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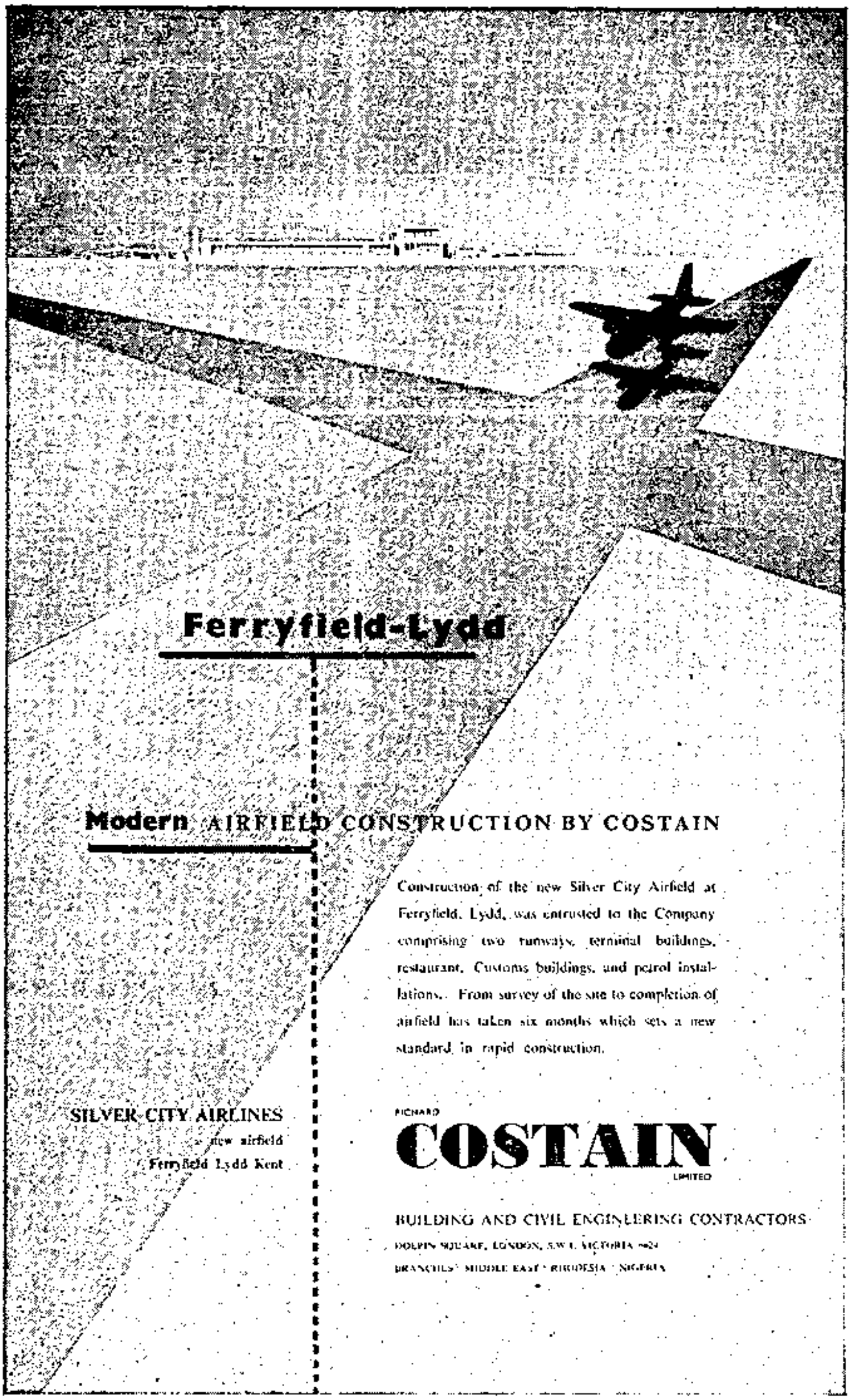
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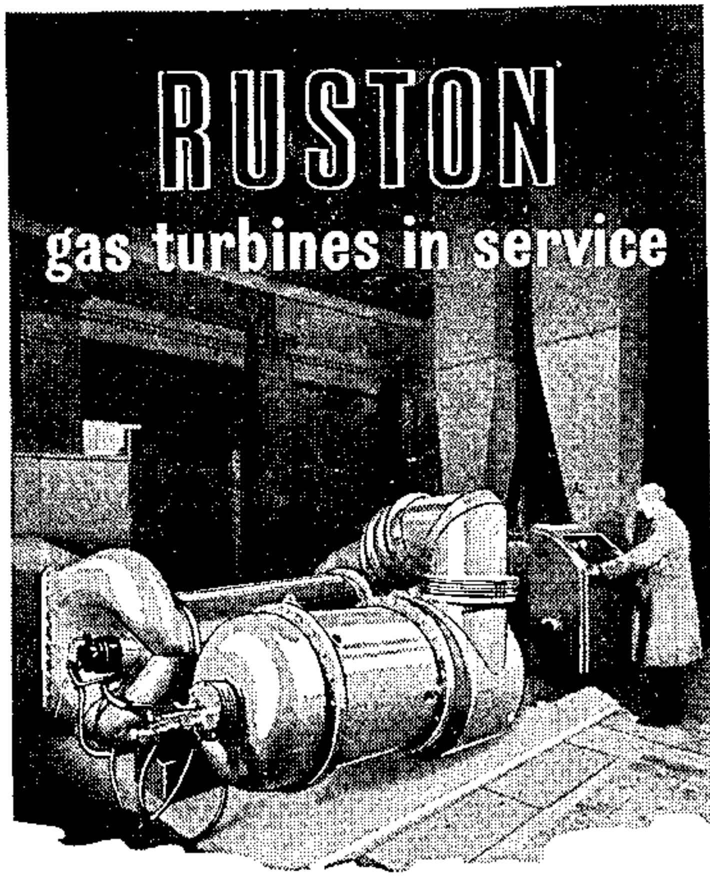
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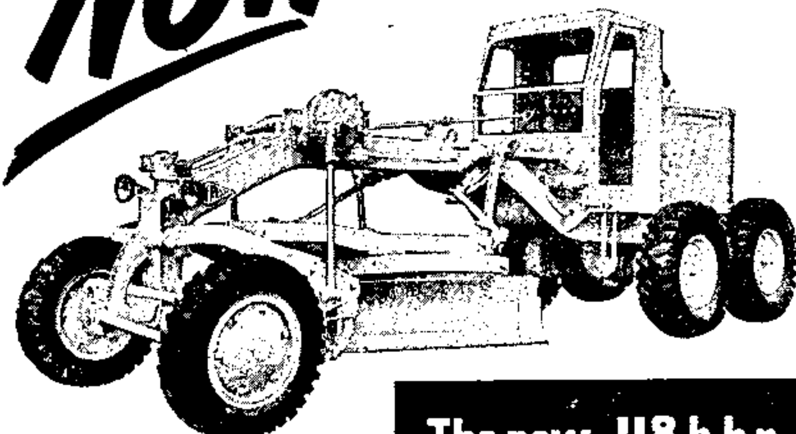

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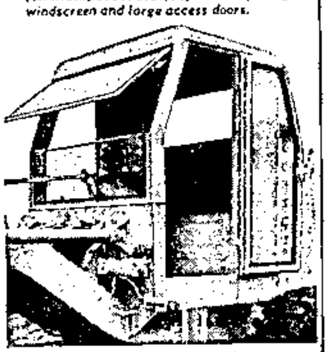

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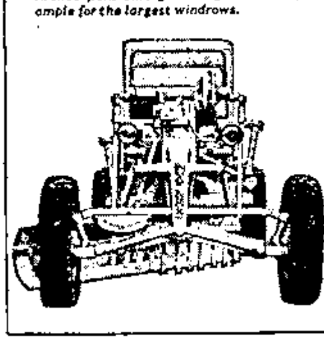

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Presentation Of The Freedom Of The City Of Rochester To The Corps Of Royal Engineers 1

Photo 2.—The Corps exercising its newly granted privilege of marching through Rochester with bayonets fixed.

Presentation Of The Freedom Of The City Of Rochester To The Corps Of Royal Engineers 2

PRESENTATION OF THE FREEDOM OF THE CITY OF ROCHESTER TO THE CORPS OF ROYAL ENGINEERS

By Colonel E. N. Bickford

THE Freedom of the City of Rochester, the highest honour a city can bestow, was, on the 22nd May, 1954, conferred on the Corps of Royal Engineers.

It was an unpromising day, cold with a tendency to drizzle and with a serious threat of rain. The ceremony, however, was to take place whatever the weather; the Director of Music was prepared to sacrifice at least half of his drum-heads, and urgent arrangements had been made to dry all the uniforms before the following day's Memorial Service at the Cathedral. Luckily the rain held off and these precautions proved unnecessary. The City Council started the proceedings admirably by giving an excellent civic luncheon for some 200 guests, and those lucky enough to be invited were well fortified against the wintry weather.

The parade was held in the Castle Gardens, a charming and most appropriate setting dominated by the ancient keep of the castle. Through the Castle Gardens runs a wide tarmac path on the edge of which the saluting base was built, with the dais on the lawn behind it. Stands and enclosures for spectators had been constructed round the edge of the Gardens and looked very gay with flags and bunting.

At 2.30 p.m. the first detachment of troops marched in, preceded by the R.E. Band under the direction of the Director of Music, Major A. Young, R.E. This detachment, 150 strong, under command of Major W. Mills, R.E., was drawn from 10 Trades Training Regiment, R.E., 11 S.M.E. Regiment and 12 S.M.E. Regiment. Their task was to line the circumference of the central lawns of the Gardens. They took post very smartly and few of the audience could have realized how much practice had been necessary for this seemingly simple drill. The R.E. Band then marched and countermarched in quick and slow time in the centre of the arena playing suitably stirring music. At 3.15 p.m. the Casket Party and Escort marched into the arena and formed up in review order opposite the saluting base, the Band taking up position behind them. The Casket Escort consisted of two troops, each of fifty men. No. 1 Troop was formed from cadets of the R.E. Officer Cadet Squadron and was commanded by Captain H. W. L. Browne, R.E. No. 2 Troop was formed from the combined resources of 11 Independent Field Squadron and 71 Field Squadron and was commanded by Captain S. G. Wilkinson, R.E. The Casket Party consisted of one Officer and three Warrant Officers.

By this time the City Aldermen and Councillors had taken their seats on either side of the dais and the Dais Party consisting of Lieut.-General Sir Charles J. S. King, K.B.E., C.B., Major-General J. C. Walkey, C.B., C.B.E. (Engineer-in-Chief) and Brigadier C. E. A. Browning, C.B.E., M.C. (Commandant S.M.E.) were seated.

The presentation Casket containing the Freedom Scroll was brought to the dais by a member of the Rochester City Police and placed on a table. As can be seen in the illustration, the Casket is a remarkably fine piece of silver. It is engraved with the crests of Rochester and the Royal Engineers and the lovely model of a galleon in full sail on its lid symbolizes the fact that the Mayor is also Admiral of the Medway.

The Scroll is beautifully written and magnificently illuminated in gold leaf and colours. Together they form a presentation of which the Corps will always be proud.

At 3.25 p.m. the Mayor of Rochester (Alderman C. H. R. Skipper) preceded by his Mace Bearer and accompanied by the Recorder and Town Clerk arrived at the gate of the Gardens where they were met by two Escorting Subalterns with swords drawn. Next to arrive was the Chief Royal Engineer, General Sir Edwin Morris, K.C.B., O.B.E., M.C., who was received by the Mayor and entered the arena with him. At this moment a trumpeter sounded a fanfare from the top of the Castle Keep, the City flag was broken on the Castle flag staff, and the Union Jack and the Corps flag on staffs on each side of the dais. This was an impressive moment and appropriately the fanfare "Freedom Call" had been specially composed for the occasion by the Director of Music. On the arrival of the Mayor and Chief Royal Engineer at the Saluting Base, Lieut.-Colonel H. T. Heard, R.E., who was commanding the parade, ordered a general salute and reported the parade ready for inspection. At the invitation of the Chief Royal Engineer, the Mayor then inspected the Casket Escort. After the inspection, the Chief Royal Engineer and the Mayor preceded by the two Escorting Subalterns, moved back to the dais where the presentation of the Casket and Scroll was to take place.

In his speech the Mayor spoke of the long association which the Corps of Royal Engineers had had with the City. The Royal Engineers began their association with the Medway Towns in 1812 when they first came to the banks of the Medway and shared quarters with the Royal Regiment of Artillery. He referred to Bishop Gundulph, the King's Engineer in 1078, who was responsible for the building of several important buildings, including Rochester Castle and the Cathedral, and whose successor is the present day Chief Royal Engineer.

He spoke of the Royal Engineer memorials in the Cathedral where are inscribed the names of hundreds of Sappers who have given their lives in the service of their country, a record of which the Corps might well be proud and which is proof of the gallantry which exists within the ranks of the Corps.

Finally the Mayor said that it was fitting that the long and illustrious history of the Corps should be joined to that of Rochester and recognized by the City.

He then directed the Town Clerk to read the Scroll which was worded as follows:—

" To the Chief Royal Engineer, The Officers, Warrant Officers, Non-Commissioned Officers and Men of the CORPS OF ROYAL ENGINEERS.

" GREETINGS: We, the Mayor, Aldermen and Citizens of the CITY OF ROCHESTER in appreciation of your glorious traditions and gallant achievements, and in recognition of the long and happy association between the City and the Corps *do by these Presents* confer upon you THE FREEDOM OF THE CITY pursuant to a resolution adopted by the Council on the twenty-ninth day of September, one thousand nine hundred and fifty-three AND THEREBY the right, liberty, privilege, honour and distinction of marching through the streets of the said City on all ceremonial occasions with bands playing, drums beating and bayonets fixed.

" WITNESS our hands this twenty-second day of May, one thousand nine hundred and fifty-four."

C. H. R. SKIPPER, *Mayor*

PHILLIP H. BARTLETT, *Town Clerk*

The Scroll was replaced in the Casket and the Mayor presented it to the Chief Royal Engineer who then signed the Freedom Roll. Replying to the Mayor the Chief Royal Engineer said:

" On behalf of all ranks of the Corps of Royal Engineers, both serving and retired, I thank you for the very high honour which you are conferring upon us to-day. We fully realize that admission to the Freedom of your ancient and historic City is a very special privilege, and one which has been in existence for many hundreds of years. We are very conscious that this honour is based on the long years of association and friendship between your City and our Corps, built up over a period stretching back to the time of William the Conqueror and strongly reinforced by our mutual co-operation during the last two world wars.

" Our long and honourable association began in the person of Gundulph, Bishop of Rochester, who was also King William the Conqueror's Chief Engineer; and it is from the King's Chief Engineers of those days that the present line of Engineers-in-Chief at the War Office is directly descended.

" Bishop Gundulph not only restored your ancient Cathedral, then almost in ruins, but he also designed and constructed the White Tower of the Tower of London in 1078, and much of Rochester Castle.

"It is therefore singularly appropriate that we should to-day be gathered together in these beautiful Castle Gardens in the centre of your City, where was forged the first link in the long chain binding your City with our Corps.

"A later, and I must admit, a less constructive link, was the demolition by the Royal Engineers of old Rochester Bridge. Built in 1397 by the King's Engineers of that day, it was blown up in 1857, with what the Press of the time described as a 'series of grand explosions,' by the men of the Royal Sappers and Miners, who had demolished the Dockyard at Sebastopol at the close of the Crimea War.

"It is a source of particular satisfaction to us of the Corps that we should be given the honour of becoming Freemen of your City in this year which marks the 27th Jubilee of your lovely old Cathedral, which enshrines many of our Corps Memorials, and which the Corps of Royal Engineers has always regarded, in a special sense, as its 'Mother Church.'

"The Corps of Royal Engineers has great traditions, rooted in history, but like the other Services it moves with the times, particularly so in the extent to which the National Service officer and other rank trains and serves with the Corps. I believe this has greatly increased the number of families in the City of Rochester who have, or have had, sons serving in the Royal Engineers.

"We are very conscious of our responsibilities for the training and well being of these men, who form a most valuable link between the Army and the civil population.

"The ultimate strength of our defence organization lies in the quality of the Territorial and Reserve formations, including the Home Guard, and the speed with which they can be brought into action. If they are to be developed efficiently and economically, these Reserve formations, and indeed the Regular Army also, must rely on close and intimate co-operation, in time of peace, with the Civic Authorities.

"For this reason we are grateful to you, Worshipful Mayor, to your Council, to your civic officials, and to all the citizens of Rochester for their friendship and co-operation with the Corps, and particularly with the School of Military Engineering, who train and work in your neighbourhood.

"You, Worshipful Mayor, as 'Admiral of the Medway' and 'Constable of the Castle of Rochester,' have a dual rôle in activities of peculiar interest to Sappers.

"We too, take a pride in our skill as watermen, and we are vastly intrigued to learn that you have entered a crew of Council officials in the 'Whalers Race' at Rochester Regatta. We shall, I hope be competing with you. Fortifications are the active concern of every Sapper and we are glad to think that your dual rôle of 'Admiral of the Medway' and 'Constable of the Castle' virtually qualify you

Photo 3.—The Mayor of Rochester (Alderman C. H. R. Skipper) making his address from the dais.

Photo 4.—The Town Clerk of Rochester (P. H. Bartlett, Esq.) reading the Freedom Scroll.

Presentation Of The Freedom Of The City Of Rochester To The Corps Of Royal Engineers 3 , 4

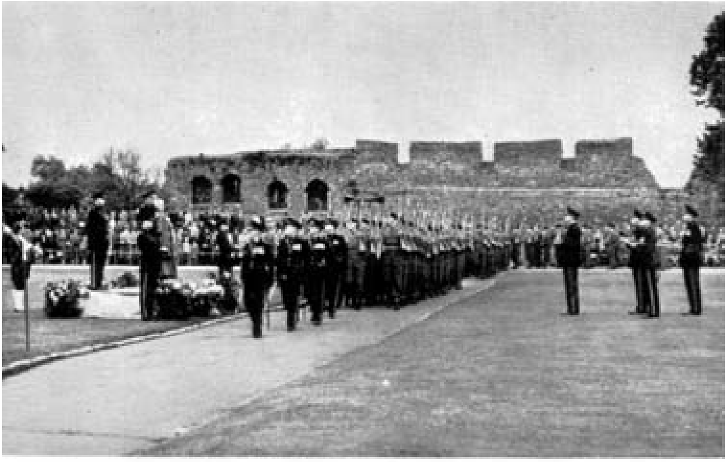


Photo 5.—The march past in column of route.

Photo 6.—The silver casket containing the Scroll.

Presentation Of The Freedom Of The City Of Rochester To The Corps Of Royal Engineers 5,6

to be an Honorary Sapper yourself. It is therefore singularly appropriate that we should be receiving this presentation from your hands.

"The lovely illuminated Scroll and exquisite Casket are truly worthy symbols of the deeper inward meaning implicit in the 'Freedom of the City.' We shall treasure them proudly and house them in the Headquarters Mess of the Corps of Royal Engineers, where they will be seen by Sappers of all ranks passing through the School of Military Engineering, the Headquarters of our Corps.

"I will conclude by assuring you once more how greatly we value the very high honour which you have conferred upon us."

At the end of his speech the Chief Royal Engineer handed the Casket to the officer of the Casket Party, which had marched forward to the dais. The Party then turned about and took post in the centre of the Escort.

The troops lining the arena then formed up to march off. Lieut.-Colonel H. T. Heard, R.E., advanced to request permission from the Mayor to march through the streets of Rochester with bands playing, drums beating and bayonets fixed. This being given, the parade marched past the Mayor and the Chief Royal Engineer in column of route. Our newly accorded privilege then became a matter of some anxiety. The road immediately outside the gate of the Gardens is exceptionally steep and very slippery. It had been negotiated many times on rehearsal with varying success, but never had the surface been so wet and there was now the additional hazard of fixed bayonets. However, the column marched away without any casualties and were given tea by the City Corporation in the neighbouring hall. The Casket Party, which had remained behind, then led a combined Civic and Military Procession, headed by the Chief Royal Engineer and the Mayor, and made up of the Dais Party and the Aldermen and Councillors of the City of Rochester, back to the Guildhall where the Casket was placed on view for the rest of the day. It was later installed in the Headquarter Mess in Brompton Barracks in time for the luncheon on the following day at which the Mayor and Councillors were entertained by the Corps.

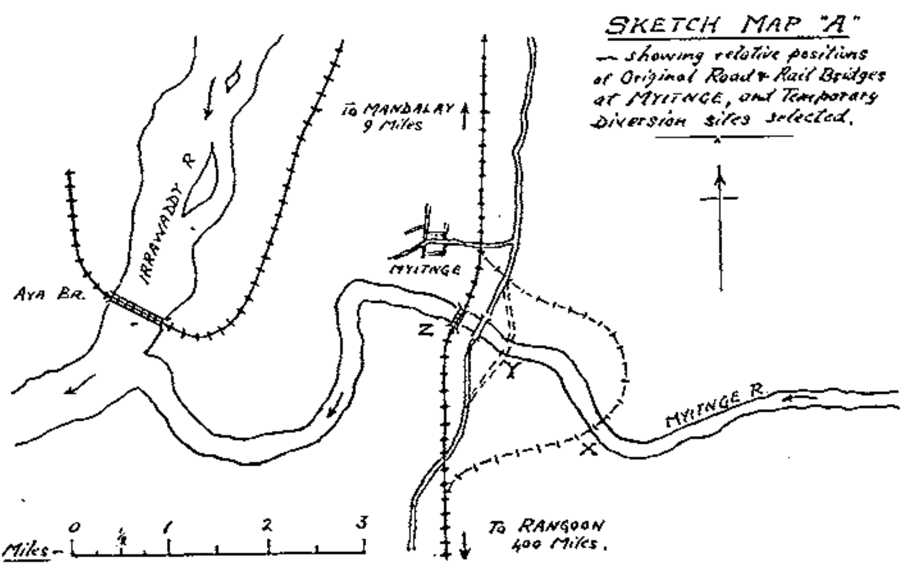
So ended an historic occasion. The ideal setting, the dignity of the ceremony and the smartness of the troops had all combined to make it one which those who were present will long remember.

