastered them. But if one may crib his conclusions without being able to follow his reasoning, it seems that the New Energy Mechanics has many features which hark back most reassuringly to our old Newtonian version—above all an absolute measure of time. Conservation of Energy (and/or matter) bobs up again in slightly different guise, and a kind of constant Momentum replaces our simple notion of unvarying Mass. The velocity of light is still sprinkled around in all the formulae to a baffling degree, but on the whole this work is streets ahead of Einstein in *general* intelligibility.

Moreover, little as one is qualified to judge, this theory of Mechanics seems to embrace, most satisfactorily, the requirements both of relativity and quantum theory, while resolving several of the more tiresome paradoxes in each. At any rate one can express a whole-hearted wish (however base one's true motives may be) that in the long run the New Mechanics may be the account of the matter which proves closest to reality.

W.G.H.B.

A SHORTER INTERMEDIATE MECHANICS

By HUMPHREY AND TOPPING

(Published by Longmans, Green & Co., Ltd. Price 15s.)

This is an excellent new text-book, dealing with all branches of mechanics up to the standard of Higher School Certificate or Intermediate Science Examinations. The presentation is clear and full, and is supported by numerous diagrams. There is a good selection of examples taken from past examination papers. There are no novel features in the treatment of problems; conventional methods are demonstrated competently.

W.G.H.B.

TECHNOLOGY OF LIGHT METALS

By A. VON ZEERLEDER

(Published by Elsevier Publishing Co., New York, and distributed in U.K. by Cleaver-Hume Press Ltd., London. Price 45s.)

The art of working the heavy metals is backed by many centuries of experience and knowledge; light metals, on the other hand, have been introduced to the workshop only in this century and the knowledge necessary for their working is slow to keep pace with their rapid development.

With the continual extension of the application of light metals to new industrial fields there arises a need for up-to-date information on the technology of the subject and to this end Dr. von Zeerleder has devoted his book, which deals in an essentially practical manner with the working up of aluminium and magnesium alloys, from the ore to the semi-manufactured goods.

As light metals other than aluminium and magnesium have not yet acquired any commercial importance the author does not deal with them in this volume.

The work is divided into two parts; the first dealing with general aspects and the second with fabricating processes.

In the first part we find attention devoted to the history and production of aluminium and magnesium, the theory, composition, physical and chemical properties of alloys, and methods of testing, including Macro and Microscopic examination. Further chapters deal with the principles of design and construction of members and components, melting furnaces, melting technique and costs. Reclamation of foundry residues and working up of scrap metal are also considered.

The second part of the book begins with chapters devoted to the production of sand castings, also gravity and pressure die castings, hot and cold rolling, extrusion processes, forging and impact extrusion.

Drawing of tubes and sections, wiredrawing, spinning and press work are next considered, and from these subjects the author goes on to deal with thermal processes applied in the manufacture of light metals, reheating and annealing furnaces, and temperature measurement.

The final chapters deal with machining practice, soldering and welding, and riveting.

The book concludes with a chapter on surface treatment, including chemical surface treatments and anodic processes, also a review of the economic considerations and application of light metals, together with brief notes on storage.

A generous bibliography is appended. The book is well illustrated and in the various tables and charts temperatures are given in both Fahrenheit and Centigrade. Stress units are given in both tons and pounds per square inch.

The translator is to be congratulated on overcoming the many difficulties in the production of a readable and lucid English text from the original German manuscript.

H.H.N.

CIVIL ENGINEERING—DRAWINGS, SPECIFICATIONS AND QUANTITIES

By J. MARSHALL RODGER

(Published by Ernest Benn Ltd. Price 25s.)

This book is a revised edition of the late Mr. Rodger's book, *Engineering Drawings, Specifications and Quantities*, written in 1934, and now brought into line with modern practice by Frank J. Crabb of the Building Research Station of the Department of Scientific and Industrial Research.

The book divides naturally into four main parts :—

(*a*) Preliminary work and drawings.
(*b*) Contracts, including comments on typical conditions of contract.
(*c*) Specifications for workmanship, materials and engineering plant.
(*d*) Quantities, which includes worked examples of typical Civil Engineering works.

The first part deals very briefly with the inception of a new project and points out what preliminary works are required and how the various plans and drawings required for contract purposes should be compiled. An interesting abstract deals with the preparation of plans for Parliamentary bills connected with Public Works.

The section dealing with contracts explains the legal position of the client, engineer and contractor, and comments on a typical set of contract conditions to show the obligations of all the interested parties.