THE MYITNGE PROJECT—1946

By Lieut.-Colonel J. J. D. Groves, M.C., R.E.

ALTHOUGH the second World War ended in Burma in August, 1945, there remained a vast amount of work for the Army to do before demobilization was even to begin.

To the Sappers this meant:—The rehabilitation of essential roads and railways. Just like that! It was no small task. First the Japanese had pushed us out of the country in 1942, and we had blown up everything there had been time to blow up as we went; next during the Japanese occupation, the R.A.F. bombed bridges intermittently and long-range Chindit forces enjoyed blowing more things to bits; finally, in the reoccupation phase, the Japs had done their level best to return the compliment.



Now to examine the situation at Myitnge (see sketch map "A"). The Myitnge River, flowing out of the Shan Hills in the East, joins the Irrawaddy nine miles south of Mandalay. About three miles from the confluence, the only main road and railway from Rangoon crossed the river at Myitnge village, on two separate bridges about 200 feet apart, where the river was roughly 600 feet wide. The road bridge had been a continuous lattice girder affair supported by concrete-filled steel columns placed in pairs about a hundred feet apart. The railway had been carried on six massive steel Warren trusses (five of 150 ft. and one of 80 ft. span) supported between bank abutments by five brick piers—of which more later!

Both these bridges had been completely demolished during the war and steel wreckage of all spans lay in a tangled mass in the Myitnge river beneath the damaged piers.

During the advance of the Fourteenth Army upon Rangoon early in 1945, the Engineers had patched up the piers of the Myitnge railway bridge and pushed across a prodigious Bailey—a triple-girder, triple-truss, continuous bridge, measuring 830 ft. between bank-seats. And it had to carry not only all the road traffic for the southward advance, but the metre gauge railway for Jeep-powered railway trains as well (see Photo 1).

So it was when peace came on "V-J Day." This quarter-mile Bailey bridge of doubtful stability had become the ultimate one-way bottleneck for all traffic between north and south Burma—apart from that which floated on the Irrawaddy, or could fly. Civilian and military lorries plied to and fro continuously. Locomotives drawing trains from the south had to be disconnected and the trucks shunted across in threes and fours by a small shunting loco, before the train could be reassembled on the north bank and lugged on to Mandalay by a waiting steam locomotive of normal dimensions. Also, at dawn and dusk, traffic over the bridge was limited to bullock carts and pedestrians only. Few bridges could have rendered more precarious service to so many trusting passengers and varied loads.

But peace and rehabilitation meant an end to this haphazard state of affairs. The engineer problem now was—how to reinstate pre-war road and rail traffic across the Myitnge river *without* interrupting the present essential flow of either!

Commander 471 Army Group, R.I.E., allotted the task to C.R.E. IV Corps Troops Engineers, and on it he employed:—

75 Field Company R.I.E. (K.G.V's.O. Bengal S. & M.).

2 (Faridkot) Field Company, R.I.E.—in the early stages only.

305 Field Park Company, R.I.E. (Bombay S. & M.).

A Plant Troop, R.I.E.

An Engineer Battalion of Japanese surrendered personnel.

Also a Railway Bridging Company, R.I.E. was attached for special purposes.

Units were concentrated and reconnaissances made during December, 1945, and by New Year's Day preliminary work had begun.

The over-all engineer plan was as follows (see Sketch Map "A"):—

(i) A diversion railway bridge, served by a newly constructed loop-line, was to be built at X.

(ii) A Bailey pontoon road bridge was to be put across the river at Y.

(iii) When the foregoing was completed, the existing temporary road-cum-railway Bailey bridge at Z would be dismantled.

(iv) The abutments and piers of the original railway bridge at Z would be rebuilt as necessary, to carry a new Warren girder bridge ordered from India.

The Diversion Railway Bridge

So far as this account of the project is concerned, it must suffice to say that the diversion railway bridge was successfully completed by the Railway Bridging Company, Royal Indian Engineers, without a hitch. The Bailey they built was a deck-loaded, single-storey, quadruple-truss affair, whose 40-ft. spans were supported by timber pile piers, which had been driven by a pile-driver mounted on the cantilevered end of a Bailey construction-bridge that had been progressively launched across the river as the work proceeded.

It was a fascinating job, and it always afforded us (whose responsibility lay at Y and Z) much entertainment and admiration—to walk upstream and watch the game at X.

This bridge was opened to traffic on 20th February—just two months after work first began.

So much for that part of the project—though it is a pity that no photographs to illustrate it are available.

The Diversion Road Bridge

The Class 40 Bailey pontoon road bridge at Y also presented no great difficulties. The approach from the south involved about an equal amount of cut and fill over approximately 150 yards, but this was readily handled by the Plant Troop, R.I.E.

At the north bank there was a cliff, fully thirty feet high, of light red clay. To cut an approach through this for access to the bank-seat was an immense labour, which the Plant Troop fairly revelled in. Not until this was done, could the bank-seat grillages, of Christchurch Cribs on railway sleepers, be built—nor the landing bays be launched.

The total distance between bank-seats was 576 ft. At each end a 90-ft. triple-single landing bay was boomed out on a Class 70 landing bay pier, having a Christchurch crib superstructure and distributing girders of our own design.

Again, from each of these piers was launched a 70-ft. double-single landing bay, resting on standard Class 40 landing bay piers.

Two end-floating bays and four floating bays—with 5-ft. gaps between landing bays—made up the whole 576 ft. of bridge.

Pontoon piers had to be anchored far upstream in the fast-flowing current, and each pier had to be provided with timber cut-waters to fend off the flood debris which was to be expected when the rains came.

This bridge was opened to traffic on 13th January (see Photo 2).

So far so good. With both diversion bridges completed—it was then possible to get on with the job of dismantling the triple-triple Bailey horror at Z.

But before we leave the Bailey pontoon road bridge so blithely—let us dwell now on the difficulty we had in keeping it open to traffic continually during the rains in June—while the river rose.

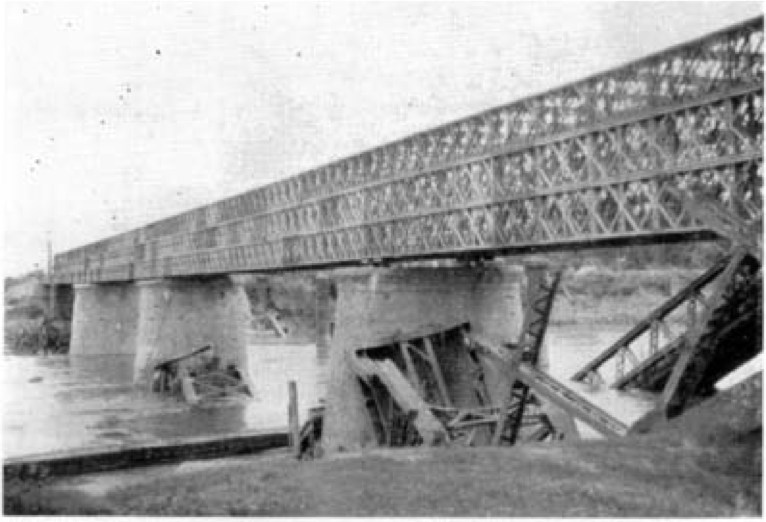


Photo 1.—Site "Z", December, 1945. The 830 ft. temporary Bailey bridge, showing original brick piers and wreckage of pre-war Warren girders.

Photo 2.—Site "Y" January, 1946. The diversion pontoon road bridge, with the continuous Bailey at Site "Z" 200 yards downstream.

The Myitnge project 1 , 2

Photo 3.—Site " Z " April, 1946. Concreting in progress at No. 5 pier. Construction bridge laid to stump of No. 4 pier.

And rise it did! Twenty-four feet it rose—but at a fairly steady rate of just under two feet a day.

Pontoon achors held and cut-waters did their job, but it will take no mechanical science tripos to see that something had to be done about the bank-seats and approaches.

The maintenance of this bridge in that crucial fortnight became a veritable nightmare. At the same time there was a crisis at site Z—which will be dealt with later. But the troops available were now strained to the utmost. As the flood water rose steadily, jacking at each bank-seat had to be absolutely continuous as more steel cribs were inserted and bolted to the ones beneath. At one critical stage when a grillage had slipped the jack operators were working entirely submerged in 4 ft. of water—only surfacing when they stood upright for a "breather" as the next man took their places. But this under-water method was soon discarded, when a scheme was evolved of bolting some projecting Bailey panels to the top chord of the landing-bay—so that the jacking could be done on dry land some twenty feet from the bank-seat.

But it was not only the bank-seats that required constant attention —for as they were raised (eventually by about twelve feet), so it became necessary to extend Bailey causeways, of single-single construction, back up the approach roads at each bank.

We did manage to keep ahead of the rains—but only just. Bridge maintenance was continuous in three eight-hour shifts per day—working strength, three platoons at full strength, including M.T. drivers.

The Indian Sapper and Miner Companies worked in rotation with the companies of the Japanese Engineer Battalion which was under command. These J.S.P. units, with their own officers directing them, worked very well. They appeared to be determined not to be outdone in prowess by the Indian units, and certainly did not let us down.

Some of the lessons which emerged from this part of the project were:—

(i) Provision of adequate cut-waters to protect pontoon piers. We used timber frames with oil-drums attached to increase buoyancy.

(ii) Provision of foolproof grillages—picketed firmly where wet clay may cause slipping.

(iii) Early anticipation of extra stores required to cope with rise in water-level, and their careful lay-out at the site.

(iv) Most thorough organization of maintenance parties—reliefs —feeding—and prompt issue of rum ration when occasion demands.

(v) Work the J.S.Ps. relentlessly—and never look surprised if they exceed your expectations.

The Main-Line Railway Bridge

Now to examine in more detail the task presented at Z site (see Sketch B).

The south abutment had been completely destroyed—so a new one of concrete was to be built.

Piers Nos. 1, 2 and 3 appeared to be undamaged.

Pier No. 4 had an ugly great crack in it, bomb damage presumably, and would require careful vetting.

Pier No. 5 had been completely destroyed. The original brick pier had been replaced by a temporary Bailey pier. A new one of solid concrete was now needed.

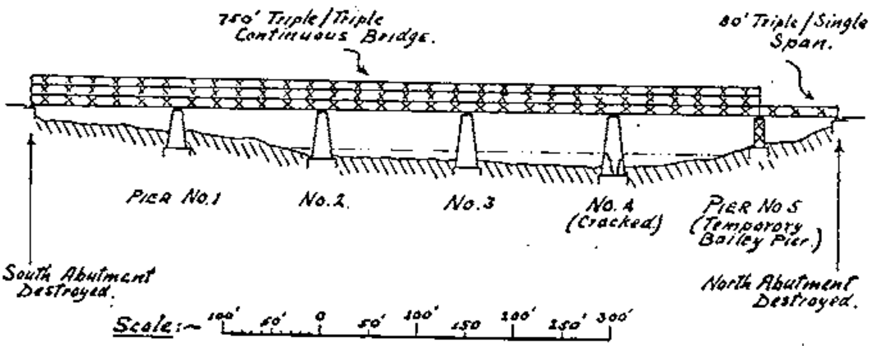
The north abutment was also missing—more concrete required.

The original Warren truss girders, as already mentioned, lay twisted in agonized confusion between and around the base of the piers.

SKETCH "B"

MYITNGE BRIDGE ~ Site Z.

Showing Temporary Bailey Bridge and damaged foundations.



Note:– Wreckage of original Warren Girder Bridge Not shown.

New Abutments

Thus, while work was proceeding on the diversion bridges at X and Y, no time could be wasted in pressing on with preliminaries at the main railway bridge—Z.

"Hyster" winches were strained to their limit in trying to drag the steel debris away from the piers, in order to prevent scouring effect of the current. In this our efforts were partially successful, but with the help of explosives and oxy-acetylene cutting sets, the worst of the wreckage was removed.

About a mile upstream, where the river ran through shifting channels, was an inexhaustible supply of sand. But before loading into tippers it all had to be bull-dozed into piles and screened by

Japanese labour. Our 1-in. to 3-in. aggregate requirements were met by Burma Railways, who undertook delivery by rail. Huge timber bins for both sand and aggregate had to be built alongside the railway embankment at each side of the river. Into these the tippers and rail-flats discharged their loads, and the flow of sand (or aggregate) into the Japs' carrying-boxes could thus be controlled.

Briefly—by the time that the railway diversion bridge was ready for traffic on 20th February, all preparations had been completed at site Z. The next operation was to strip down the great triple-triple Bailey to a skeleton of single-storey construction. At the same time rocking-rollers were jacked into position at all points of support (it was still too heavy for fixed type rollers) and the railway track and decking was removed.

De-launching and dismantling then proceeded smoothly, and was completed in four weeks.

Shuttering for the new abutments at each bank had meanwhile been erected and concreting proceeded—as a continuous operation until both abutments were finished.

A New Pier No. 5

Before starting on the new concrete Pier No. 5, 75 Field Company was ordered to build the timber shuttering. This is shown in position in the centre of the composite photograph No. 3, and it really was a fine bit of carpentering—18 ft. high, with rounded ends and faces battered to a slope 5 : 1 as for the original brick piers. Also it had to be built in sections in order to facilitate erection and dismantling.

Another consideration was that of getting the concrete from the mixers into this huge tower of shuttering. Again—a close examination of photograph No. 3 shows how it was done.

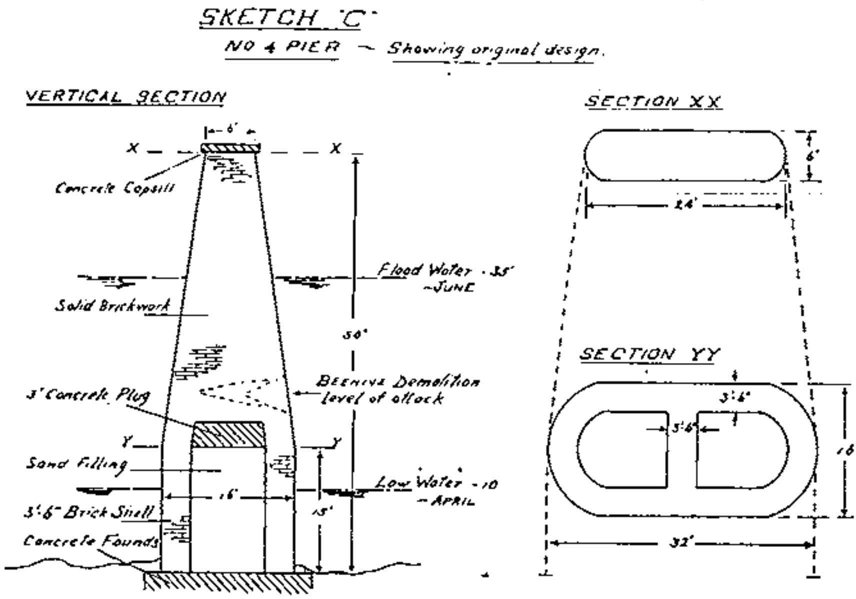
Sand and aggregate gravitated from the bins into the J.S.Ps'. carrying-boxes. These were tipped by hand into each of the four concrete mixers which were working simultaneously. The mixers discharged their concrete into corrugated iron troughs mounted on scaffolding, which directed it down into a home-made elevator, of 1½ cu. yds. capacity, which was itself a hopper with sloping floor.

When the elevator was filled, it was hauled up its steel tower (formerly a railway signal gantry) by cable from a 3-ton winch lorry, tripped when it reached the right height, and the mix poured into the pier shuttering. Here the concrete could be directed to either end of the pier by a man who operated a very "Heath Robinson" but effective kind of see-saw of C.G.I. troughing.

The morning that we started pouring concrete at No. 5 Pier, more than 1 cwt. of grease having been smeared on the inside of the shuttering, excitement was really tense. Officers held their breath (the C.R.E. had his fingers crossed too), the old subahdar of 75 Field Company was scratching his ear, the "jawans" smiled broadly, and only the J.S.Ps. remained inscrutable!

But it all worked like a charm, and No. 5 Pier was "in the bag."

Pier No. 4



Meanwhile a shattering discovery had been made at No. 4 Pier, which stood out in midstream. During March the water level of the river dropped low enough to reveal just how badly it was cracked. In fact there appeared a gaping hole, and a bit of prodding showed that it was nothing more than an empty shell of shaky brickwork—the original sand-filling having been washed out through the cracks!

An obvious solution was to drive sheet-piling around the whole pier and then encase it in reinforced concrete. But after trying to sink some test-piles this idea had to be abandoned, because of the steel wreckage which still lay partially buried in the river bed.

The only alternative was to fill the cracked shell of the pier with concrete. It was therefore decided to cut off the pier 6 ft. above the present water level, i.e., about sixteen feet above the river bed, and then pour the concrete into the cavity exposed.

At this level the pier measured 14 ft. thick and nearly 30 ft. wide. To cut it off with pneumatic picks was out of the question. Any normal service explosives would be likely so to shatter the already damaged base that the pier would collapse on its own foundations—when the *impasse* would be complete.

The solution was Beehives! Twenty-four of these shaped charges were fixed to the face of the pier, and " presto "—the pier was still there! But with that blow we had cut out a nick about three feet deep across the whole width of the pier. So another twenty-four Beehives were fitted into the nick (see Photo 4) and down it came.

When the smoke cleared away, we were relieved enough to find the stump of the pier still sitting on its base, but a little disconcerted to discover solid brickwork where we had cut it off—instead of the cavity expected. So pneumatic drills were put to work, with the air-compressor standing on a Bailey pontoon raft moored alongside.

About six inches of the stump was duly chipped off. Then came another surprise—solid concrete!

There was only one thing for it—continue drilling. Another three feet of it—and we were through to the cavity sure enough.

We could now see how the original pier had been constructed (see Sketch C). The outer shell of brickwork was 3 ft. 6 in. thick, and a 3 ft. 6 in. web-wall in the centre had divided the lower portion of the pier into two sand-filled compartments. The sand had been capped-off by the 3-ft. concrete plugs, and above that had been solid brickwork.

The Downstream Compartment

In the case of our No. 4 Pier, the upstream compartment was certainly insecure, and two great gaping cracks extended from somewhere near the river bed right up to the concrete plug. This will be dealt with under a later heading.

But the downstream compartment was fairly sound. However, the only small crack had been big enough to let all the sand run out in the last two years and our pumps could make but little headway when we tried to drain it dry.

A further complication was that when the sand was washed *out* of these cavities, the soft mud of the river bottom had been washed *in*. Somehow we would have to get rid of all this mud before insertion of the concrete filling could begin on a clean floor.

The Field Park Company accordingly made friends with the Base Workshop in Mandalay and very soon produced a most effective sludge-pump. This was lowered by a gantry through the hole cut in the concrete plug. A battery of three trailer fire pumps was connected to it in series and the result was that mud and silt was ejected at a rate of over two tons per hour. Pumping continued until practically no solid matter was found in the effluent—and then we were ready for the concrete filling.

It had been relatively simple at No. 5 Pier which stood high and dry on the north shore of the river, but it will be remembered that No. 4 stood in about ten feet of fast-flowing water, over a hundred feet from the bank. The solution adopted was to leave our four concrete mixers in their positions, but to re-direct their delivery troughs into travelling-hoppers which ran down "Decauville" tracks fixed to the deck of a bastard kind of half-floating Bailey bridge which connected No. 4 Pier to the shore. This can be seen in the left-hand portion of the composite photograph No. 3.

These travelling-hoppers were counterbalancing in action, and the loaded one would be discharged into the same hopper-elevator that had done so well at No. 5 Pier—and was now to be re-erected on a raft to serve No. 4.

The difficulty here was that there was some twelve feet of water in the cavity to be filled—and we could not pump it out. We had no rapid-hardening cement, so again we had to improvise as best we could. After various experiments and thorough trials the Field Park Company produced this time a sort of "stove-pipe" into which the concrete could be poured, and down which its flow might be regulated so that the mix was emitted at the bottom in continuous "dollops"! At the same time the "stove-pipe" affair could be gradually raised by a chain-tackle and gantry as the operation proceeded.

Again—concreting was continuous until the downstream cavity had been filled solid.

Nobody can say quite how good (or bad) that concrete was—but it *did* set, and as one subaltern remarked: "It couldn't be worse than the muddy water that was there before!" Also the Resident Engineer of Burma Railways pronounced it "Good"—so it was so!

The Upstream Compartment

The upstream compartment, with its large gaping cracks, was a very different problem—and by now (mid-May) we were beginning to worry about the monsoon rains, and flood menace.

So having cut the hole through the concrete plug and pumped out the mud and silt—we added a 4-ft. rim of concrete to the edge of our mangled pier-stump, to ensure that no sudden rise in water-level would put an end to the project. We called this "the anti-flood rim" (see Photo 5).

Then, in order to stop the turbulent effect of the river's current rushing straight into the cavity through the wide cracks, we allowed a large tarpaulin to unroll itself, down the upstream end of the pier's outer face—having weighted the edge of the tarpaulin with short lengths of railway metal. This was fairly effective. But obviously if we were to pour green concrete into the compartment, as we had the other, it would ooze out of the large cracks before it had a chance to set, and since it was not possible to pump the water out, the only way of ensuring a satisfactory job would be to make an under-water reconnaissance, and maintain under-water supervision while it was in progress.

So we persuaded a salvage unit, which was operating on the Irrawaddy above Mandalay, to lend us a Bengali diver—complete with diving helmet, suit, air-line and pump.

By the time that preparations were complete for the descent into our Pier No. 4 a great throng of spectators had gathered on the bank. The Bengali lost no opportunity to dramatize the event, and even after the helmet had been clamped over his head he made a few becoming gestures as he disappeared through that narrow hole in the concrete.

The river level had by now risen until the plug itself was awash, so when once he was through the hole he was lost to view in the muddy water beneath. Pumping continued steadily at the rate prescribed and more air-line was paid out in response to the tugs from below. Then after another five minutes the line went completely slack.

Obviously the expert was satisfied to work without interruption, so those of us who stood watching from the anti-flood rim relaxed again—and pumping continued with the same even rhythm.

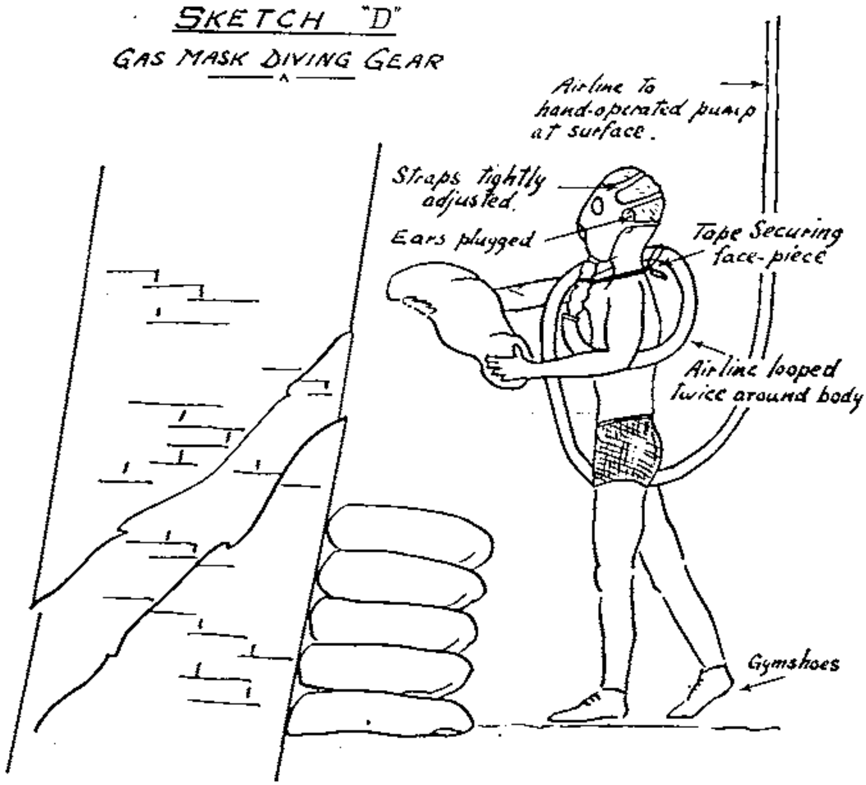
Another minute elapsed. Then suddenly we saw one highly inflated leg of the diving suit frantically lashing about—just beneath the plug hole. Trouble indeed! The Bengali was promptly fished out, and when his helmet was removed his wails of frightened indignation were greeted with roars of applause from the river bank.

But nothing would induce him to repeat the performance. In the murky confines of the flooded compartment he had been gripped by claustrophobia, and in his panic forgot to operate the air-release valve. His suit was consequently blown up as tight as a football, and when he floated up he was trapped, spreadeagled under the concrete plug, until we pulled him out by the leg.

He disappeared within the hour taking his diving suit and helmet, but we insisted on keeping the air-line and rotary hand-pump. Before the day was out we had the air-line shackled to the face-piece of an ordinary gas mask, and were astonished how well it worked (see Sketch D on next page).

However, we were still pondering over the problem of this pier when, one morning it was found that the plug had completely vanished! Actually it had become loosened by all its previous rough treatment and had simply fallen down inside the flooded compartment.

If it had settled fairly and squarely on the bottom all would be well—we could pour concrete on top of it. But no such luck. A fresh reconnaissance in the diving mask revealed it to be wedged just three feet above the bottom, apparently held up by the bomb-distorted brickwork (Sketch E(i)).



By this time we were well into June and the water level had steadily risen. On the Bailey pontoon bridge a little upstream the grim struggle with jacks and Bailey causeways was nearing a climax. Here, at No. 4 Pier we had built up our anti-flood rim around the edge of the pier-stump, until now the depth of water inside was just over thirty-one feet!

We found that only a few people were physically capable of working for any length of time in a greater depth than twelve feet when using the gas-mask diving kit—and these were three of our British officers. As the depth increased each day, two of these officers had trouble with their ears—one being admitted to hospital.

The third had managed to find a good method of plugging his ears—first with grease, then cotton wool carefully tamped in, then a pad with adhesive tape to hold it down, and more grease over the whole lot.

Even so he found it necessary to go down slowly—pausing for about two minutes at 10 ft. depth while the ear drums seemed to take up the pressure—then another two minutes at 20 ft. before going down the full 30 ft. Once down there he found it not too uncomfortable working at that depth for an hour or so at a time.

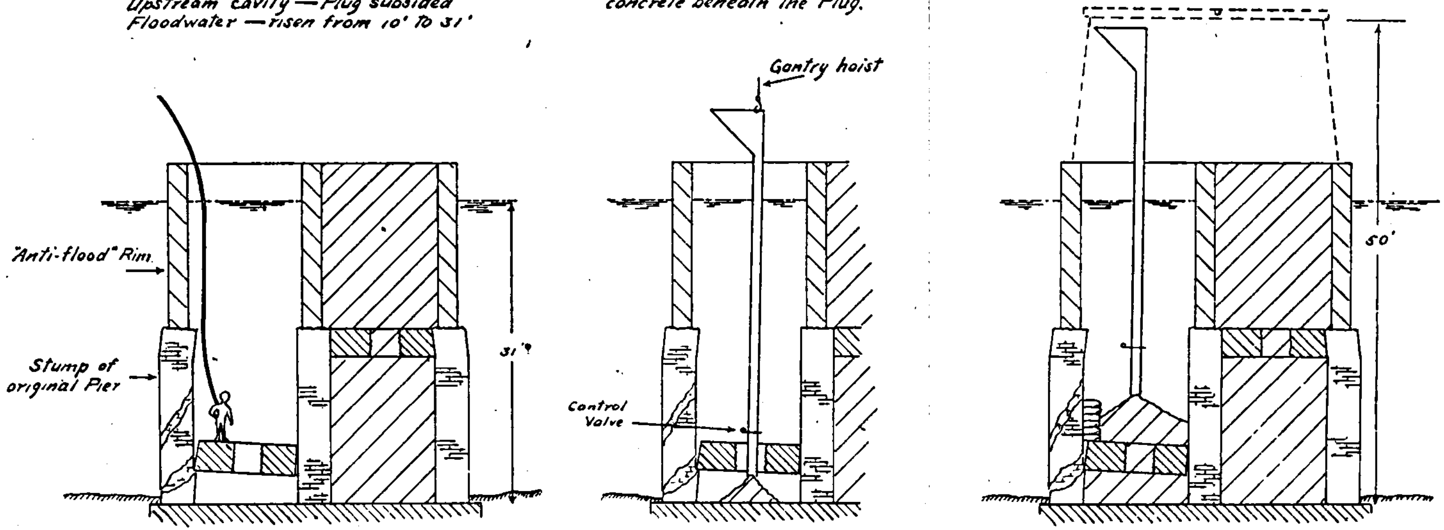
SKETCH "E"

NO. 4 PIER — Progress of Repair

(i) Downstream cavity — concrete filled.
Upstream cavity — Plug subsided
Floodwater — risen from 10' to 31'

(ii) Upstream cavity — pouring concrete beneath the Plug.

(iii) Sealing the cracks — concreting continued.



This was just as well—because it was absolutely essential to know what was going on at the bottom of that cursed upstream cavity, where the concrete plug was jammed.

Here, a few tips about diving with this sort of equipment may be of interest:—

The water of the Myitnge river was quite warm so there was no hardship on this account. But like most tropical rivers, the water was a dirty yellow and so it was not possible to distinguish any objects at a greater depth than 4 ft. except by feel.

In fitting the face-piece of the respirator, it was important that the adjusting straps were severely tightened. To ensure that the face-piece would not easily be knocked off accidentally, when working down below, the breathing-tube was held in place by a tape which was tied loosely round the diver's neck (see Sketch D).

The airline, which was shackled to the respirator breathing-tube, was passed underneath the left arm, up the back and over the right shoulder, down the front of the body again and between the legs, thence up to the surface. The reason for looping it over the body in this fashion was to ensure that no inadvertent tug on the airline disturbed the face-piece, while at the same time both arms were free to work without hindrance.

Apart from his face-piece, the diver wore nothing but bathing trunks, socks and sand shoes. In this instance we found that the usual weighted belt for counteracting buoyancy only a nuisance, because not only was there no diving suit which could become inflated, but there were plenty of hand-holds down below.

Thus it was, that with our diver some thirty feet from the surface to supervise, it was now possible to start pouring the concrete filling into the upstream cavity (see Sketch E(ii)).

We had had some difficulty with our original "stove-pipe" contraption because of a tendency for the mix to arch, and stick in the metal pipe. But now we had a new design—made of canvas, 40 ft. long and tapered from 12 in. top to 24 in. bottom. This was the product of some all-night stitching by the *Mochi* of 75 Field Company, and with it we had no similar trouble.

Our "Stove-pipe Mk. II Canvas" was therefore lowered through the hole in the submerged plug and concreting began. When the top of the mix reached the underside of the plug, the diver would signal to stop pouring and withdraw the "stove-pipe." He then went feet-first down the plug-hole himself and, lying on his back in the restricted space, pushed the concrete out to the edges of the cavity with his feet. This operation was repeated three or four times, until there was no space left for the diver to work in—and he believed that the concrete was fairly well pushed up into the corners. The "stove-pipe" then filled up the remaining crater beneath the plug —and we were ready for the next phase.

This entailed filling the cracks in the outer wall, as well as the remainder of the cavity itself. Sandbags filled with concrete of a strong mix were lowered into the water, picked up by the diver, and placed by hand to seal the cracks (see Sketch E(iii)).

This underwater revetment proceeded by stages of 4 ft. rise at a time, after which the "stove-pipe" delivered its continuous flow of concrete to the centre of the cavity—into which further bags of concrete were also thrown as additional stiffening.

The process was continued until we were safely above any further possible flood height.

During the underwater pouring of concrete, the water within the pier had become so highly impregnated with cement that the diver who functioned in these final stages suffered some rather unpleasant after effects. Wherever the skin became slightly abraised it was attacked by the cement. This included the tips of all his fingers and also the vicinity of contact between the airline and his bathing trunks (see Sketch D). It took over a month to grow new skin, although the effect was fortunately not noticeable at the time he was submerged in Pier No. 4!

The repair of the base of this single pier had been a very arduous business—and the progress so far has been described in detail. This may make it appear rather more difficult than it really was. But the problems facing us could scarcely have been more uncommon and for that reason our solutions are perhaps worth recording.

Rebuilding the top of the pier, to bring it up to rail level, was thenceforth comparatively simple. The shuttering we had used at No. 5 was struck, and re-erected on the firm base we had now built for it at No. 4. The four concrete mixers; the "Decauville" travelling-hoppers; the elevator-hopper; the see-saw troughing—all combined to get the concrete into the right place again (see Photo 6).

With that the Myitnge bridge project was completed, on the 6th July, 1946—just six months after work began.

Conclusion

Let it not be supposed that we thought our repairs to No. 4 Pier had been ideal, or in accordance with any text-book. They were not—but they were practical, and they have been proved adequate.

The technical purist should contemplate also the three main limitations which affected the project:—

(i) *Materials* We had to rely on available surplus war stocks, of which, for example, there was no rapid-hardening cement at all.

(ii) *Equipment.* Unit War Equipment was supplemented only by that which we could " scrounge " or actually fabricate in the Field Park Company.

(iii) *Time.* It was governed by, firstly, the imminence of our own demobilization orders, and secondly, the floods of the monsoon season.

It would rather be labouring the issue to attempt to tabulate the lessons which emerged from our Myitnge experiences. Perhaps the two things which most astonished us were—the effectiveness of our own improvisations, and the prodigious enthusiasm of apparently every Indian sapper and J.S.P. who was employed on the project.

A month later saw the J.S.Ps. being shipped back to their occupied homeland, while our Indian sappers were returning to their country to face the bewilderment of partition and self-government.

We handed over the three bridges at Myitnge to the Burmese authorities as follows:—

At Site " Z." The new abutments and repaired piers were ready to receive the Warren girder spans which had been ordered from India, and Burma Railways were already beginning erection on the south bank prior to launching.

At Site " Y." The pontoon bridge carrying the temporarily-diverted road traffic was handed over to a newly-trained unit of Burma Military Engineers, for maintenance and ultimate dismantling.

At Site " X." Burma Railways continued to run trains over the diversion line until their permanent bridge at " Z " was open When this was so, they were able to take up the metals and hand over site " X " to the P.W.D. as a semi-permanent road bridge to replace the floating bridge at Site " Y."

It may be added by way of postscript that a recent visit to the Burmese Embassy in London has elicited the fact that, in spite of prolonged interruption by the rebel forces in 1947/8, the bridges at Myitnge continue to-day to support all traffic between Rangoon and Mandalay.

At the same time an opportunity has been taken to remind Burma Railways that, in spite of its eight years of good service, the base of No. 4 Pier might well bear an unhurried scrutiny in the light of this article.

Photo 4.—Pier No. 4. Decapitation by Beehive charges. Ready for the second blow.

Photo 5. — The anti-flood rim, showing Indian Sappers and Miners working alongside J.S.Ps.

Photo 6.—Site "Z" June, 1946. Pier No. 4 nearing completion, and the new Warren girder span ready for launching on the south bank.

The Myitnge project 4,5,6

THE 2nd FIELD COMPANY, R.E., 1940–2
FROM DESERT TO THE JUNGLE

By MAJOR K. M. ROBERTSON, R.E.

INTRODUCTION

THE following personal reminiscences of the period 1940–2 were written primarily for the Officer Commanding the 2nd Field Squadron who is bringing up to date a history of the unit. On reading them through I was struck by what a " stick and string " existence we lived in those days. Parts of it might almost have belonged to a quite separate and earlier war. Because of this and because my story almost exactly covers what may be called the amateur period, it is told again here, complete in itself, as a short history of the unit over that time.

It is interesting to reflect how much more professional we have become since then. No doubt we are more efficient, but I doubt if we enjoy it so much. Certainly life in that period never lacked variety.

Twelve years is quite a long time to look back and try and remember the detail of things. Therefore I apologize if there are any inaccuracies.

* * * * *

I joined 2nd Field Company in December, 1940, just in time to see General Wavell's " Exercise " develop into a real battle and end in brilliant victory; our first of the war on land. The company took part in it, albeit a long way back.

For us it started by the C.R.E. collecting together in a hut one afternoon all the carpenters from 2nd, 12th and 54th Field Companies and ordering them to make as many dummy tanks as they could by the following morning. The design was very simple, one squat frame representing the turret on top of another larger and sloping frame representing the hull. Made of timber and hessian canvas daubed with paint, the tanks were to be collapsible so that a number of them could be packed on a 30-cwt. lorry. They were only intended to be low fidelity dummies for misleading enemy aerial reconnaissance. All night long the hut, which had to be repaired and specially blacked-out for the task, shook to the noise of the hammers and sawing of wood as the dummies were mass produced on an assembly line principle. By the following morning eighty had been completed and during the day were moved up to play their part in the battle around Sidi-Barrani.

Leaving Mersa Matruh, we worked our way forward to Bardia, picking up Italian mines, disposing of " Thermos " bombs, mending roads and pumping water both for ourselves and for droves of Italian prisoners as well.

These tasks were normal enough and it was the "free-for-all" system of supply and maintenance which characterized this period for us in the Western Desert. The supply of vehicle spares and the primitive system of repair and maintenance had broken down under the desert strain, so that everyone's transport was in a shocking state. The Italians obligingly left us a stock of their good diesels and any number could be obtained by rummaging about for them. The company M.T. sergeant, McIvor, did us well. A diesel man himself, he searched the desert with a hawk-like eye, both for vehicles and diesel fuel which the Italians also thoughtfully left in plentiful supply. He seldom came back empty handed. For the rest, it was as much as a truck was worth to leave it unattended: it either disappeared or disintegrated. Greedy hands appeared from nowhere to grab wheels, autovac, carburettor, all.

Besides vehicles the Italians also did us well. Their jerseys were cosy and warm and their boots for the small footed not too bad. Our own rations were good but they improved with macaroni and tunny fish added for variety. "Recoaro" water was a passable substitute for soda with whisky and in any case was better than the salty stuff one normally drank.

Perhaps it was bad that such a state of affairs should prevail, but it must be remembered that our administrative services were stretched to the limit. The L. of C. ran for hundreds of miles across desert and before stores ever reached the theatre they had to be shipped all the way round the Cape of Good Hope. Indents were seldom met for a very long time and then only when one's formation was priority for replacements.

Other things were in the wind, however, and in February, 1941, the company returned to Egypt as part of 6th Infantry Division (later re-designated 70th) training to invade an island somewhere (Rhodes?). At Kabrit on the Bitter Lake we had a taste of combined operations, old style; rowing boats and all that. In those days a "L.C.M." was the big thing. The invasion never came off, however, as Rommel forestalled it by his desert offensive. One evening not long before things were due to be loaded at Port Said, we lost all our transport, bar one lorry and a water cart, to the Guards Brigade, who left for the desert in a hurry. Our hopes of peace and ease in our immobility were dashed the following day when we ourselves left for the desert—in a dirty old train.

April and May, 1941, saw us back in Mersa Matruh and in Bagush. We collected a few trucks from somewhere (legally!) and carried on our task as best we could, strengthening the defences and laying mines. These were the old "Gyppo" pattern Mark II with a chemical initiator. A horrible mine, manufactured in great quantities in workshops in Cairo, it did at least fulfil a vital necessity. One cannot but admire the ingenuity of the design which enabled it to be improvised in millions in a primitive country like Egypt.

In spite of receiving from railhead one box-load fully primed and fit to burst, we luckily had no accidents. C.R.E. 4th Indian Division under whom we were working at the time, even saw fit to compliment the company on its mine-laying and disarming rules.

While in Bagush we became affiliated to the 23rd Infantry Brigade and in June were placed under their command for movement to Syria and participation in the campaign against the Vichy French. The campaign was quixotic and short lived. Our brigade fought in the central sector, lying in the plain between the Lebanon and Ante Lebanon ranges. It advanced from Metulla in North Palestine to near Baalbek, with its temples to Jupiter and Venus, in Syria. There was little or no air activity. We boasted a few Martin " Marylands " with blue circles around red circles; the French put up a few " Marylands " with red circles around blue circles. The effect they both had was as great as the difference between them.

It was during the advance that a patrol of the company had the singular distinction of receiving in surrender the keys of Hasbaya—a place of many noisy inhabitants but few houses. The patrol entered with the bren gunner riding a donkey because his feet were sore. The chief gendarme of Hasbaya was standing with his minions drawn up behind him. With pathetic solemnity he approached bearing a great bunch of keys—they belonged to the local jail apparently. The patrol halted (at Temple Bar so to speak) and amid much acclamation and noisy protestations of affection, the keys were handed over. With a magnanimous and almost royal gesture they were duly returned to the gendarme and the patrol repaired to the Police Station for coffee and *arak*. The bren gunner's sore feet had obviously stirred the sympathy of the local transport board for four old chevrolets were produced, the only four, and the patrol became motorized. In this way it rejoined the advance guard at break-neck pace, warnings at danger spots about mines only serving to make the drivers drive faster. The repercussion came on dismounting in front of a rather puzzled advance guard commander—a demand for " baksheesh " and gasoline.

The sapper tasks the company met were, in a small way, nearly all those associated with an advance through broken country. Craters in the road were filled (by hand), mines were disarmed, barricades of stone were cleared and the booby traps in them removed. We even had one river to cross where the bridge had been demolished—the only water obstacle we met the whole time we were in the Middle East. The gap was 96 ft. and was bridged with two spans of small box girder supported by Christchurch cribs on the demolished pier. Later the gap was used for training in more advanced bridging—a large box girder was put up! (See Photo 1.)

After the armistice with the French the company changed its affiliation from the 23rd Brigade to the 16th, with whom we had trained at Kabrit. The division assumed garrison duties and detachments of the company were stationed at Aleppo and at Ain Sofar, 6,000–7,000 feet up in the Lebanon—a glorious spot. Later defences were started in a rather desultory fashion north of Baalbek on the assumption that the Germans might come through Turkey if Russia collapsed. Being a side-show, stores were particularly hard to come by, especially timber. Much of what we got came by nefarious means from a sergeant in the Foreign Legion near Homs. He was an Englishman and it was a pity we could not keep up his acquaintance. I suspect the timber came from out of his troops' billets, or more probably the troops' next door.