The section dealing with specifications is perhaps the most detailed in the book and deals with most aspects of Civil Engineering. It includes several typical specifications which provide a useful guide to those engineers concerned in their drafting.

Lastly the chapter on quantities explains simply how the taking off, multiplying, abstracting and billing of a schedule of quantities is carried out.

This book will have two main uses. Firstly the experienced engineer will find it a concise reference book of Civil Engineering practice. He will find particularly valuable the frequent references to other sources of information, such as British Standard Specifications, Codes of Practice and the many publications of the professional engineering bodies and institutions connected with Civil Engineering, which will enable him to obtain amplification of any point which has perforce to be condensed in a work of this nature.

Secondly the young engineer who is working for the examinations of the professional engineering institutions will find much of value, especially in the chapter dealing with Quantities which is often apt to be a bugbear to the inexperienced.

In conclusion this book is to be strongly recommended for any engineering reference library where there is no doubt it will provide a fund of information of Civil Engineering practice.

M.B.A.

A UNIVERSITY TEXT-BOOK OF PHYSICS VOLUME II (REVISED)—"SOUND"

(Published by Charles Griffin & Co., London. Price 20s.)

Messrs Griffin & Co. Ltd. have undertaken the revision of their well-known *Textbook of Physics* and the second volume dealing with Sound has recently been published. This work was carried out by Dr. W. S. Tucker who for some fifteen years has been an Honorary Member of the Institution of Royal Engineers and is well known to many Sapper officers from his work as Director of Research at the Air Defence Experimental Establishment, at Biggin Hill, until 1941.

Dr. Tucker has now brought up to date the volume dealing with Sound that was produced some fifty years ago by J. H. Poynting and Sir J. J. Thomson and with his exceptional experience gained during the large scale research for the application of sound to Army purposes, he has been able to extend the scope and value of this text-book. The research and experimental work carried out by the teams of the Acoustical Section of A.D.E.E. dealing with the long distance travel of sound, meteorological effects on the sound path, accurate location of a source of sound (Gun Sound Ranging and Aircraft Sound Locators) and other large scale work, were beyond the scope of the ordinary researcher into acoustic problems and this revised text-book could not have been so complete without the permission of the War Office to include such matter.

This new volume should be of interest to many Sappers and those who study it will find it lucid and complete. Dr. Tucker has modified and simplified the presentation of the theory by adopting the calculus for the calculations, which is more suited to the present-day students of physics and to Sapper officers.

Chapters IX and X will interest many Sappers who were connected with A.A. Searchlight units before they were handed over to Gunner charge; the development of the sound locator is briefly described. They also include, describe and illustrate the long-range detection of aircraft systems that were developed, but though sites were acquired and actual construction was authorised, the advent of Radar was just in time to supersede them. The slow travel of sound compared to the speed of light of Radar naturally made acoustic warning of aircraft approach out of date—particularly as the increases in speed of aircraft just prior to the war was already reducing the value of sound methods with the increasing "lag of sound."

Chapter XI on the Acoustics of the Concert Hall should also interest the mathematician and the musician—and may well help the designer of halls for lectures or conferences apart from music.

A.P.S.

MATHEMATICS AND THE IMAGINATION

By EDWARD KASNER AND JAMES NEWMAN

(Published by G. Bell & Son Ltd., London. Price 15s.)

"If you do not expect the unexpected you will not find it, for it is hard to be sought out and difficult"—so Heraclitus warns us; the authors of this book invite us to take up his challenge and explore, as gaily as we may, the highly unexpected ways of recent progress in mathematics.

We are accustomed to marvel at, and frequently to resent what we regard as the irresponsibility of modern painters, poets and musicians. They cast aside too lightly, as we think, the restrictions of harmony, metre and perspective: the laws of formal structure and good order which must surely underlie any worth-while interpretation of the universe. And yet, little though the world knew of it, just such a revolution was taking place in Mathematics decades before post-impressionism was ever thought of; in *Mathematics*, if you please, of all sciences the most respectable, least subject to vagaries of hypothesis and most firmly grounded upon the solid and undeviating highway of eternal reason. Perhaps if we had understood a little more clearly the implications of the Mathematics of Infinity and the New Geometries we should have been less ready to carp at Cèzanne or even Mr. T. S. Eliot. But that is as may be; the fact remains that most of us have at least come to terms with these more self assertive revolutionaries in the world of taste and art: how few of us have found courage to explore the strange new currents in the realm of thought to which these others are perhaps no more than the outriders?

We have all of us, I imagine, felt this gap in our intellectual armoury; the more so since the New Physics has provided its astonishing vindication of Probability Theory and multi-dimensional geometries. Mathematicians have been led, by their inexorable pursuit of completeness, and self consistency, into conclusions which emptied out bathwater *and* baby with a vengeance, not only transcending what we could visualize or comprehend, but seeming to make nonsense of all our common sense and basic intuitions. "The whole is not greater than many of its parts" —fiddlesticks! And how can two lines in a surface never meet and not be parallel? Surely these things are but *jeux d'esprit*; very subtle, no doubt, and pleasing to the academic mind, but such elegancies will have no application, no more relevance than the ingenious paradoxes of Zeno who proved that Achilles could never catch the tortoise. And then, to shatter our complacency, came Relativity and the Wave-mechanics, displaying all these weird new notions firmly embedded in the structure of their universe. Today few shreds of our former superciliousness remain and yet—we repeat—how few of us have come to grips with this strange new quicksand on which the foundations of our thinking seem to tremble.

Are we afraid of engulfment? I think it is more that the pontifical jargon in which all this stuff is expressed discourages us into feeling that, try as we will, we shall never understand even the language that the natives talk in this odd land, let alone explore the territory with freedom, profit or enjoyment. In this book we have at least the beginnings of a remedy.

Mathematics and the Imagination is not such a popular self-educator as traverses the ground of Higher School Certificate in a manner condescending to the (presumably) impoverished capacity of our intellectual digestions, nor yet does it philosophize ponderously upon the limitations of human knowledge. On the contrary it takes us somewhat as we are: puzzled, interested, reasonably intelligent; and leads us firmly, but most engagingly into just those devious ways which we had written off as forever beyond our compass. Infinities, transcendentals, probability, topology, many dimensional and curved spaces are the matter of our discourse; we touch them lightly and in spots, but always with an eye to the deeper and, basically, logical difficulties and illuminations which they contain. We emerge scarcely less puzzled, it may be, but at least with a feeling that we have plumbed the measure of these deeps and found the exploration a refreshing one withal. If such things ring a bell with you at all, this book can be highly recommended. W.G.H.B.

TECHNICAL NOTES

ALUMINIUM BRIDGE AT SUNDERLAND

(*The Railway Gazette* dated 28th October, 1949)

The article describes a double-leaf trunnion bascule type bridge, of which the whole of the movable spans, except the kentledge boxes, are of aluminium. The bridge is a road-cum-rail bridge of 121 ft. 1½ in. between centres of trunnions and provides a 90-ft. clear waterway. It is designed to carry a 70-ton bogie railway wagon and a 75-ton road vehicle, plus 56 lb. per sq. ft. on the footways. The clear width of roadway is 18 ft. 6 in. The plate for the bridge is of B.S., A.W. 15 type alloy with an ultimate tensile stress of 15 tons per sq. in. The total weight of aluminium alloy in the moving spans is 51½ tons, and this represents about 40 per cent of the weight of an equivalent steel structure.

TRANSPORT OF BRIDGE STRUCTURES

(*The Railway Gazette* dated 25th November, 1949)

To facilitate rail transport of pre-assembled steel parts for railway bridges from shop to site, the German railways have designed and are now putting on trial a new vehicle (or, as they prefer to call it, apparatus).

It consists of a longitudinal I-beam, 100 cm. high and 25 metres long, rigidly supported at points 1.3 metres from each end by steel frames resting on bogies. The upper flange of this strong beam is 3.9 metres above rail level and can be used for the edgewise suspension of the steel structure to be transported.

Structures less than 22 metres in length can be safely handled by adjusting the steel support so that the beam overhangs at one end, thereby ensuring that the load is never far removed from the pivots to which it can be secured against lateral sway caused by wind or centrifugal force. For even greater stability it is also possible to suspend the load eccentrically.

Tests were carried out at a speed of 25 m.p.h. although in practice the speed has been limited to 15 m.p.h.

CASTELLATED SYSTEM FOR STEEL BEAMS

(*The Engineer* dated 23rd November, 1949)

A method of increasing the bending strength of rolled sections has been evolved by Mr. G. M. Boyd (patent rights, Appleby-Frodingham Company).

The method, called "Castellated Construction," is claimed to be a simple and economical method of increasing the strength of a section without increasing its weight, and it takes the form of flame cutting to a pre-determined undulating profile (mathematically calculated) along the web. One of the resulting two pieces is then turned end for end and rejoined to the other piece by welding, in such a way that the crests of the undulations meet.