It was at this time we reconnoitred the railways from Aleppo northwards into Turkey for demolition. One bridge, the viaduct of Hara Doura, was a colossal steel lattice structure supported on two great steel pylons 250 ft. above a gorge. In remarking to a French railway engineer that it would be a pity to wreck such a bridge, he replied, " That is just what a French sapper said a short while ago when you were coming from the other direction." Fortunately no one had to do it, but we planned to cut both piers and the centre span and this would have sent the whole thing crashing 250 ft. below. (See Photo 2.)

One day in September, 1941, with next to no notice, an advance party from the company boarded a cruiser at Beirut and slipped off mysteriously into the Mediterranean. Very early in the morning two days later the rest of the company found itself on the quayside in Alexandria and within a few minutes was aboard H.M.S. *Jervis*, a flotilla leader bound for Tobruk. It was a happy choice of ship. We had made her acquaintance the year before when she had put in to Mersa Matruh. No praise is too high for the slick good humoured efficiency of the Royal Navy and the hospitality they extended during the twelve hours we were aboard. The voyage was uneventful apart from an unidentified aircraft and a call to " action stations " at sunset off Sollum (the Egyptian frontier), when the fighter escort turned for home. At night the ship was given full steam and it was an exhilarating experience racing through the pitch darkness at over thirty knots, the ship trembling with the speed from end to end.

We entered Tobruk undetected, right under the muzzles of the enemy guns and just forty-five minutes too soon as reckoned by the enemy bombers. We disembarked at the double over a swaying improvised gang-plank laid across a sunken ship. The kit bags were thrown ashore by a feverishly working team of bluejackets. Meanwhile an Australian unit, on relief, was filing aboard by another gangway and the narrow decks were jammed with men and equipment. From one end the tide of Australian bush-hats flowed and from the other ebbed a receding wave of British steel helmets. It was the only positive way of checking how the change-over was going. In fifteen to twenty minutes it was all over, the *Jervis* cast off and turned for Alexandria, we embussed for the brigade holding the eastern sector, and the enemy bombers, determinedly but too late, came in to enjoy an empty harbour.

During September and October such scenes were repeated each night during the fortnightly period when there was little or no moon. In this way the 70th British Infantry Division relieved the 9th Australian Division which had so gallantly held the fortress since Easter. The relief proceeded without loss until the last night of all, a night when the moon was beginning to be a little too bright. The mine-laying cruiser, H.M.S. *Latona*, was seen and bombed. She was not badly crippled, but she used to carry up the ammunition to the fortress and on this occasion she took fire while the fire fighting gear was damaged. She had to be abandoned and sunk by our own gunfire, while her crew and passengers were transferred to another ship and returned to Alexandria. The incident is mentioned because the O.C. of the company, Major Guyon, was in her at the time. He had not accompanied the unit the month before, as he had been sick and on this occasion was on his way to rejoin.

The purpose of our division relieving the 9th Australian was two-fold. Firstly, the Australians had had over six months' continuous fighting and secondly fresh troops were required for the break-out, due to coincide with an advance from the Egyptian frontier in November.

It is not generally realized that the defence and break-out of Tobruk in 1941 was quite a separate and distinct operation from what happened in 1942, when the place eventually fell. They were totally different garrisons on each occasion and between these times our advance had carried far past, to Benghazi and beyond, and Tobruk had lapsed into a L. of C. area. The general public is apt to consider as one, the heroic and successful defence of 1941 and the equally heroic but far less fortunate events of 1942.

On arrival the company was placed in support of the 16th Infantry Brigade, holding about an eight-mile stretch of the perimeter which constituted the eastern sector. At that time there were some 4,000 yards between the opposing front lines, but in the middle of no-mans' land we did hold a series of strong points, isolated by day and in contact at night only. It was an Italian division which faced us, of which I think there were altogether two. This collection was bolstered by one good German division holding the area of the Salient, where the grim Easter battles with the Australians had taken place.

Our initial task naturally enough was strengthening the defences. This involved thickening the minefields, assisting the gunners to dig deeper into the rocky ground, assisting the infantry in maintaining their posts, improving conditions inside the tunnels and galleries which formed the dressing station, overhauling the demolition charges on the Artillery O.Ps. and the mass of bombs with their electric circuits on El Gubbi aerodrome (to be fired in the event of an airborne attack). We mended roads (with sand, stone and sea water!) we dug a hangar below ground with a raising platform for one of the two "Hurricanes" left, we pumped water, we instructed other arms in the peculiarities of the teller mine (new just then). We were indeed quite busy.

As the ground was very largely rock, one of our most treasured possessions was an armoured demolition wagon with a powerful compressor inside. A great steel box of a thing, it was a relic acquired by the Australians from an ill-fated armoured division earlier in the year. Because it was such an obvious target we painted it to look like a derelict Italian lorry and I am glad to say it escaped attention.

While all these things were going on we maintained a section with each of the forward battalions. Their task, besides helping in the construction of defences, was to accompany the infantry on their patrols and deal with the mines. Here we ran up against a difficulty. The infantry whom we were obliged to accompany had orders never to return without making contact first with the enemy. That is every patrol was a fighting patrol—good for morale and ascendancy. That did not always suit our sapper book. Quite often we would have preferred to go out quietly, pick up a few precious teller mines and bring them back for instructional purposes. It was in just such a foray that we had our first casualty due to ground action. Lieutenant Christie and a party of sappers were out with a patrol of 2nd Queens. They picked up their teller mines without event and then had to lug them round while the patrol went on to make contact. In the ensuing engagement the patrol suffered casualties. No doubt useful tactical information was gained but the mines were lost. Among the casualties was Corporal Stevens who I believe died in captivity very shortly afterwards. The moral points to a better liaison with the infantry, where the sapper point of view must be better represented.

As October wore on and November came, preparations for the break-out increased. It was also obvious that the enemy was up to something. He closed up considerably on the perimeter, reducing the distance to some 1,000 yards and mopping up our outposts already mentioned. Coincident with the orders we received for the break-out were others telling us what to do in the event of airborne attack, sea-borne attack and various possible forms of break-in. A strong enemy patrol did at this time penetrate our forward posts in the vicinity of the El Adem road, searched about and went out again. Beyond the anti-tank ditch one night a party picking up mines for the break-out bumped an Italian who claimed he was picking up the same mines for a break-in! In the event our break-out, which was launched from the eastern sector, forestalled the enemy break-in by some three days and it was Germans we found opposing us,

Photo 1.—Quarun bridge, construction of large box-girder.

Photo 2.—The railway viaduct of Hara-Doura.

The 2nd Field Company RE 1940-2 From Desert To The Jungle 1,2

Photo 3.—Tobruk seen across the harbour.

Photo 4.—Tobruk, desertion and ruin.

The 2nd Field Company RE 1940-2 From Desert To The Jungle 3,4

Photo 5.—Ceylon, the company's first jungle camp.

Photo 6.—Up-country Ceylon (5,000–6,000 ft.).

The 2nd Field Company RE 1940-2 From Desert To The Jungle 5 , 6

not Italians. The division from the Salient had been moved round unknown to us for their intended venture over the same ground.

The company's part in all this was to construct eight bridges over the anti-tank ditch to enable our tanks to get out and a ninth bridge for returning traffic. A platoon (Christie's) was to be attached to the infantry cover screen while the bridging went on. The anti-tank ditch varied between twenty and fifty yards in front of our forward posts and could be bridged in each of the chosen places with a stock span of R.S.Js. Our difficulty was that the ground was rocky and much work was entailed in sinking the bank-seats so that the deck would be level with the ground. Being in front of our posts, work with picks, in order to be quiet, was slow. Booby traps along the edges of the ditch had to be cleared as well. The work was undertaken some nights previous to the break-out by ourselves and the 54th Field Company, who until the break-out had temporarily relieved us in the eastern sector. 2nd Black Watch, who held the line at that moment, provided listening posts farther out into no-man's-land. Besides being quiet, care had to be taken that the excavations were filled with wood and covered with sand, so as not to draw attention from the air the following day. The sites were chosen in conjunction with 1st R.T.R. who were to use the crossings when the time came. Being so mobile they had a disconcerting habit of asking if the site could be moved fifty yards or so after a nights' digging. However, goodwill prevailed in the end and sites favourable to all were developed. About the same time the "map reference muddle" appeared. The desert is featureless and, with only small-scale maps, it was not surprising each site accumulated more than one reference until it looked as if there might be twenty bridges not nine. Once the bank seats were dug however, this trouble disappeared.

Sound carries far in the desert and the lorries carrying the bridges were to be stopped some 400 yards short of the site and the equipment manhandled from there. The decking was to be wrapped in hessian to muffle the familiar rattle and no spikes were to be used—everything was to be lashed. For the lorries, easy starters were stipulated and no diesels. Transport was by then in such a state that it was not an easy condition to fulfil.

On the night of 21st November the break-out silently began. 2nd Queens sent out the infantry screen and 2nd Field Company, with a detachment of 12th Field Company to help, laid their bridges according to plan. Just before dawn the "Matildas" rumbled up and crossed over. As the sun came up all hell broke loose. A stray Italian officer, soon captured, paid the company a pretty compliment. "The sappers did their job impeccably," he told the interrogating officer, "the first we knew of the attack was the tanks approaching our lines." For the rest it was grim fighting, for as I have said it was Germans who appeared in the sector and not Italians.

As was only to be expected, the bridges were shelled fairly heavily but escaped serious damage. One was hit, but only part of the decking splintered.

To summarize; as a piece of bridge building it was perhaps very simple, but as a bridging operation to be executed undetected in front of one's own forward posts, it was an achievement.

There then followed a precarious period in the life of the fortress. A narrow corridor was driven to the Ed Duda feature and manned by the 14th Infantry Brigade. It was originally intended that, after some forty-eight hours, forces advancing from the Egyptian frontier should link-up with the corridor. Rommel put in a bold counter-stroke, however, and the advance from the frontier went out of gear. The result was that the fortress corridor was left in the air, not for forty-eight hours, but for about three weeks. Inside the fortress, with its perimeter some thirty miles long, there were no reserves at all. It was fortunate a stalemate ensued, the enemy also lacking the resources for an attack. During this period all three Field Companies (2nd, 12th and 54th), busied themselves mining the flanks and end of the corridor. And so November passed into December with its biting cold winds and occasional rain.

The advance from the frontier eventually got under way again, the link up was made and Tobruk fortress ceased to exist as a separate entity, becoming a normal integral part of Eighth Army. It was then when the battle had moved on that the company's most unpleasant task of all had to be done and it was the one in which we suffered the most casualties. We, together with 12th and 54th Field Companies, were ordered to pick up all the mines between the old perimeter of Tobruk and El Adem. These minefields were extensive and having been fought over and subjected to shelling were in a very sensitive condition. The Germans too had not yet learned what we had just learned about sympathetic detonation. Their teller-mines were laid too close and on one occasion the exploding of one mine had set off a line of 900. Finally the only records held, and they were sketchy enough, were our own.

Therefore it is not surprising that we soon started losing lives. Lieutenant Gompertz was killed disarming a teller-mine, the ration truck on its way out to the working parties went astray and blew up killing the driver and the ration N.C.O. More and equally tragic accidents followed.

In disarming teller-mines our practice, learned from the Australians, had been to push in the arm and remove the cap before lifting the mine. It was not long before it was observed that this very act sometimes exploded the mine. There were Italian mines too, laid by the Australians, where the shear wire had corroded and been replaced by a match stick! From then on, whenever possible, mines were destroyed *in situ*.

This task of clearing mines made December, 1941, and January, 1942, gloomy months, which were not improved by seeing our division go back to the fleshpots of Egypt while we remained to finish the clearance. It finished in due course, however, and the Chief Engineer Eighth Army, Brigadier Kisch, himself killed on a mine later, expressed himself well pleased.

A brief stay in Egypt was followed by a move to Syria where the company was stationed in the hills outside Damascus and in sight of Mount Hermon. Thick snow lay on the ground, the camp was inadequate and cold. It was lucky our stay was short. As happened when we were in Syria before, brisk orders came for a move and the company headed south into Palestine. The odds were on a return to the desert, since Rommel was beginning his offensive which eventually carried him to El Alamein. The guess was wrong, however, as an excited Sapper pointed out at a halt in Palestine. " We're for Blighty," he exclaimed, " You go and ask the engine driver— He's going to Suez! " But the Sapper too was wrong, we were meant for Rangoon, but it fell before we got there.

At Suez the company embarked with the 16th Infantry Brigade Group in the *Nieuw Amsterdam*, justifiably the pride of the Holland-America line and the Dutch merchant Navy. Alone and at speed the ship zig-zagged its way across the Indian Ocean to arrive in mid-March at Colombo. Rangoon having fallen meanwhile, the brigade was used to strengthen the garrison of Ceylon, which was woefully weak, while the remainder of 70th Division went to India.

Two more different places than the Western Desert and Ceylon it would be hard to choose. Instead of the barren and featureless windswept spaces were the neat plantations and humid jungles. Having once found it hard to obtain a trickle of water from aqueducts the Romans built, we now learned what it meant to be visited by tropical storms which raised the level of the rivers fourteen feet in one night. The people of the Middle East, and Egypt in particular, are voluble, dirty, quick to show their feelings, rude and aggravatingly persistent. The inhabitants of Ceylon on the other hand are an aloof and enigmatical people, clean, silent, polite, but underneath the surface are passions which often lead to murder.

There was a great deal new to learn. The ways of the Germans and the Italians we had come to know, but the Japs by all reports were something quite different. Exaggerated myths, unworthy of us, began to grow up about them. Commanders were groping for some form of tactics which would suit the conditions then so unfamiliar. They were embarrassed by the scale of transport which blocked the narrow roads and which in Malaya had proved an easy prey to encirclement. Ideas were needed on how to whittle down the overlarge administrative tail. The light khaki clothing needed changing for olive green. White mosquito nets had to be dyed and cut to suit hanging in tents and among trees and not from barrack-room ceilings. As in the desert before, the first of the old institutions to go was the topee and again nobody noticed its passing.

On arrival the company, with the 16th Infantry Brigade, was stationed at Peradinya near Kandy. The place was later to become Lord Louis Mountbatten's Headquarters. Our first task was to assist the brigade in improvising some form of camp until more permanent camp structures could be obtained. The brigade's coming had been unexpected and very little had been arranged. The totally new conditions after a sea voyage made the first few weeks somewhat rough.

Jungle training soon began in real earnest and it was not long before we learned a bitter lesson in what watermanship on rivers in the East really means. Four valuable lives were lost when an assault boat was carried over some rapids in the Mahaweli Ganga, some miles below Kandy.

Apart from training, preparations had to be made to meet a Japanese invasion should it come. In these the company had to find a permanent demolition party to stand by the long railway bridge which crosses the Mahaweli Ganga thirty miles inland from Trincomalee. A large bridge of vital importance, it was essential that it should not fall intact into an invader's hands. Yet a more difficult target to protect, and at which to maintain a bridge garrison, it would be hard to find. Right in the middle of thick jungle, the only access was by the railway itself and for this purpose a rail-car was placed at the company's disposal. The greatest risk lay in the fact that a small enemy party could easily infiltrate through the jungle from the uninhabited coast and capture the bridge before it could be destroyed. For climatic and other reasons the bridge could not be kept indefinitely at state of readiness "A." Quite a pretty little tactical problem and I don't pretend that we ever solved it. As it happened the Japanese never came. Without them, maintaining the demolition party "out in the blue" and keeping them on their toes was difficult enough.

It is with the 2nd Field Company training in jungle warfare and preparing to play its part if the Japanese invaded Ceylon that this reminiscence must close. I was posted to another company of 70th Division, then in India. Although I followed the subsequent doings of 2nd Field Company with a close interest, there are others who are better qualified to record them than I. I hope they will tell of how the company went to India and played "longstop" in the Arakan Campaign. Of how they joined Bernard Fergusson's brigade for the second excursion of the Chindits into Burma. And how in Burma they pioneered routes for their brigade through the deepest of jungles, helped to construct "Aberdeen" airstrip and attacked Indaw.

IMJIN FERRY

By CAPTAIN H. D. VERNON-BETTS, R.E.

INTRODUCTION

THIS article is written from the point of view of the troop commander on the spot for the benefit of other troop commanders both present and future. Some of the material in it may be of interest to more senior ranks and perhaps some of the incidents and comments may remind them of the pleasures (and frustrations) of being a troop commander.

GENERAL

The ferry operations with which this article deals were carried out in front of our F.D.Ls. during August, 1951, in the middle of the rainy season in Korea. There was no enemy activity during the period, all warlike activities being confined to our own forces.

The country in the immediate vicinity of the ferry was almost all paddy or ploughed fields with one fair-weather approach track, about two miles long, from the main road to the ferry site. Movement off the track was usually impossible due to our own minefields. The ferry was for personnel only and the track was, therefore, only required to carry a small amount of traffic. There was a large unmined ploughed field at the ferry site which served as a parking and off-loading area.

At this point the River Imjin was about 550 feet wide when operations began. The home bank was a cliff, 150 feet high, down which steps had to be cut. The cliff continued below water level, giving a minimum depth of six feet at the water's edge. The far bank shelved gradually at a slope of about one in ten and was of coarse, sandy gravel, interspersed with large rocks.

It was decided that the site was suitable for a flying ferry, the equipment to be used being the American M.2 raft. This is composed of open bipartite pontoons of wooden construction, with wooden box-shaped treadways clamped to the handrails of the pontoons. Three piers were used with sufficient treadways to provide a 6-ft. ramp at each end. This type of raft can carry a Class 9 load.

The operation can best be divided into three phases, each phase covering a flood period.

PHASE I

Troops

Two troops of a field squadron R.E. were engaged, each relieving the other in turn. These reliefs were very necessary owing to the extremely uncomfortable living conditions on the site. In addition Troop Commanders arranged their own reliefs by sections, usually one section at a time being on the site.

Building

It was decided that the rocket propelled Holdfast was the best method of getting the cable across the gap. This fearsome instrument consists of a 6-ft. spike with a rocket on the end. Attached to the end of the spike is $\frac{3}{8}$-in. R.A.F. balloon cable coiled down in a series of tubs. The rocket is mounted on a launching rack, pointed in the general direction of the other bank, and fired electrically. At the top of its flight the rocket curves over and falls, sticking into the bank on the far side. All went well on this occasion except that the spike did not stick in. However, the cable was across the gap.

Buried baulk anchorages were dug on either bank, that on the home bank being about thirty yards back from the cliff edge. On the enemy bank a sheer legs was erected. The cable was passed through a snatch block suspended from the top of the sheers by a steel wire strop. This system was used to prevent the movement of the cable cutting the sheer lashing.

A simple home-made traveller was used, with $2\frac{1}{2}$-in. cordage guys belayed round the upstream treadway at opposite ends of the raft. In addition a safety line of balloon cable was clamped round the beam of the traveller and round the centre of the upstream treadway. Later a timber baulk was lashed across the boats on the upstream side of the same treadway and the safety line was secured to this.

The cable was tensioned by means of a straight pull with a carrier. The end of the cable was passed round the buried baulk and a towing cable clamped on a considerable distance forward of the anchorage. The carrier then pulled on this towing cable until the main cable was tight. The end was now clamped round the anchorage, the carrier slacked off and the towing cable was removed. The cable was about ten feet clear of the water at its lowest point which was near the enemy bank. On the home bank the cable was about seventy-five feet clear of the water.

This method of tensioning, although it worked, is not to be recommended. Control of the carrier is not fine enough and towards the end of the haul, as the cable comes out of the water, a slight movement of the carrier results in a very large increase in the tension of the cable. When the command to stop is given it takes a moment for the driver to apply his brakes. During this interval the carrier slips back and tension is lost. In this case the cable had to be overtightened to counteract the slipping back and fortunately the cable finished up in the right place. This was probably more good luck than good judgement.

Flood I

The ferry had just been completed when the Troop Commander was hit by flying fragments while trying to shoot a hole through a steel picket. (This is a good way of making a hole, but it cannot be done with high tensile steel pickets. These were !) Happily he was not badly hurt and the other troop took over shortly afterwards.

The first heavy rain fell at once and came down in torrents from 2000 hrs. to midnight and spasmodically for the rest of the night. By dawn the river had risen about five feet and the current had increased from its normal 2 ft. per sec. to about 5 ft. per sec. All equipment was intact. The river continued to rise until midday, reaching a maximum height of 9 ft. and a speed of 7 ft. per sec. Large quantities of debris were coming down, mostly logs and pieces of Chinese improvised rafts. Ferrying was quite out of the question and all efforts were concentrated on preserving the equipment.

From this time onwards systematic readings of depth and current speed were taken. These readings later proved of considerable value in forecasting the behaviour of the river in subsequent floods and also in forecasting when ferrying could be resumed.

Operations

By the following morning the river had dropped sufficiently for the power utility boat to operate. The quantity of debris had diminished, but the current was still too swift for the raft.

Information now came through that this was the only ferry in operation on the divisional front and that a patrol of about 700 infantry and porters, who had been trapped on the enemy bank by the flood, were to return over it.

At about 1400 hrs. a successful trial run was made with the current running about 5 ft. per sec. This speed was undoubtedly excessive and the raft required careful handling to avoid straining the cable and the guys. At 1500 hrs. the infantry started to arrive on the enemy bank. The ferry operated continuously for the next five hours without a stop and without a hitch.