This method increases the depth of the section by 50 per cent, the section modulus by 56 per cent and the moment of inertia by 135 per cent, so that the load carrying capacity of large spans is more than doubled. The shear stress is of course reduced, but this only affects short spans.

CROSSTIE (SLEEPER) SEALING COMPOUND

(*The Railway Age* (U.S.A.) dated 8th October, 1949)

British civil railway practice for many years past has been to use sleepers treated with heated creosote under pressure. Whilst the life in the track of such sleepers varies according to nature of subsoil, the timber used, traffic etc., it is of the order of twenty-five to thirty years.

By contrast overseas railways, particularly in America, use large quantities of untreated sleepers, cut from local timber, and the life of these is comparatively short, often no more than five years, and climate, apart from the other factors leading to decay and disintegration, has a much greater effect on such sleepers than on treated types.

As a compromise a U.S.A. firm has developed a coal-tar sealing compound, known as Compound No. 16, for application to sleepers already in service in the track. The compound is stated to enter and fill cracks and splits in the wood and to spread over the top surface forming a water-excluding seal.

The compound is best applied by spraying and a tractor mounted plant carrying 55 gal. has been devised for this purpose. The liquid can also be brushed on but this method is obviously more expensive. The spraying method has the advantage that dirt is blown out of the cracks as the compound is applied. Brushes are used to work the compound into deep cracks and around the plates. It is necessary to place lightweight metal shields over the rails to keep the running surface clear of the spray.

The work is carried out by a foreman and five men and 1 gal. of the compound is found to be sufficient to coat the average of 3.65 sleepers.

The process is claimed to reduce risk of fire from hot coals or ashes from locomotives and is of particular advantage in cold climates in that by excluding water from cracks it reduces further splitting caused by expansion when accumulated water freezes in winter. Such expansion has been found to straighten the "S" irons driven into the ends of defective sleepers.

The process might have some application on military railways in cases where lines laid with untreated sleepers during periods of rapid expansion, without any possibility of assessing future requirements, are later found to be required to remain on a long term basis.

Much re-sleepering of such lines is now necessary after seven or eight years' use and in view of the general timber shortage, particularly of woods suitable for normal creosote treatment, the compromise method might be practical and economical until good treated sleepers are again readily available.

THE DESIGN OF STEEL FRAMES

By PROFESSOR J. F. BAKER, O.B.E., M.A., Sc.D., M.I.C.E., M.I. STRUCT. E.

(*Journal of the Institution of Structural Engineers* dated October, 1949)

It has long been appreciated that failure of a structure does not follow from the overstressing of a single member of the frame. The critical member, stressed beyond the elastic limit, enters the plastic range and suffers distortion which causes a redistribution of stress and the transference of load to other adjacent members of the frame.

Professor Baker's paper gives an introduction to methods which are being explored to give a rational method of design for plastic failure of frames, without increasing the amount of design calculation to unacceptable proportions.

The economy of plastic design is best illustrated by the case of a normal fixed ended beam under uniformly distributed loading. By elastic theory the end moments due to the end fixity are twice the magnitude of the bending moment at mid span. For plastic failure, however, overloading of the highly stressed ends would first induce plastic stretch within the depth of the section to push up the resisting moment of the beam. Further loading would cause a yielding at the ends of the beam and the mid portion of the beam would be called upon to take up an increased proportion of the moment. Thus the bending moment at the ends would be successively reduced and that at mid span increased until both were of equal value. Therefore collapse is dependent on load redistribution until full stress is reached at three sections of the beam instead of the accepted two points in the present orthodox design.

To design within safe limits the allowable working load would be based on a percentage of the load causing plastic failure.

It has long been appreciated that orthodox pin-jointed design assumptions for steel frames give erroneous results, and although the design methods are popular due to their simplicity, account should be taken of the end restraint provided by normal beam to stanchion connexions.

It is to be hoped that plastic methods of analysis will in time produce a simple solution for this and other structural problems too complex for rapid solution by elastic theory.

USE OF COPPER AND GALVANIZED STEEL IN THE SAME HOT WATER SYSTEM

(*Heating and Ventilating Engineer and Journal of Air Conditioning* dated November, 1949)

Various materials have been used successfully for the tanks, cylinders and pipes of domestic hot water systems ; the most common being copper and galvanized steel for tanks and cylinders, and copper, galvanized steel, lead and lead alloys for piping.

A number of failures of galvanized steel hot water tanks and cylinders were reported towards the end of the 1930's and investigations into these failures by the British Non-Ferrous Metals Research Association led to the conclusion that the failures occurred in certain areas of the country where copper pipes were used in association with galvanised steel tanks.