The importance of a simple but sound organization for loading and unloading cannot be too strongly stressed. When men are exhausted after a long and difficult patrol, they are in no mood for being " mucked about." All assistance that *can* be given by the crew *must* be given. A helping hand for the men as they climb aboard, an extra lift with a Bren gun, a pat on the back, all help in the smooth running of the ferry.

In this case all loading took place on the down-stream treadway. Six men were put into the stern half of each pontoon, starting with the offshore one, and a further six were spaced along the treadway, making a total pay load of twenty-four. Unloading was carried out in the order, inshore pontoon, treadway, centre pontoon, offshore pontoon. This ensured that the inshore pontoon did not ground during unloading.

Controlling the raft was not easy, due to the slope of the cable. This entailed constant alteration in the lengths of the guys during a crossing. Command of a flying ferry cannot be taught from a book. It is a matter of practice over a considerable period. Not just one or two trips, but upwards of a dozen or more are required before complete confidence comes.

The advantages of a good crew are many. In operating a flying ferry in a strong current orders must be given and obeyed in split seconds. Delay in obeying the orders of the commander may cause disaster. A common result of delay is that the raft gets broadside on to the current, throwing a terrific strain on the cable and on one of the guys, the other being slack. This is a difficult position to get out of and happened three times to our ferry in the initial stages. Fortunately control was regained each time before any damage was done.

The crew numbered eight, composed of two in each end pontoon on the guys, one in the centre pontoon controlling the S.W.R. safety line, two breastline men and the commander. It was found that a ninth man, preferably a senior N.C.O., was very useful as a sort of deputy commander and general odd-job-man. In addition there were two breastline men stationed on each bank.

Administration and Communications

The mud caused by the rain created considerable administrative problems. While passengers could march to road-head on the main road if necessary, supplies for the ferry detachment had to come in by vehicle. The fair-weather track soon cut up and eventually only carriers could get through.

Rations were exclusively American "C" type rations, a very useful pack under these conditions. Water supply was another problem. Owing to the turbulence caused by the flood, water could not be drawn from the river and all drinking water had to be brought in cans from the nearest water point. Another case of "Water, water everywhere, nor any drop to drink"!

Communications on squadron and regimental nets were difficult, if not impossible, owing to very heavy interference from other stations. The best method of communication was by telephone from a near-by Australian listening post. On the site however, excellent internal communications were maintained on No. 31 sets. One was usually placed on the raft, the other on top of the cliff in charge of the troop operator on the squadron net. Results were always good in spite of the blanketing effect of the cliff.

Phase II

Operations

Ferrying now continued spasmodically for about a week. Patrols of up to company strength with porters were ferried both ways. At one stage night ferrying was carried out. This presented no unusual difficulties, but called for greater care in reducing speed before coming in to the bank. A certain amount of difficulty did arise over seeing the " traveller " in the dark. The correct positioning of the " traveller " is, of course, the key to successful control. Fortunately it was almost always possible to obtain a silhouette against sky or water. A spot of luminous or white paint might well be an advantage.

Flood II

Again the weather broke and torrential rain brought another flood. On this occasion rain fell during the afternoon and throughout the night, resulting in an overnight rise. By dawn the river had risen sixteen feet and was still rising. Current speed was up to 10 ft. per sec. and very large quantities of debris were coming down, including parts of an American M4 rubber pontoon bridge farther up stream. The sheer legs on the far bank were three parts submerged.

At 0700 hrs. the cable started to dip in the water and at 0715 hrs. it caught the first piece of debris. This was a large log about twenty feet long and about twelve inches thick. The cable " played " this log for about five minutes, alternately allowing it to float downstream and then, as the tension took up, whipping it clear out of the water and hurling it far upstream like a leaping salmon. Eventually the log was thrown off and in rapid succession two more were caught and " played." The last was a massive log which, after a few minutes, caused the sheer legs on the far bank to overturn. About 200 feet of the cable flopped into the water. Every five seconds the cable was swept downstream, tightened, and leapt out of the water in a sheet of spray only to fall back in again. It was a most impressive sight with the cable behaving in almost human fashion. Time and again it leapt clear over a mass of debris which, if it had caught, must have snapped the cable. Sometimes the cable would make its leap as a log was passing over it, and the log would soar twenty or thirty feet into the air. The cable lasted six hours under this treatment and eventually parted under a large load of debris at 1300 hrs. It was an excellent demonstration of the strain which this type of cable can withstand.

The river eventually rose to a height of 18 ft. above its original level, with a current speed of 11 ft. per sec. No equipment, other than the cable, was lost. It should be noted that the traveller was withdrawn to the top of the cliff when the flood started.

Rebuilding

The original troop now took over the task of replacing the cable. A rocket propelled Holdfast was again used with similar results to the first one. Again, however, the cable was got across the gap. The sheer legs and the enemy bank anchorage were both moved back about fifty feet to higher ground.

Considerable difficulty was experienced in tensioning on this occasion, and several methods were tried. A quick-release device was incorporated, the cable being parted and joined by shackles close to the home bank anchorage.

Tensioning was first tried with a D7 bulldozer. The only result of this was that the 'dozer bogged down in the heavy mud. An attempt was then made using the P.C.U. of the 'dozer with a single gain tackle. This attempt was abandoned when the P.C.U. nearly caught fire ! Another 'dozer with a winch on it was summoned to tension the cable and unbog the first 'dozer.

While waiting for this to arrive it was decided to try using an ordinary cordage tackle and manpower. Somewhat to everyone's astonishment this method worked ! The tackle was a 2 × 2 using 2½-in. manila cordage with about fifteen men hauling. The tackle was left in place hooked into one of the shackles for future tensioning and to operate the quick-release device if required.

It should be mentioned that the purpose of the quick-release device was to enable the cable to be lowered on to the bottom of the river in the event of another flood. Whether this would have saved the cable or not is open to doubt. During the next flood the ¾-in. S.W.R. cable at another ferry farther upstream was parted although it was lying on the bottom. This may have been due, however, to the sheer legs floating free and dragging on the cable.

Operations

While rebuilding was in progress, the river dropped to its normal level and ferrying restarted as soon as the cable was in place.

The river continued to drop and eventually the stage was reached when there was insufficient current to operate as a flying ferry. An attempt was made to employ outboard motors with the raft still attached to the traveller, but this proved too dangerous and too difficult to control. For a short time afterwards the raft was used as a free ferry with a single outboard motor. This did not prove very satisfactory owing to the unreliability of the motor and the fact that it only had two speeds, " flat-out " and " stop " ; usually " stop." Eventually the raft was taken out of service and the power boat, with a pontoon lashed on either side was employed instead. A contributing factor in taking this step was that the enemy bank shelved more and more gradually as the water dropped until the raft was grounding fifty feet from the water's edge.

The power boat ferry was quite successful, although it could not safely take as many passengers as the raft. Also, as it had to go about 200 yards upstream on the enemy side to find deep water, the time of turn-round was much longer. Fortunately, owing to the tactical situation, the ferry was not in great demand and the power boat could cope easily with all traffic.

Administration and Communications

During the second flood the mud problem became much worse, a case in point being the bogging down of the 'dozer. The road, which had recovered somewhat during the dry spell, rapidly became completely impassable to all vehicles except the occasional carrier. All credit is due to the excellent Sapper drivers of these carriers for getting through under such conditions. Few could have done it. As it was, supplies for the detachment often had to be brought up by porters, when even the carriers could not get through.

This brings up an important administrative point, and that is that all small detachments should carry a twenty-four hours reserve of rations. This particularly applies to engineer units who are so often scattered about in "penny packets" in inaccessible places. The extra strain imposed on the "tail" in having to get rations up in the first really bad twenty-four hours could have been avoided if a reserve had been carried.

Wireless communications were still the same. Very bad usually on the No. 19 and 62 sets but perfect on the V.H.F. 31 sets.

Phase III

Operations

As the weather improved, work was concentrated on a new ferry farther upstream. This was to be a Class 50/60 vehicle ferry and consequently the road became a top priority. The mud became less of a problem as the new road moved forward towards our ferry site and then swung away to follow the line of the river to the new site. Routine work continued at the old site while construction of the approaches and the installation of the cable proceeded at the new one.

Flood III

On the 28th August heavy rain started to fall soon after dawn and continued all day. During the afternoon winds rose to near hurricane force, bringing with them a torrential downpour which lasted for nearly two hours.

By midday the river had started to rise slowly and precautions were taken at both sites to safeguard the equipment. The current during the slack period had been down to 1 to 1½ ft. per sec. Now the familiar pattern started again. The first debris appeared, the river rose and the current increased. One company was, however, ferried back between 1600 and 1700 hrs. in river speeds of 8 to 9 ft. per sec.

Word now came through at our ferry site that, emboldened by our success, another patrol of nearly two companies would also be coming back across it as soon as they could get there. This was the largest party for some time and as things turned out they could not have chosen a worse time.

By 1800 hrs., when the first bedraggled figures began to appear on the enemy bank, the river had risen 18 ft. and the current was up to 10 ft. per sec. Considerable amounts of debris were beginning to appear and the river was rising at a rate of nearly three feet an hour.

It was decided to try to take the raft across on a trial run in spite of the conditions. Under careful control it made the first crossing successfully, although there was constant danger of water coming in over the bows. Both the Commanding Officer and the Squadron Commander were on board. In spite of the successful crossing however, it was obvious that, with any worthwhile pay load, the raft would be too dangerous.

The return trip started with six infantry as passengers. Half-way across, with water heaping up round the bows, one of the guys snapped. The raft immediately swung head on to the current and stopped, held only by the safety line. For half-an-hour the raft hung in the middle of the river with the water rising and increasing quantities of debris swirling past on both sides. By some miracle the raft was not actually hit although there were some very close shaves.

Eventually, a jury rig was organized with the safety line and the remaining guy. Slowly the raft edged towards the bank until it was close enough for a breastline to be thrown. The raft was pulled in and a slightly shaken crew and passengers stepped thankfully on to dry land.

The time was now 1930 hrs. and the river had risen 23 ft. Current speed was up to 12 ft. per sec. and all hope of ferrying had to be abandoned. During the night the river rose to a record height of 32 ft., with an estimated current speed of at least 15 ft. per sec. At 0400 hrs., in spite of all precautions, the water reached the cable and the fierce current soon parted it.

Soon after dawn the river started to go down. Large Chinese log rafts, bits of bridge and innumerable logs were pouring downstream in an endless flow. About 1000 hrs. a successful crossing was made with the power boat alone, dodging debris on the way over. The patrol started to come back six at a time and by 1500 hrs. all were safely across. All credit must go to the American operator of the power boat for his skill in this operation.

Conclusion

It was decided soon afterwards for tactical reasons, not to reconstruct our ferry and all efforts were concentrated on the new one which went into operation a few days later.

The ferry had been in operation, in one form or another, for three weeks, during which time it had survived one flood and been washed out twice. It was undoubtedly at its most efficient as a flying ferry in speed, load and reliability, the three essentials of a good ferry.

Many lessons were learnt or re-learnt and, for the benefit of those who might have to operate a ferry under similar circumstances, these lessons and some observations are given below :—

1. Tensioning a long cable *can* be done by hand. Do not despise the "old-fashioned" methods. In this case 650 ft. of ⅝-in. S.W.R. were tensioned by hand. Fineness and accuracy of control are essential.

2. Where used, sheer legs and anchorages must be placed well back and above the highest known flood level. Although the cable itself acts as a fore and aft guy, an upstream guy (or two in "V" formation) is recommended. If this had been used during Flood II the sheer legs would not have overturned and the cable might have held.

3. Safe operating speeds of current should not exceed 4 to 5 ft. per sec., while the minimum figure is about 1½ to 2 ft. per sec. Under this speed, operation of a *flying* ferry becomes uneconomical.

4. Accurate and conscientious river readings are essential for forecasting river behaviour. The first job on starting a new crossing should be the installation of depth and current indicators. Make sure that the depth indicator is long enough to cope with the highest possible rise.

5. The importance of safety precautions cannot be too strongly stressed. These apply to the equipment as much as to the personnel. Small things like paddles in the boats, a lashing on the outboard motor, bailers, spare lashings, and of course life-jackets, while obvious, are often overlooked and their absence when needed may well cause disaster. It is difficult to lay down a standard set of safety precautions. The only way to do it is to think of all the unpleasant things which *could* happen and then take action to deal with them if they *do* happen.

6. The rocket propelled Holdfast is a useful method of getting a cable across a wide gap. One hundred per cent spares are essential however, and do not count on the spike sticking in.

7. Do not forget the importance of a *simple* but sound organization for loading and unloading. Simplicity is the keynote. Spend a little time working out *how* you are going to give your orders to the passengers and try to make the *reason* for the order apparent when you give it. A "happy" ferry is an efficient one.

8. The supply of rations, water and new equipment presents an everlasting and everchanging problem. In our case the mud was probably exceptional and the difficulties greater than might normally be expected. However, the importance of reserve rations for isolated detachments is a lesson it is better not to have to learn the hard way.

Author's Note.—Since this article was written in October, 1951, extensive research with the rocket Holdfast has proved it to be highly effective and a very useful device.

A NOMOGRAM FOR FRICTION LOSS IN PIPES

By CAPTAIN R. G. BORTHWICK, B.Sc., R.E.

INTRODUCTION

THE use of nomograms for calculating the pressure loss, due to friction in pipes is not new, and some justification is perhaps necessary for inflicting upon the indulgent reader yet another of these labour-saving devices.

The military engineer now deals with a variety of fluids and requires a simple and rapid means of calculation of pressure loss without resort to tables and slide-rule. The accompanying nomogram has been designed to meet this need, and is thought to be unique in that it can deal with more than one fluid. By its aid, friction losses may be measured to the degree of accuracy normally demanded in the field, for all the fluids liable to be encountered, other than steam or air (see Appendix A). In order to indicate the derivation of the nomogram, its limitations and use, the subject of fluid flow is considered briefly and practically.

FLUID FLOW

On the subject of fluid flow much has been done and is still being done. All experiments agree and theory shows that the Manning formula (1) is true and forms a basis for further experiment. The loss of head in feet of the fluid per foot length of pipe (hydraulic gradient):—

$$\frac{h}{L} = \frac{4fV^2}{2gD} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where V = Velocity of flow in ft. per sec.
D = Diameter of pipe in ft.
g = Acceleration due to gravity.
and f = a friction factor which, by analysis and test, is known to be a function of Reynolds Number (R_e)

Reynolds Number R_e is a dimensionless ratio expressed as:—

$$R_e = \frac{VD}{\nu}$$

where ν is the kinematic viscosity of the fluid.

For laminar or streamline flow the Reynolds number is below 2,000 and the friction factor $f = \frac{16}{R_e}$. In most practical cases R_e is greater than 3,000 and the flow is then turbulent. The friction factor, under such circumstances is more difficult to define mathematically, and various authorities have fitted formulae to the results of experiment on smooth pipes.

Blasius[1], Stoever[2] and others give the form:—

$$f = C.R_e^{-n}$$

where values given by authorities vary, e.g.

Lewitt[3] $C = 0.064$ and $n = 0.23$
Blasius $C = 0.08$ and $n = 0.25$

for values of R_e up to 10^6.

McAdams[4], Stanton and Pannel[5] and others give the form:—

$$f = a + b\ R_e^{-n}$$

which follows the experimental curve more closely up to R_e of 4×10^6. All of the above formulae apply to smooth pipes only. For rough pipes Prandtl[6] has given a different function derived from the more recent experiments of Nikuradse. This includes a roughness factor obtained from the measured degree of roughness in the pipe.

Practical Considerations

In practice, the condition of the pipe surface is difficult to assess at any time, and will vary both with the material and the state of any corrosion that might occur. Consequently, it would be more reasonable to base the frictional loss on the most adverse condition expected. This may only be guessed from experience and is likely to vary considerably, so that one formula to cover all fluids and pipe conditions in practice will only be approximate. The problem therefore resolves itself into how close an approximation can be found, within the limits of a simple formula.

In the present case, a nomogram is required based on a formula to cover the following fluids normally dealt with by the military engineer:—

Water—for Domestic supply and heating.
Brine—for refrigeration.
Fuels—for bulk petroleum installations.

It would be convenient to include in the nomogram both steam and air, but this has been found to be impracticable and a separate nomogram is given for these. (See Appendix A.)

The first fact that emerges from consideration of the fluids given is that, whereas water is likely to cause quite a considerable change of pipe roughness due to corrosion and tuberculation (formation of organic growth, etc.), this will not be so in the case of petroleum products. Secondly, military installations are quite often of a temporary or semi-permanent nature so that in the short time of use, little change of pipe condition may be expected. This latter indicates

[1] Blasius H. *Mitt Forschungsarb* 131 (1913).
[2] Stoever, H. J. *Applied Heat Transmission*. McGraw Hill (1941).
[3] Lewitt, E. H. *Hydraulics*. Pitman (1949).
[4] McAdam, W. H. *Heat Transmission*. McGraw Hill (1942).
[5] Stanton and Pannell. *Transactions Royal Society* (1914).
[6] Prandtl, L. *Forschungsheft V.D.I.* 361 (Berlin) (1933).

the use of the smooth pipe formula, whereas the former requires some account to be taken of expected roughness after a period of use. In the case of the petroleum products this will give a margin for increased demand which may occur in war-time.

As explained previously, expected roughness during use is difficult to assess, and will not be attempted here. It is more logical to consider new pipe, which has some initial roughness and, if necessary, increase the friction factor to meet expected future changes in pipe condition. The formula for smooth pipe (e.g., glass) will therefore be adjusted to allow for the initial roughness of new pipe. Drew[7] and Heywood[8] have both shown in experiments on new steel pipe that this is practicable up to R_e of 10^6 with a deviation of $\pm$ 10 per cent in f.

Pipe Material

One other fact must be considered, and that is the material of the pipe and its diameter. Even in the new condition, the roughness of, say, a cast iron pipe is not to be compared with that of a similar steel pipe, and as the diameter increases so the relative roughness decreases. So it is necessary to decide on a common pipe material and limit the diameter range.

For material, only steel (which includes wrought iron) need be considered. Some petroleum lines may use rubber, in which case the values for friction loss will be a little high thus leaving a margin of about 10–20 per cent for increase of capacity. Cast iron and concrete will not be considered as these have only limited use in the service.

With regard to diameter, only the range from ½ in. to 10 in. (the maximum likely to be used) has been considered.

Formula Derivation

It is now necessary to derive the formula to be used, in the light of the above. With the fluid flow unlikely to exceed a Reynolds number R_e of 10^6, the friction factor will be taken as $f = C\,(R_e)^{-n}$, adjusted for new steel pipe of a mean roughness ratio of $\frac{D}{K} = 1{,}000$. From Drew's curves, the values of the constants valid ($\pm$ 10 per cent) up to a Reynolds number R_e of 10^6 for this roughness ratio are $C = 0.06$ and $n = 0.2$.

Hence:

$$\frac{h}{L} = \frac{V^2}{D} \cdot \frac{4}{2g} \left(0.06 \left(\frac{VD}{\nu} \right)^{-0.2} \right)$$

(D in ft. and ν in ft.^{2} sec. units.)

[7] Drew, T. B. and Genereaux, R. P. *Transactions A. Inst. Chem. E.* (1936).
[8] Heywood, F. *Proc. Inst. C.E.* 219 (1925).

Simplifying:

$$\frac{h}{L} = 0.00373 \frac{V^{1.8}}{D^{1.2}} (\nu)^{0.2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Converting to d in inches and ν in centistokes:

$$\frac{h}{L} = \frac{0.00373 \times 19.7}{9.8} \frac{V^{1.8}}{d^{1.2}} (\nu)^{0.2}$$

$$= 0.0075 \frac{V^{1.8} (\nu)^{0.2}}{d^{1.2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This is in fair agreement with the formula proposed by Dr. Blair (Proc. I.M.E., 1952) who gives for water ($\nu = 1$) in new steel pipe:—

$$\frac{h}{L} = 0.00728 \frac{V^{1.8}}{d^{1.24}}$$

This, with similar formulae for other types of pipe, was obtained from consideration of all available data to date, and gives a value for the loss a little less than that obtained from the proposed formula(3).

Other well known and much used formula of the same type may also be compared, e.g.

Hazen-Williams:

$$V = 1.318\, Cm^{0.63}\, i^{0.24}$$

hence i or $\frac{h}{L} = \frac{49.8}{C^{1.85}} \frac{V^{1.85}}{d^{1.166}}$

Substituting the value $C = 120$ for new steel pipe

$$\frac{h}{L} = 0.00664 \frac{V^{1.85}}{d^{1.166}}$$

This formula is in general use in the U.S.A. for oil pipelines and gives values generally larger than that obtained from formula (3) for water and petrol, and would allow for probable corrosion.

Thrupp:

$$h = \frac{L.V^2}{3{,}200\, D^{1.24}}$$

i.e., $\frac{h}{L} = .00681 \frac{V^2}{d^{1.24}}$

This formula is quoted and the values tabulated in R.E. Vocab. Group III, Section 15, Subsection 3, for water and are greater than that obtained from formula (3).

When considering fluids of varying densities, it is more convenient to consider the frictional loss as a pressure loss in lb. per sq. in. (p).

To convert: $p = \frac{h \times \text{Density}}{144} = \frac{h \times 62.3 \times s}{144}$

(where s = specific gravity of fluid relative to water at 60° F.)

Similarly, the flow measurement is more conveniently measured in gallons per minute (G) rather than velocity (V).

$$G = 2.05\ Vd^2$$

$$\therefore\ V^{1.8} = \frac{G^{1.8}}{3.63\ d^{3.6}}$$

Substituting the above in the proposed formula (3)

$$\frac{h}{L} = 0.0075\ \frac{V^{1.8}}{d^{1.2}}\ (\nu)^{0.2}$$

$$\text{gives}\ \frac{p}{L} = 0.000894\ \frac{G^{1.8}}{d^{4.8}}\ (\nu s^5)^{0.2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The term in brackets is a function of the fluid only and varies with the temperature. Therefore, it can be conveniently scaled on the nomogram against the various fluids at selected temperatures. The values for the term $z = (\nu s^5)$ are tabulated below for the given fluids:—

Fluid	*Temperature*	ν	s	s^5	$z = \nu s^5$
Water	60° F.	1.11	1	1	1.11
	120° F.	0.57	0.988	0.941	0.536
	140° F.	0.472	0.983	0.918	0.434
	160° F.	0.41	0.981	0.905	0.371
	180° F.	0.362	0.979	0.899	0.325
Brine Na Cl 20%	20° F.	3.11	1.159	2.092	6.51
	10° F.	3.87	1.162	2.12	8.23
	5° F.	4.38	1.164	2.14	9.37
Avgas	32° F.	0.74	0.737	0.217	0.161
	68° F.	0.62	0.72	0.189	0.117
M.T. Gas	32° F.	0.95	0.746	0.231	0.22
	68° F.	0.76	0.73	0.207	0.157
Avtag	32° F.	1.35	0.795	0.317	0.429
	68° F.	1.07	0.78	0.29	0.31
Avtur	32° F.	2.80	0.814	0.357	1.00
	68° F.	1.82	0.8	0.327	0.595
	104° F.	1.35	0.786	0.281	0.38
Dieso	32° F.	8.0	0.863	0.476	3.8
	68° F.	4.6	0.85	0.445	2.043
	104° F.	3.1	0.837	0.41	1.27

How to Use the Nomogram (See Plate 1)

The nomogram consists of five vertical lines, one of which is unscaled and is referred to as the support line. The four scaled lines are, from left to right, the fluid line ($z = \nu s^5$), the d line (pipe diameter in inches), the G line (flow in gallons per minute and barrels per hour), and the p line (pressure loss in lb. per sq. in. per foot run and per mile).

The nomogram may be read from any direction, which means that, given the fluid in the pipe, and two of the three remaining quantities d, G and p, the third may be found. Thus, for the example shown, water at 60° F. is to be pumped at 500 gallons per min. in a 5-in. diameter pipe, the pressure loss per foot run of pipe is required.

With a straight edge, join the fluid line at the point Water 60° F. to the G line at 500 g.p.m. and mark the point of crossing the support line. From 5 in. on the d line lay the straight edge to pass through this crossing of the support line and to read the value of 0.0285 lb. per sq. in. per foot run of pipe on the p line.

Knowing the pressure head available, the diameter of the pipe required may be found. For example, if 0.03 lb. per sq. in. pressure were available per foot run of pipe and it is required to deliver 500 g.p.m. of water as before, laying the straight edge from 0.03 on the support line, gives a diameter between 4 and 5 in. In such a case, the nearest pipe diameter above is taken, i.e., 5 in. in this case and the actual pressure drop will be 0.0285 lb. per sq. in. per foot run as before. In the same way, knowing the pipe diameter and pressure head available, the delivery rate may be obtained.

In reading the nomogram the following points are to be borne in mind:—

(i) The support line must be crossed with each pair of readings.

(ii) The readings are limited to new steel or wrought iron pipe and will be approximately 10 per cent too low for cast iron pipe and 20 per cent too high for synthetic rubber piping.

(iii) The readings are also limited to turbulent flow between R_e 3,000 and $R_e.10^6$ when inaccuracy increases rapidly. If in doubt, R_e may be checked from the following:—

$$R_e = \frac{3{,}780\ G}{d\nu}$$

G = gallons per min.; d = pipe diameter in.; ν = kinematic viscosity centistokes

It is suggested that the nomogram be detached, pasted on a piece of hardboard and varnished. A strip down the support line must be left unvarnished for pencil marking the crossing of this line.

Conclusion

The work which the military engineer is being called upon to undertake is daily increasing in complexity. The design of water supply and bulk petroleum lines is already a common Sapper task and a knowledge of pressure losses in such lines is essential.

It is hoped that the use of this nomogram will simplify the problem of pressure loss and allow a considerable saving in officers' time. If so, it will have achieved the object for which it has been prepared.

APPENDIX "A"

Steam and Air

The transmission of steam and air in pipes presents a more complex problem than that for liquids previously discussed, for two reasons.

Vapours and gases are compressible and, consequently, with a fall in pressure due to friction, there is a corresponding change of volume and density. As the weight flowing past any section per second is constant, it is more usual in this case to consider the quantity flowing in terms of weight. However, the change in density along the pipe also means a change of kinematic viscosity, but luckily this change is small for the normal range of pressure loss met in practice and can be conveniently neglected.

The second complexity is that the flow may be isothermal, adiabatic or at constant total energy. For example, compressed air flowing in a pipe is an isothermal flow, i.e., the temperature remains constant with exchange through the pipe wall; on the other hand, with superheated steam in a well lagged pipe the flow approximates more to adiabatic flow, i.e., no loss or gain of heat. The outcome of this is that the pressure drop during isothermal flow is less than that for adiabatic flow for the same frictional resistance.

In practice, for the velocities and moderate lengths of pipe considered, there is very little error in assuming isothermal flow for both air and steam under the same conditions as for liquids. The variation of temperature and pressure must be considered for the initial conditions where the error would be appreciable if this variation were neglected, though the desity along the pipe will be assumed constant.

With the exception of air hose, pipe material for air and steam is almost entirely of steel and, as with the liquids, only this material will be considered. The friction loss in standard air hose is approximately 40 per cent less than for the same nominal diameter of steel pipe over the normal compressed air ranges of pressure and air quantity.

From consideration of the above and other factors, such as roughness and corrosion already discussed for liquid flow, the flow of air and steam will be taken to follow the same formula (3) as for liquids, i.e., isothermal. Due to the differing conditions of flow some conversion of the formula will be necessary. As stated above, it is more convenient to consider the quantity flowing in pounds per minute W where

$$W = 0.3275\, Vd^2 \rho$$

$$\text{and } V^{1.8} = \frac{7.5}{d^{3.6}} \frac{W^{1.8}}{\rho^{1.8}}$$

and substituting in formula (3)

$$p = 0.0391 \frac{W^{1.8}}{d^{4.8}} \left(\frac{\nu}{\rho^4}\right)^{0.2} \text{ lb. per sq. in. per 100 ft.} \quad ..(4)$$

or as $\frac{1}{\rho}$ is the Specific Volume V which may be obtained direct from steam tables and tables of properties of air, formula (4) may be more conveniently written

$$p = 0.0391 \frac{W^{1.8}}{d^{4.8}} (\nu V_s^4)^{0.2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

It should be noted that the specific volume V of air also depends upon the relative humidity. The variation is small especially when the humidity range will normally be 40–90 per cent with a mean at, say, 60 per cent, at which value this nomograph has been calculated.

How to Read the Nomogram (See Plate 2)

This nomogram may also be read in any direction so that given the initial condition of the air or steam and any two of the three remaining quantities: pipe diameter, quantity flowing or pressure drop, the third may be found.

The nomogram consists of, from left to right:

(*a*) The quantity scale, in lb. per min. and also scaled in cu. ft. per min. of free air, i.e., air at atmospheric pressure and temperature for use in compressed air calculations.

(*b*) The support line followed by (*c*) the pipe diameter scale.

(*d*) The pressure loss scale in lb. per sq. in. per 100 ft. run and in inches of water gauge for air-conditioning calculations.

(*e*) The final line is the start line for the steam or air condition.

This line is gridded for temperature and pressure variation, and is erected at an air temperature of 70° F. and a steam temperature of 300° F., the air and steam temperatures being scaled at the bottom and top respectively. Four common air pressures are given and it must be noted that these are absolute pressures, as are those for steam. Most Service air compressors are rated at 100 lb. per sq. in. gauge pressure and the line has been marked at this pressure. The saturated steam line is drawn from atmospheric pressure to 300 p.s.i.a. and from it the superheated steam lines at convenient pressures.

The following three examples will illustrate the use of the nomogram under differing circumstances:—

1. *Compressed Air*

100 lb. per sq. in. gauge, 50 cu. ft. per min. in a 1-in. diameter main. Ambient temperature 70° F. Starting on the right-hand line at the 100 p.s.i.g. mark, lay the straight edge across the support

line to the 50 cu. ft. per min. free air on the quantity line. Mark the crossing of the support line. From this crossing, lay the straight edge through 1-in. pipe diameter to cut the pressure loss line at 0.74 lb. per sq. in. per 100 ft. For 1-in. diameter air hose, including necessary connexions, the pressure loss is reduced by approximately 40 per cent so that in this example the pressure loss would be:—

$$0.44 \text{ lb./in.}^2 \text{ per } 100 \text{ ft.}$$

2. *Saturated Steam*

200 lb./in.² absolute. 100 lb. per min. flowing in a 6-in. diameter pipe.

From the saturated steam line at 200 p.s.i.a. run horizontally to the start line. From this point the procedure is as above, giving a pressure loss of 0.067 lb. per sq. in. per 100 ft. of pipe.

3. *Air Conditioning*

Conditioned air at 70° F., 4,000 cu. ft./min. in 20-in. duct. Although the pressure initially would necessarily be above atmospheric, it is only a question of a few inches of water gauge which makes negligible difference to the result. Beginning on the start line, air 14.7 p.s.i.a. at 70° F., cross the support line to 4,000 cu. ft. per min. free air. From the support line crossing lay the straight edge through the 20-in. diameter to cut the pressure loss line at 0.23 in. water gauge per 100 ft. of duct.

Example

Water at 60° F. to be pumped at 500 g.p.m. in a 5-in. diameter pipe.

Pressure drop = 0.0286 lb. per sq. in. per foot run or = 150 lb. per sq. in. per mile.

NOTES

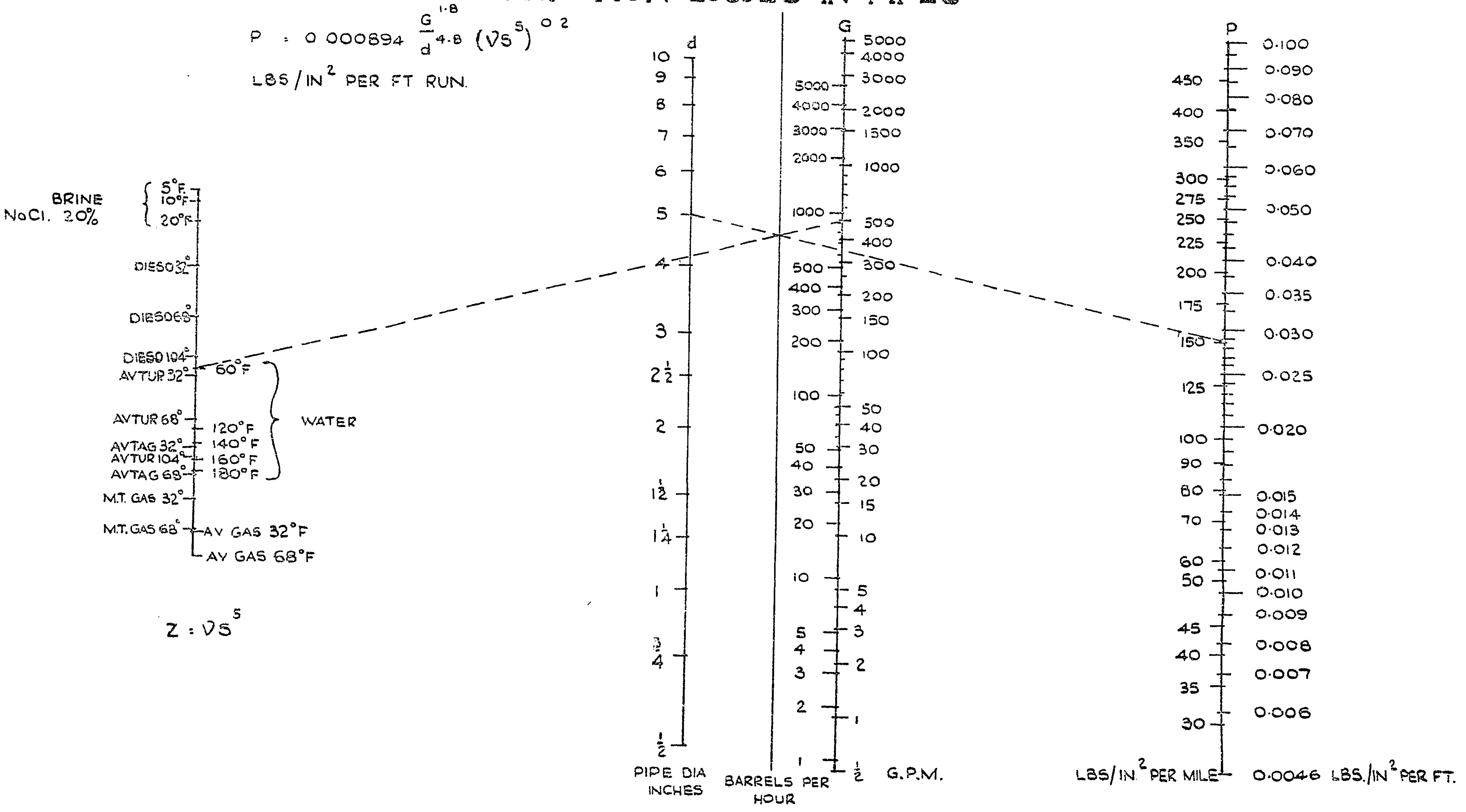
(i) Support line must be crossed between each pair of readings for z, d, G and p.

(ii) New steel and wrought iron pipes only. For new cast iron add 10 per cent to pressure drop. For synthetic rubber piping deduct 20 per cent.

(iii) For fittings, equivalent length L in. of pipe (diameter d in.) to be ..ed, given by the following ratios

	$\frac{L}{d}$		$\frac{L}{d}$
90° Bend	15	Stop Valve open	5
Joints	5 per 100	Reflux Valve	50

FRICTION LOSSES IN PIPES

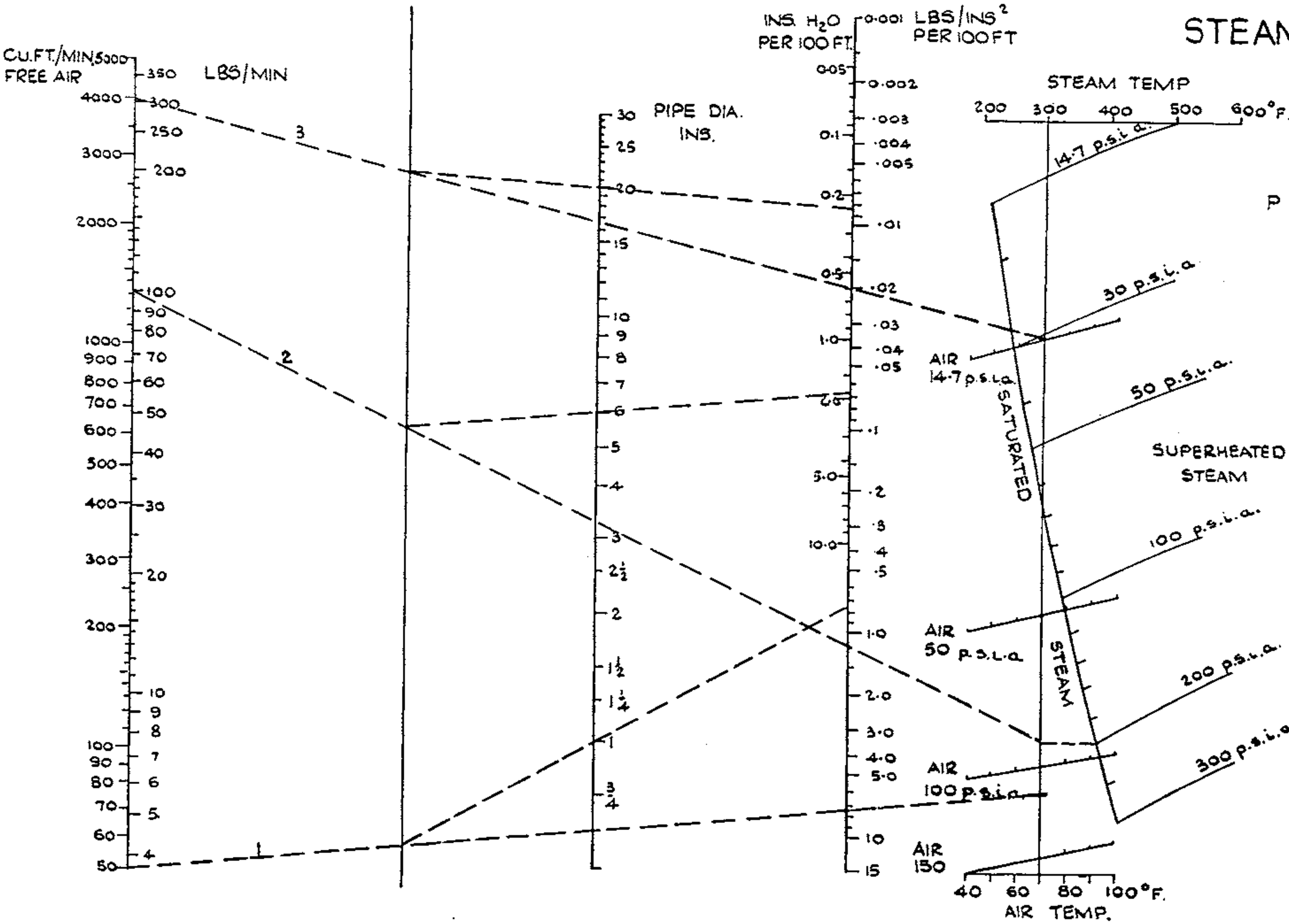


FRICTION LOSS IN PIPES. STEAM AND AIR.

$$P = 0{\cdot}0391\ \frac{W^{1{\cdot}8}}{d^{4{\cdot}8}}\left(\frac{\nu}{\rho^{4}}\right)^{0{\cdot}2}$$

LBS. PER SQ. IN. PER 100 FT

NOTE.
AIR AT 60% R.H.



DISPOSAL OF OLD MINEFIELDS IN U.K.

By CAPTAIN R. H. HOUGH, G.M., R.E.

INTRODUCTION

THIS paper attempts to outline some of the present-day techniques and problems in clearing an old anti-invasion minefield in England, the responsibility for which is vested in H.Q., B.D. Unit (U.K.) R.E.

THE CLEARANCE OF MINEFIELDS

During and after the war all known and suspected minefields were systematically cleared, until to-day the only known ones remaining are:—

Trimingham, Norfolk.
Fairlight Glen, near Hastings, Sussex.

These minefields had each been considered in 1946 to be impracticable clearance propositions and Parliamentary Authority was granted for them to be fenced off in semi-perpetuity. At present work is in progress at Trimingham in Norfolk.

TRIMINGHAM MINEFIELD

The minefield is approximately four miles long, it contains an estimated 4,000 mines. The beach is sandy—in fact it was a famous holiday beach in pre-war days—and the cliffs are predominantly of sand with some patches of clay and occasional outcrops of chalk and marl. These latter contain many fossils and one of the present civilian employees tells stories of recovering the skull of a sabre-toothed tiger many years ago. Sad to say, nothing so exciting has been found in recent times.

The cliffs have an average height of about 200 feet and are unstable. Cliff falls have occurred throughout the length of the minefield and the positions of the mines now bear little or no resemblance to their original ones.

It has been found that as the cliffs fell a few mines exploded, many became buried, only to reappear after further erosion, and some mines got into the beach. These were the greatest worry to the B.D. organization for they gradually moved into the sea under tide action and were then carried to various holiday beaches down the coast.

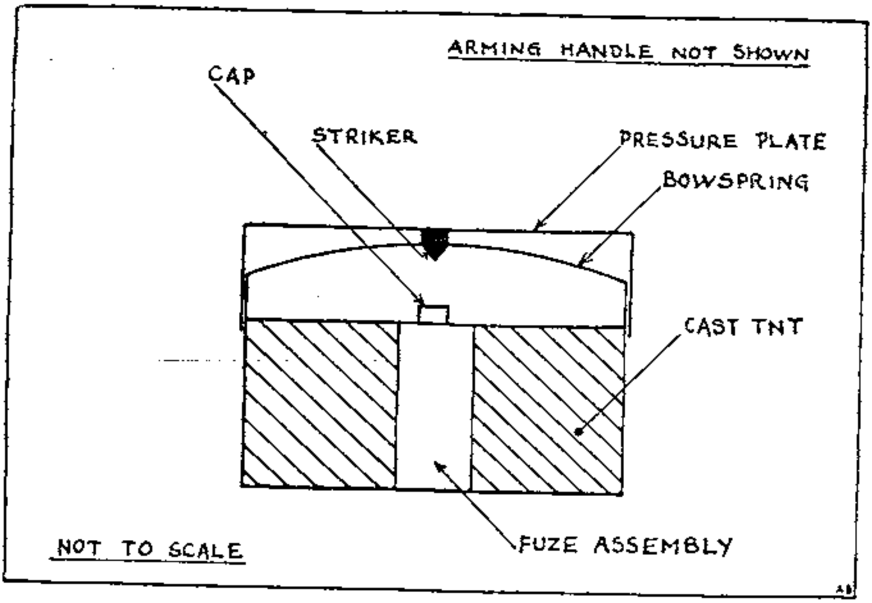


Fig. 1.—B type C mine ready to fire.