As a result of laboratory experiments it was found that certain types of water are capable of dissolving minute amounts of copper from the pipes of the hot water system. When the water containing the copper comes into contact with the galvanizing of the tank, electrolytic action causes rapid attack on the zinc coating resulting in rusting and ultimate perforation of the tank.

The rate at which the action proceeds is influenced by a number of factors such as the copper solvency, hardness, and temperature of the water.

The general conclusion is that the hot water system should be constructed throughout of copper, or of galvanized steel, unless previous experience in the district shows it to be safe to use these materials together.

TEST ON A FULL-SIZE PRESTRESSED CONCRETE GIRDER

(*Engineering News Record* of 3rd November, 1949.)

While interest in Great Britain on the new prestressed concrete form of construction is reaching fever-pitch, an article appearing in the American journal *Engineering News Record*, for 3rd November, 1949, may be of interest to all engaged in the design or construction of bridges. The same principles, of course, apply to any form of construction using prestressed concrete.

Four hundred U.S. engineers were recently invited to witness a test on a bridge girder, 160 ft. span and 6 ft. 7 in. in depth, containing 80 cu. yds. of concrete, and weighing 150 tons. The girder is a prototype of those soon to be placed for Philadelphia's newest bridge. It is claimed to be the largest structural member ever to be subjected to a scientific test.

It was of a modified T-section, having a bottom flange 2 ft. 6 in. wide, a web 7 in. thick, and a top flange 4 ft. 3 in. wide. 256 high-tensile wires, each 0.276 in. diameter were used to form four cables. Two cables ran horizontally along the bottom flange, while the remaining two formed parabolic curves through the web. The Magnel system of post-tensioning was used, two wires at a time being stressed. The wire used had an ultimate strength of 242,000 lb. per sq. in. and a yield point of 213,000 lb. per sq. in. The concrete strength at twenty-eight days was 7,200 lb. per sq. in. The design stresses were based upon a steel wire yield point of 160,000 lb. and a concrete strength of 5,400 lb.

Although loaded to calculated failure, with nearly 400 tons of super load distributed equally at eight points along the girder's length, collapse did not, in fact, occur, due to the reserve of strength in both steel and concrete shown in the figures quoted earlier.

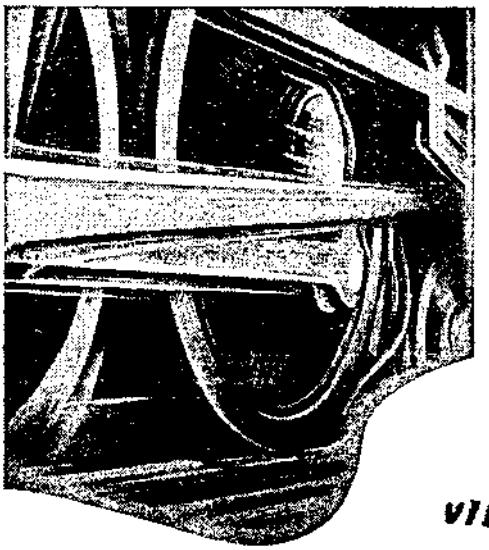
Total post-tensioning in the four cables was 955 tons, stretching them 9 in. Creep and shrinkage accounted for a loss of 2 in. of this stretch, equivalent to 15,000 lb. per sq. in. The resultant tension in the steel produced compression in the concrete more than sufficient to prevent a reversal under the maximum designed live-loading, consequently there could be no chance of cracking of the bottom flange concrete in the actual girders to be used for the bridge.

The first incremental test load was 55 tons, making, with the dead load of 150 tons a total load of 205 tons, producing a deflection of $\frac{3}{4}$ in. This represented the normal design load condition. There was, as expected, no sign of cracking. A further 35 ton increment (making 240 tons total load) produced a deflection of $1\frac{1}{2}$ in. with still no sign of cracking. A further 22 tons caused the first tension cracks and a deflection of $2\frac{7}{8}$ in.

When the super loading finally reached 378 tons, making a total load of 528 tons the deflection was $15\frac{3}{8}$ in., at which point the test was stopped. By this time extensive vertical cracking had occurred.

At one stage in the test when loaded to approximately half the ultimate load, the load was removed to demonstrate the complete closing up of the cracks.

The results of such a test as the one described above surely point to the vast opportunities offered by the use of prestressed concrete in this country. These opportunities are not likely to be missed. The Ministry of Works have already devoted considerable energies in developing this new science, and have designed several large structures now in course of construction throughout the country.



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