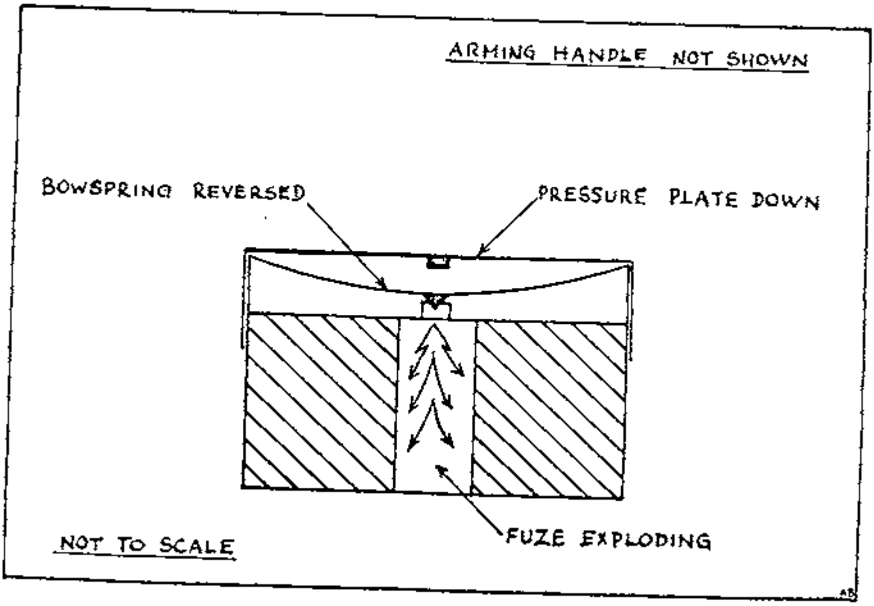


Fig. 2.—B type C mine exploding.

Summarizing, at Trimingham the mines are to be found:—

(*a*) in the beach, at depths governed by tide action and often about six feet deep.

(*b*) In the cliffs, mines may be found a few inches deep, as originally laid.

(*c*) They may be found in cliff falls, up to about thirty feet depth.

The B Type C Mine

The only type of mine used at Trimingham was the B Type C which was produced in vast quantities in the early days of the war. It weighed about 60 lb. of which 25 lb. was cast T.N.T. (see Photos 1 and 2 and Figs. 1 and 2). The mine was designed as a dual purpose anti-vehicle/anti-tank mine and originally had an actuating pressure of 100 lb. The mechanism was extremely simple. The striker was held clear of the percussion cap by a bowspring curved upwards. The lid of the mine rested on this bowspring (see Fig. 1).

When a small load was applied to the lid nothing happened but if the critical load was exceeded the bowspring was reversed thus firing the mine (see Fig. 2).

To prevent accidents when laying or lifting, an " arming handle " was provided. This protruded about two inches out of the side of the mine. When pressed in it prevented the bowspring reversing so that the mine could not fire. When it was pulled out the mine was ready for use. The mine was covered with a weatherproof rubber cover.

Present Condition of the B Type C Mine

Where a B Type C mine has lain undisturbed it is usually found that the arming handle has rusted to the mine, but the rubber cover is still intact and often the mine is serviceable. Mines that have been in the sea may be rusted through or deficient of their lids. The majority of mines are in a condition between these two extremes. It is often found that the bowsprings have rusted through. This means that the resistance to firing of these mines is negligible and any attempt to push the arming handle in will probably explode the mine. Unfortunately this state of affairs cannot be detected by visual examination. The fuses vary from very sensitive to completely insensitive, but there seems to be little guarantee that the fuse and the mechanism of any one mine will be in a similar state of deterioration.

Destruction of Mines

When a mine is located it is disposed of by placing a pound of explosive in contact with its side. Mines are never moved before demolition as the risk is considered unjustifiable. This, of course, is very unpopular with the neighbouring householders for the 25 lb.

of T.N.T. does cause a considerable blast effect and claims for damages are frequent. Experience is showing that a definite connexion exists between weather and wind conditions, the place of origin of an explosion and the resultant damage.

When a mine is detected it may be several feet below ground level. A hole is excavated between the digger and the mine (the object being to reach the side of the mine without breaking the "bridge effect" of the sand above the mine). In dry running sand, 5 ft. deep, this will take several hours' work, though under better conditions it may take five minutes. Usually a gardener's trowel is used but there are occasions when a shovel has to be used.

Methods of Finding Mines

Apart from visual search the following methods are employed:—

1. No. 4A Detectors.
2. E.R.A. Locators.
3. Armoured Dozers.
4. High Pressure Water Jetting.

The 4A Detector

This instrument is considerably more efficient than is generally realized in the Army. Properly tuned and maintained it will indicate the presence of most metals and the oscillating tune given by it can be so controlled as to reduce indications from small metallic trash to a mere background noise. The unit frequently detects B Type C mines at 2 ft. depth and occasionally at 2 ft. 6 in. with these detectors—which are no different from the G1098 ones. At least one man in the B.D. Service has a sufficiently good "ear" to use the detector under a barbed wire fence or near old Dannert wire.

When a party is using the No. 4A Detector a section of the cliff is selected and is worked in strips about six feet wide from bottom to top. The party consists of two or three men according to cliff conditions. One man uses the detector and is assisted by a mate who has a trowel and marker tape. Where the cliff is very difficult the mate supports the detector man and the third man handles the marker tape. It has already been said that the cliff is worked upwards. This is to prevent a man, should he fall, from crashing into an unswept area. A constant guard has also to be kept against dislodging clods of earth which might roll down the cliff and over the tapes into the danger area.

New detector-men have a tendency to work far too long and officers and senior other ranks are particular offenders in this respect. The more experienced a party is, the more often they will exchange duties. A morning and afternoon tea break serves a useful purpose here as it prevents fatigue from excessive concentration.

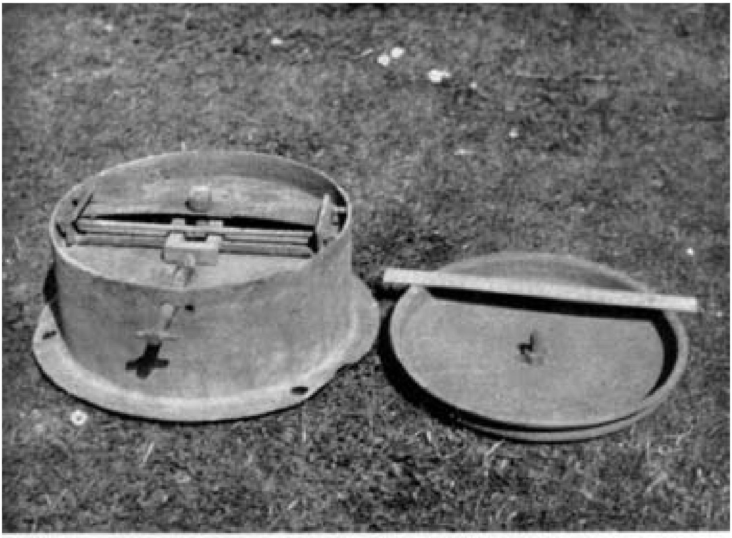


Photo 1.—B Type C mine with rubber cover and lid removed.

Photo 2.—B Type C mine complete as frequently found to-day. Note arming handle and rubber cover.

Disposal Of Old Minefields In U.K 1 , 2

Photo 3.—Using a No. 4A detector on soft cliff. Note how one man assists the other.
(*Photo: Eastern Daily Press, Norwich*)

Disposal Of Old Minefields In U.K 3

When detected and confirmed by excavation, mines are marked by a wire cone about three feet high and bearing a small flag. These home-made wire cones show up better than the small issue tetrahedrons and, having practically no wind resistance, do not blow over. At the end of the day's work the mines found are demolished individually. It is undesirable to destroy mines as they are found as there is a distinct danger of rendering other, as yet unfound, mines more sensitive.

The E.R.A. Locator

This instrument was produced by, and takes its name from the Electrical Research Association. Basically it consists of a detector unit and an A.C. bridge. The detector unit contains two mu-metal elements whose electrical properties change according to the magnetic field passing through them. Broadly speaking the presence of a ferro-magnetic body in the earth causes increases and rarefactions in the density of the earth's magnetic field as shown in Figs. 3 and 4. (See page 263.)

The locator can be used to produce a graphical plot of the density of a magnetic field, but for mine locating it is used in conjunction with a needle instrument the deflections of which give an adequate indication of ferro-magnetic influences. When used for mine locating the operator wears a harness with a bamboo pole sticking out some six and a half feet in front of him. From this pole the detector unit is suspended by a gimbal-like bracket. Behind the operator there is another pole with a counterbalance weight. The detector unit is connected by a multi-core cable to the A.C. bridge and its appurtenances which are contained in a metal box. The various controls and dials in this are operated by a second operator, whilst the man actually detecting has a slave dial on his harness to indicate the changes in field.

The E.R.A. is sufficiently sensitive to locate a B Type C mine at about five feet depth, and on level going gives rapid sweeping.

Its failings are however, that:—

(*a*) It requires two skilled operators.

(*b*) It is very fragile—so much so that on road journeys, it has to travel on mattresses and even then may be unserviceable on arrival.

(*c*) It is very expensive.

(*d*) It is too cumbersome for use on cliffs, though excellent on beaches.

(*e*) Its extreme sensitivity is an embarrassment in " dirty " areas where it locates minute pieces of scrap iron causing endless digging. This is a serious problem, for continued digging, resulting only in finding rubbish, tends to make for careless digging, which in turn results in accidents.

(*f*) It has to be used from south to north.

The Armoured Dozer

Where mines are deeply buried in the debris from cliff falls the armoured dozer offers a safe and rapid means of clearance. An armoured Size II (D7) Dozer is used in conjunction with a Size I normal dozer and a detector party.

The procedure is as follows:—

(*a*) A suitable area of beach is swept and cleared of mines. This area is normally at least a hundred yards long and stretches from below the high water mark to the cliff base.

(*b*) The detector party checks the base of the fall from ground level to as high as they can conveniently reach. Any mines found are destroyed and it is then safe to assume that there are no mines within two feet of the surface.

(*c*) The armoured dozer now takes a cut from the bottom of the fall taking care not to go more than one foot into it.

(*d*) The detector party now checks the new face.

(*e*) The unarmoured dozer removes the spoil to the sea.

(*f*) Items (*c*) to (*e*) inclusive are repeated.

This process of cutting into the base of a pile of fallen cliff will eventually bring all the fall to beach level and will expose any mines. It is, of course, essential that the dozer operator always cuts out less debris than the range of the detector has shown to be clear.

Other safety precautions normally enforced are:—

(*a*) The operator of the armoured dozer automatically stops work if anyone comes within a hundred yards of him.

(*b*) A man with binoculars watches the dozer blade constantly. Should he see anything dangerous he attracts the operator's attention by waving a red flag.

In recent years, this system has been extensively used with very few dozer casualties. Properly performed it results in the mines being found by the detector party, *not* by the dozer.

High Pressure Water Jetting

This process is used to locate mines in piles of sand, sand screes and heaps of relatively light soil.

Although the application of the process at Trimingham is involved, the theory is simple.

An old bren gun carrier is converted to a " monitor " by erecting a forward armour screen about four feet high. Protruding through this screen is a high-pressure nozzle which can be traversed and elevated by an operator who stands behind the armour watching operations through a periscope.

The monitor is fed with water through an 8-in. flexible hose connected to a high-powered Leyland pump supplying about 100,000 g.p.h. at 150–200 p.s.i.

The jet of water will wash out the base of a scree or fall thereby exposing the mines and in some cases destroying them.

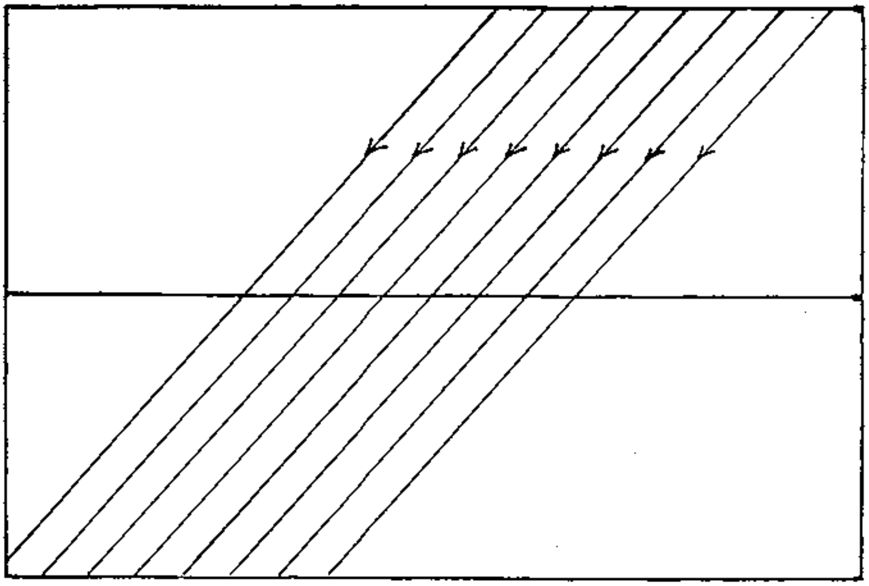


Fig. 3.—Earth magnetic field undisturbed.

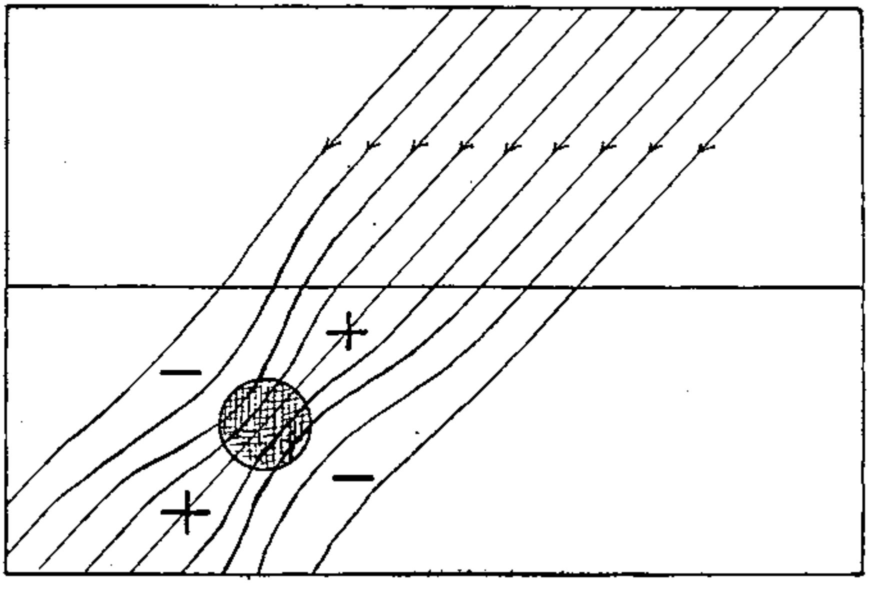


Fig. 4.—Earth magnetic field disturbed by ferro-magnetic object.
+ indicates increase in density of field.
– indicates decrease in density of field.

At Trimingham there is a tidal race which appears about twelve times per year with very little warning. This race removes or deposits up to five feet of sand from the beach and therefore makes it impossible to lay pipe lines or erect static pumps there. As a solution to this problem a pipe line is to be laid along the cliff top.

Initially water will be taken from the sea by a pump mounted on a converted ten-tonner chassis. This will be moved as the tide moves and will be connected by a flexible pipe to a static pump on the cliff face. The installation of this pump on the side of a steep unstable cliff has been a most interesting "skyhook" problem. From this pump the pipe line will go up the cliff face, being held in place by steel pickets driven on either side of the pipe and welded to it. There will be a booster pump at the top of the cliff from which the cliff top main, almost three miles away, will be filled.

Monitors will be tapped into the cliff top main by pipe lines running down the cliff wherever required.

In the event of a tidal race warning the monitors will have to be disconnected from their pipe lines and will proceed down the beach to the nearest cliff track.

At one point a monitor will have to be lowered over the cliff edge to work along a ledge some fifty feet lower down.

The Commencement of the Task

When clearance of the minefield was attempted in 1953, there was no means of access to the beach and no way of properly reconnoitring the cliff from the top. The least unlikely piece of cliff was therefore chosen and swept from the top downwards. This produced about seventy mines and much valuable data. It also taught that a man can use a detector whilst dangling from a rope. Later a dozer was able to work down to the beach and construct a track. After about 10,000 cubic yards of earth had been moved the track was passable for tracked vehicles.

This track is now being protected at its foot by steel piling to prevent high tides causing damage.

Labour Force

The troop responsible for the task consists of:—

Officers (Captain)	1
W.O.IIs	1
Sergeants (Pl. Op.)	1
Sergeants (B.D. trained)	2
Corporals and Sappers for M.T. Plant and G.D.	4–5
Civilians G.D. and Tradesmen ..	20 (approx.)

The Sappers are on normal rates of pay and lodge in private houses, as there is no military accommodation. The civilians receive an extra 4d. per hour when engaged on certain tasks.

The recruitment of civilians has been a constant difficulty as East Anglia offers considerable opportunity for good labour at better rates than those of War Department. The present British element of the labour force is the result of long and careful selection, whilst the German element has been with Bomb Disposal since the end of the war and is, naturally, very experienced.

At present it is envisaged that the task will take three years to complete. It is the policy to " make haste slowly " as haste is, literally, fatal in this kind of work. This is one of the reasons why a larger labour force is not employed.

During the last twelve months the troop has carried out a number of other tasks outside the scope of this article. Mention should however be made of the valuable assistance given by a troop of 39 Corps Engineer Regiment on the clearance of a shingle beach near Salthouse, Norfolk.

Labour Constants

It is regretted that in an article of this type labour constants cannot be given for work at Trimingham. This is because it has been found dangerous to advertise rates of work because of the danger of some inexperienced person trying to apply them under circumstances which are not, in fact, identical with the Trimingham ones.

THE ROYAL MONMOUTHSHIRE ROYAL ENGINEERS (MILITIA)

By Lieut.-Colonel D. A. Smith, M.C., R.E.

THERE seems little doubt that at some time or another those serving in the Corps have seen Officers and O.Rs. wearing a cloth shoulder title " R. Mon. R.E." and wearing a cap badge that from a distance looks like the badge of a cavalry regiment. There is equally little doubt that the vast majority of those who see these two unusual sights have little or no idea of the history and tradition that make the R.M.R.E. a little different from all other regiments in the Corps. At a time when tradition is often counted of little worth there have been many bitter struggles to preserve the traditions built up over a period of nearly 300 years. The Regiment is proud of being part of the Corps and it is proud of its history. But how did all this start ?

In the year 1660 a regiment of militia was formed in the County of Monmouth and from this beginning the Regiment traces its history. There is no record of the first Commanding Officer, but Henry, third Marquis of Worcester, later first Duke of Beaufort, raised all the troops in the area. In 1697 the Regiment consisted of seven companies with a strength of 490 men and in addition possessed a troop of horse consisting of fifty-three sabres. In those days soldiering was a hard business and part of the sentence of a court martial on a deserter reads " to be hanged and there to remain hanging until he rot off." A further punishment of 400 lashes with the whip is recorded for " getting drunk frequently on detachment."

At this period the Regiment was light infantry and was embodied in 1696 and again in 1760. For the latter embodiment an extract from the order reads as follows : " It is His Majesty's pleasure that you cause the Militia of the County of Monmouth to assemble with convenient speed at such Place or Places as you shall think proper and march from thence by such routes and in such divisions as you shall think most convenient to Cardiff where they are to be quartered and follow such orders as they shall receive from Lieut.-General the Earl of Ancram.

Given at the War Office this 21st day of March 1760."

A nice comparison with present-day movement and mobilization orders !

In the year 1778 the Regiment was commanded by the Duke of Beaufort and was embodied again for the American War. On 22nd June of that year it was reviewed by the King in Windsor Great Park. His Majesty was accompanied by the Queen, and the Duchess of Beaufort was also present " dressed in the uniform of the Regiment." Thereafter the Regiment was embodied on many occasions, one covering the whole of the period of the Peninsula War. In 1804 the Regiment became a " Royal " Regiment and was in 1832 known as The Royal Monmouthshire (Light Infantry) Militia.

At this time the whole of the Militia in England was inactive and in 1852 the Government sought to pass the Militia Bill. It was introduced in Parliament by the Home Secretary, Mr. Spencer Walpole, who, urging the necessity, quoted the words of Edmund Burke, " Early and provident fear is the Mother of safety ; for in that state of things the mind is firm and collected and the judgement unembarrassed ; but when fear and the thing feared come on together and press upon us at once, even deliberation which at other times saves becomes our ruin, because it delays decisions, and where the peril is instant the decision should be instant too." The Bill was passed and the Regiment once again formed.

In 1854 there followed another embodiment and the Regiment was the first to volunteer for active service, the officers offering £5,000 to equip it for the purpose. The offer was rejected. During the Crimea War, Officers and O.Rs. of the Regiment served with the 23rd Royal Welsh Fusiliers.

In the year 1877 the following notice appeared in the *Army and Navy Gazette* :— .

"This Militia Regiment [Royal Monmouthshire] we hear on account of its great efficiency has been selected by the authorities as one to be converted into an Engineer Corps and is likely soon to change its Light Infantry character."

Then on 27th March of the same year the *London Gazette* records that "The Queen has been graciously pleased to approve the conversion of the undermentioned Militia Regiment as follows :— The 'Royal Monmouth' from 'Light Infantry' to 'Engineers'." Again in the *London Gazette* of 23rd November of the same year "Her Majesty has been graciously pleased to approve of the Royal Monmouthshire Militia being in future designated "The Royal Monmouthshire Engineer Militia'." And so the Regiment had become part of the Corps.

The first Adjutant was Captain Sir Arthur Mackworth, Bt., R.E., and in 1878 the Regiment trained for the first time at Chatham. In the year 1896 a further change in the title was made and the Regiment became The Royal Monmouthshire Royal Engineers (Militia). At this time it shared the distinction of the double "Royal" with the Royal Anglesey, but with their passing as an active unit it is now unique in the Army in this respect. At the outbreak of the South African War the Regiment made a voluntary offer to send a section and this was accepted. It consisted of an officer, a sergeant, a corporal, a second corporal and twenty-two sappers and it served with the Bridging Battalion, R.E. A further complete company was sent later the same year and having started the campaign on that most well loved of all sapper tasks—"road bashing"—was placed at the disposal of the Director of Railways in exchange for the 20th Field Company, R.E. It remained thus employed for the remainder of the campaign.

The year 1908 brought about a far-reaching change, for under the Haldane Reforms the old Militia became the Special Reserve, a force which was created simultaneously with the new "Territorial Force," and as such the Regiment became a unit of the Army Reserve. The officers having "assented" were transferred from the Militia to the "Special Reserve of Officers" retaining the rank and seniority which they held while in the Militia. Other ranks were given the option of joining the Special Reserve or taking a free discharge. The former involved the new liability of service abroad in time of emergency, probably with a regular unit.

When mobilization came in 1914 no men were, in fact, sent to regular units. The Regiment mobilized one "Siege," two Railway and one Depot Company. It is interesting to note that during the

1914–18 war the R.M.R.E. maintained its own units from its own depot and in addition raised five further companies, three Siege and two Army Troops. It trained and sent to the war a total of seventy-six officers and 2,113 other ranks. The end of hostilities saw the virtual demise of the Special Reserve. The companies were disbanded and the Regiment reduced to a cadre of one officer and five other ranks.

In 1925 under the scheme of the new Supplementary Reserve, (largely through the efforts of the late Colonel H. E. M. Lindsay, C.B., a former C.O. and a retired regular Sapper, and at the time the Honorary Colonel of the Regiment, and also the late Colonel R. S. Forestier-Walker, D.S.O., who served with the R.M.R.E. in South Africa in 1900), permission was granted from the War Office to raise two Army Troops Companies, R.E., S.R., " to take over the title and traditions of the Royal Monmouthshire Royal Engineers (Militia)." This was indeed a proud occasion. As events turned out the R.M.R.E. was the only descendant of the old Militia and Special Reserve to be resuscitated. Training was performed under the same conditions as for the Territorial Army. Early in 1939 the two Army Troops Companies became Army Field Companies and as such went to war in September of that year. There being only two companies, there was no immediate job for the Commanding Officer, and the whole of Regimental Headquarters wound itself up and were absorbed by the Corps in other employments.

It is not intended here to deal with the activities of these two companies during the campaigns of the last war. The two original companies greatly distinguished themselves in the operations ending at Dunkirk and received a special word of commendation from the Commander-in-Chief, the late Lord Gort, V.C.

As before, the end of hostilities saw the disbandment of the two companies and again for a while the Regiment ceased to exist. However once again the War Office were persuaded, and in 1948 the Regiment was re-formed as an Army Engineer Regiment. This was a big step, as in addition to being a Regiment in its own right it is now able to conform to the regimental formation within the Corps. So the traditions of the Regiment were once again preserved, together with the traditions of the old Militia. We are proud of our traditions which, together with those of the Corps, we constantly strive to maintain.

MAN-MANAGEMENT IN THE ARMY AND IN INDUSTRY

By BRIGADIER M. C. A. HENNIKER, C.B.E., D.S.O., M.C.

IN a recent letter to the *R.E. Journal* Major Keelan is provocative. Let us see exactly what he says. I quote the following from his letter.

> "I was once a regular Sapper officer; now I am a farmer. The farmer's personal income is directly affected by the efficiency with which he organizes his labour. Meticulous thoroughness in this respect, coupled with the farmer's willingness to lose even more sweat himself, can result in the reduction of an already tiny labour force by one man and a consequent saving of £300 a year. If the farmer wastes only one minute of one man's time each day, it costs him £1 a year with agricultural wages at their present level (£6 a week).
>
> "How many Sapper officers regard the efficient employment of their men with this care? A great deal of rubbish is written about time wasted in the services, but I confess I find it better not to look back . . .
>
> "It is a regrettable truth that farmers, whose world is one of narrow profit margins, hard work, and long hours, are very chary of taking on ex-servicemen: too often it merely depends on the fellow's rank whether he is good at wasting other people's time, or his own."

It would be impertinent for me, having soldiered for over twenty-eight years, to question Major Keelan's facts about farming. But I cannot resist recording that for a number of years I owned a farm myself. I sold it in 1946; and I believe I am the only living man who succeeded in losing money in agriculture during the war years. Like Major Keelan " I confess I find it better not to look back . . ."

Still, I have learnt something about farming; and one of those things is that it is not unlike any other industry in its attitude towards its labour. That is why I head this paper " Man-management in the Army and in Industry," rather than " . . . on the Farm." So let me use the word industry henceforth to include the farm.

I must ask one more indulgence; namely to use the words " workmen " and " owner " in a particular sense. By workmen I mean those who hold subordinate positions in industry, who draw their pay weekly, and who are represented often by a trades union. Some may be females and a few may be slackers, but under the convention which I here employ, they are all workmen. It might in some ways be better to use the word " workpeople " rather than workmen, but you get into trouble over the singular; there is an oddity about a " workperson " which I prefer to avoid. So let it be workmen.

The term "owner" is properly speaking to-day a rare one in industry. Most industries are owned by shareholders, or the government, and are represented by a Managing Director, a Board of Directors or perhaps even a Director General. But in this paper I mean by "owner" the individual who actually manages the workmen; either because he really owns the business himself—as many farmers do—or because he is deputed by the shareholders to run the business for them. It is a convention.

It will be seen that when once we consider nationalized industries we get involved in political issues which I propose to avoid. So I restrict myself here to private enterprises.

Having cleared the ground, we can study the relationship in the Army and in industry between the officer and his men and between the owner and his workmen. It will be seen that there are many differences.

First, you have but to attend a pay parade in the Army, or watch the workmen receiving their pay from the owner in industry, to perceive the greatest difference. Although in the Army the officer sits on one side of the pay table and the soldier salutes at the other, both men are, in a sense, on the same side of it. Both draw their pay from the Treasury. It does not matter to the officer how much he pays out, providing he abides by the Pay Warrant. Indeed, the officer frequently finds himself in the shoes of a trades union official taking up the cudgels on behalf of a soldier to browbeat the Treasury into paying his man some disputed allowance. The officer also pays out with his own hand, which in the larger industries the owner does not do; though in the small farm he does. Many of the bonds that bind soldier and officer in good times and bad stem from this system. One cannot conceive an army, certainly not a British Army, in which an argument could arise between officer and soldier over pay. Both regard the Treasury in an identical light.

In contrast, let us look at the owner paying his workmen. Immediately one sees the difference. Every penny the owner pays comes from his own pocket. When times are good he can afford to pay a bonus; but when times are bad (which is perhaps half the time) he must count every penny he pays. The owner and his workmen are, in every sense of the phrase, on the opposite sides of the pay table. The owner cannot afford a kind heart. When once he finds he cannot pay a man he must pay him off. The man may be a good-hearted workman, he may have a wife and four children; but if he cannot earn his wage he must go.

However much the Army officer may pride himself on man management, he is never faced with this very difficult problem. This is the first difference. The next leads straight from it.

Let us next examine the employment of the men. Imagine an outpost of the Empire—a rarer phenomenon to-day than thirty years ago, but not an extinct one. Imagine a fort containing a platoon under an officer. While the officer and his platoon occupy the fort nothing of note happens; but everyone knows that if once the fort is abandoned the valley it dominates will become a scene of arson, rape and banditry.

The officer's problem in the fort is threefold. First, he must keep up the morale of his men; secondly, he must keep them well trained; and thirdly he must keep them fit. These three problems are interrelated. They have nothing whatever to do with money, pay or economics; but they demand high qualities in both officer and his men for a successful solution. The good officer makes his men do some form of training every day, he sees that they are shaved and properly dressed for parades, he teaches them things like geography for their 3rd Class Certificate, he inspects their meals, he makes them whitewash window ledges and he makes them play football. He exercises infinite patience, goodwill and initiative; but nothing that he does has any productive value, such as would appeal to the owner of industry. In the purely industrial sense the officer is wasting his own time and the time of his men. Calculated in man-hours, on a forty-hour week, the time "wasted" represents untold wealth. Yet if the officer were incapable of organizing this prodigious "waste," the arson, rape and banditry mentioned above would end in an embroglio that caused fifty times the waste to some careful owner of industry in Great Britain itself. Thus we see that the Army officer requires quite different qualities from the owner of industry in his outlook on the employment of his men. The owner is seldom concerned with finding employment for those for whom no work exists. The officer frequently has to "think up" some employment for them; and he must always make it appear to be worth while and important. In one sense the good officer is "wasting other people's time" on a big scale; yet in another he is earning his pay in difficult circumstances.

Now let us consider the outlook of the workman on the one hand and the outlook of the soldier on the other. Perhaps they both come from the same district. The workman toils at his work and receives his regular wage. He puts his heart and soul into the work. He belongs to that splendid breed—industrious, law-abiding and skilled at his trade. What the workman longs for is steady, continuous employment with an occasional rise and a prospect of owning his own home at the end of it. What of the soldier? He is a soldier at heart. He too toils at his work. He is honest, conscientious and loyal. But one day, with no warning at all, he is suddenly transferred from Aberdeen to Abadan. What does he do? He throws his hat in the air, and cheerfully embarks in the utmost discomfort in a troopship. This takes him to a place he has never before heard of, where he lives in a tent, gets bitten by mosquitoes and suffers from prickly heat, tinea and impetigo. Yet being a good soldier he makes no serious complaint. He languishes on this foreign service till the military machine returns him to Aldershot. Soon a grateful Government sends him uncomplaining to Korea, Malaya, Kenya or the Canal Zone for a second dose of the same medicine. He may have become an expert in " wasting his own time," but he is a valuable asset to his Country and the Army. The good workman would object very strongly to all this. Both men are good men and the both have diametrically opposite views on their work.

Every experienced officer can quote examples of the idle kind of soldier; the " break-off-sir, please-for-a-smoke-sir-please " kind of soldier. Every officer will admit that these men are a confounded nuisance; but sometimes (by no means always) they turn up trumps in a battle. Every experienced officer can remember the man he blessed above all men in the days of battle; the man he swore he would never forget. Yet when the battle is over and peace is won, this same man sometimes seems quite different. He is just a cheerful rogue, and an adept at " wasting time." All the same, in his own setting, the setting of battle, he is a Soldier and Man—spelt with capitals. The value of this man is hard to equate in civil life. In industry his value is *nil*; but without him in battle there would be no industry in peace-time. Scorn him not, but try to make use of him.

Then there is the man who is by nature a worker. I shall never forget my chief clerk when World War II ended. He was in an early release group and was " demobbed " in September 1945. He worked away in the Orderly Room till 11 p.m. on his last night with the divisional engineers. Everything had to be in perfect order before he could bear to leave it forever. And he was not unique; there were many like him in every rank and every unit. I cannot believe these men would waste the owner's time in industry. Indeed, when one visits industrial Britain one sees ex-soldiers everywhere, many of them working very hard—the Desert Rat, the Red Beret, the Jungle Hat of the Fourteenth Army and the unbecoming " cowpat," worn by the rank and file throughout the world, under the euphonious name of Beret, Khaki G.S. Whenever I speak to these men, as I have done in Darlington, Sheffield and Hull, I am always reminded how true to military type they run. I see all the types I know so well: the colourful characters, the dim little bespectacled ones, the swashbucklers and the horticulturists, the rogues and the scallywags, and the good men and true. I find no difficulty in knowing what to say to each of them, and no difficulty in forseeing how they will reply. Sometimes I wonder whether industry could not learn something from the Army in how to treat them. Industry cannot apparently avoid many futile disputes about relatively unimportant issues.

This brings me to the common ground between Army and industry: the time when both suffer shortage of men. When the owner is short of men he must make up his mind whether it is worth while hiring more. Here he is guided mainly by economics. If more men on his pay roll will earn him more profit he will hire them; and when they cease to earn him his extra profit he must fire them.

The officer, however, is in a different position. In battle, or on a sapper project, it may be physically impossible to get more men, however desirable they may be. Nor is it always easy to get more men at any time, because of the system of establishments. On these occasions, therefore, the officer is in the same position as many an owner who would like more men but cannot afford them. How do the two compare?

In the higher reaches of military existence the Army is perpetually confronted with "manpower shortages." It is difficult to believe that the captain of industry is more efficient in this respect than his counterpart in the War Office. We saw in the war that both soldiers and civilians had much the same standards of personal efficiency. I submit that the Army has little with which to reproach itself here.

On the lower levels, when men are scarce, much depends on the standard demanded by those in authority. Every experienced officer has seen the good troop leader who really gets 100 per cent from his men; and the bad one who makes a hundred excuses for the shortcomings of his troop. A tremendous responsibility rests upon the middle piece officers—majors mostly—to encourage the one and help the other. The middle piece officer must recognize the subaltern who achieves results with the full co-operation of his men and the subaltern who does it by driving. He must spot the subaltern who is too kind, and the subaltern who is a muddler, and the one who makes everyone so fed up that nothing happens.

Here, I feel, lies the real test. The subalterns of to-day are the cross section of the potential leaders of the nation. They must be, from the nature of things, the same men who will set the pace throughout the country when their National Service is done. Personally, I feel that on the whole these boys are excellent; and on the whole I believe that the majority of majors do their duty by them. But there is no room for complacency.

The Army to-day has a solemn duty to mould the young in the right way. It must put the young soldier into the job that will suit him best. The young officer must see that the young soldier works hard at the work he is given. But it is on the middle-piece officer (usually a Regular or Short Service Officer) that the main burden lies. He is in intimate touch with the subalterns and not too removed from the private soldiers. It is he who must demand the standards with the backing of his seniors. A great responsibility rests upon all of us to-day in this respect, and we cannot afford to be complacent with what we achieve.

Such are the somewhat random thoughts that Major Keelan's letter provokes in my mind. Let me try and sum them up as a conclusion.

(*a*) Officer and owner have totally different outlooks on the question of pay. Officer and soldier have a certain identity of view, owner and workman have none.

(*b*) The officer frequently has a task which is thoroughly uneconomical as a business proposition. He has to keep men occupied. The owner is seldom in this position.

(*c*) Workman and soldier have different views on steady employment. The workman yearns for it; the soldier must welcome change.

(*d*) Soldiers who excel in battle are not always so good in normal times. These men must be preserved in the Army. Industry has little use for them.

(*e*) There are real hard-working men in the Army and in industry. Indeed, all the Army types are in evidence in industry. Does industry always make the best use of them?

(*f*) When the owner is short of men he can be guided by economics in whether or not to take on more. The Army is seldom in this position. Too often the Army must make do with those it has. Here it is on common ground with the owner who cannot afford more men even though he would like them.

(*g*) In the higher reaches, it is submitted that the soldier is as skilful as the captain of industry in coping with manpower shortage—he is so experienced in it.

(*h*) On the lower levels the junior leaders are, because of National Service, identical men in the Army and in industry. The difference—if any exists—comes in the quality of supervision they receive.

(*i*) The quality of supervision is mainly in the hands of the middle-piece officers (majors) supported by their seniors. Here I am forced to admit a considerable range of achievement.

(*j*) No senior officer can be entirely satisfied with this range; and the improvement in the standard is largely in their hands. Senior officers must recognize good from not so good.

The short conclusion is therefore this: Conditions in the Army and in industry are so different that the same technique for man-management cannot hold good for both. None the less, we are driven to the old thought that there are no bad regiments; there are only bad officers. If we agree with Major Keelan's contention—and most of us will admit some truth in it—it is not at our men we should look, but at ourselves. Perhaps, then, industry should do so too.

A SAPPER SECRET WEAPON OF WORLD WAR I

By MAJOR-GENERAL M. N. MACLEOD, C.B., D.S.O., M.C.,

THE Battle of Cambrai, fought on 20th November, 1917, is famous in British annals as a great tank victory. But, for the Corps, it has another claim to fame; as the birthday of a Sapper war-baby, about which historians have hitherto said little, but which played a substantial part in the Cambrai success, and an even greater part in the victories of 1918 which brought the first World War to an end.

Though a Sapper, this war-baby should, by rights, have been a Gunner; since it was, in fact, a new artillery technique used for the first time in the Cambrai bombardment, the first to be delivered without any preliminary registration. This, in itself, might not be particularly remarkable, since bombardments delivered in this way have since become almost commonplace, but, at the time, it was a very remarkable event indeed; how remarkable cannot be appreciated without some knowledge of the artillery methods previously in use, and the views of artillery officers in those days.

It should be remembered that prior to 1914, the British Army had always fought in distant and unmapped countries; and all its tactical methods had to function without any help from a map. "Map-shooting" had never even been considered by the artillery, who had expected to be able to do most of their firing over open sights at easily visible targets. "Indirect" fire—in which the gun was laid by means of a dial sight (a telescopic sight mounted on a graduated circle attached to the gun), an aiming point, and a clinometer—was, of course practised; but it too postulated a visible target, since, in both sorts of fire, the aim was controlled by "ranging," i.e., by firing a few trial rounds and observing where they fell in relation to the target.

When good maps became available, in 1915, the ranges and bearings of targets could be got from the map, but not the bearings of aiming points, which were not generally map points, and were always much closer to the gun than the target. Maps therefore helped to get ranging started—for, with indirect fire, ranging could not begin unless, and until, a fairly good guess had been made at the angle to set on the dial sight—but they did not enable ranging to be dispensed with. On the contrary, all Gunners quickly learnt from experience that map values always needed correction before the target was hit; and, as a corollary, one and all acquired a deep and well-founded distrust of unranged fire which persisted to the end of the war.

These trial and error methods of gun aiming were unavoidable in the conditions envisaged before the war started; but in the conditions which developed as the war progressed, they were subject to severe limitations. One of these was, of course, that only targets which could be seen from the battery's O.Ps. could be ranged on; and even on these, ranging might be impossible if another battery happened to be trying to range on the same, or some near-by target at the same time, since it was then impossible to distinguish the shell bursts of either battery from those of its neighbour.

When it became necessary to mass great numbers of guns in narrow sectors of the front in order to support a big infantry attack, ranging had to be most carefully organized by the artillery command, and spread out over a long period. Invariably it was noticed by the enemy, and correctly diagnosed as the herald of a coming storm. However, although the enemy could not be taken by surprise, if targets were sufficiently visible and enough time was allowed, a reasonably accurate bombardment could be counted on: and a reasonably accurate bombardment generally enabled the infantry to capture their objectives. Trouble, however, always arose when attempts were made to follow up and exploit the success in the manner prescribed by tactical theory. The first attempts to do this, at Neuve Chappelle and Loos, were so costly and so unprofitable that the idea of "mobile" exploitation had to be abandoned, and all attacks "limited," the infantry being ordered to consolidate any ground gained, and hold it against counter attacks until the artillery could be brought up to support a further advance.

A move of the artillery meant, however, that they had to register an entirely new set of targets, and to do, generally in a few days, the job for which, before the initial attack, they had been allowed almost as many weeks. Naturally the job could not be done as well; sometimes it could hardly be done at all. Inevitably, the quality of their fire fell off as the advance proceeded, until it became little more than a rain of shells on the enemy's whole position, converting the ground over which the offensive had to pass into an impassable morass.

This peculiarity of the offensives of 1916 and 1917 became notorious, and caused no little perplexity. Without artillery the infantry could not advance at all, and yet the effects of artillery seemed to make any advance progressively more difficult. Defeat, instead of weakening the enemy seemed to leave him stronger than before. There is, however, nothing strange in this if the difficulties of the artillery are understood, and the decisive importance of accuracy in artillery fire is conceded. This peculiarity is, indeed, in itself, striking evidence of the tactical influence of accurate artillery fire; and the fact that so many British offensives of these years were continued under conditions which made accurate artillery fire impossible, shows how little weight was attached to this factor by the British High Command.

At Cambrai a change was made in the procedure; but not with any idea of securing greater accuracy of fire. On the contrary, the change was calculated deliberately to sacrifice accuracy in order to secure surprise; and, in spite of the misgivings of the artillery commanders, the bombardment was delivered without any previous registration. To understand how this came about the circumstances leading up to the Cambrai battle must be recalled. The great British summer offensive had just petered out in the mud of Passchendaele with staggering losses. The French Army, shaken and disheartened by the ghastly failure of the Nivelle offensive earlier in the year, seemed to be on the verge of mutiny. In September, the Russian Army, after a heavy defeat at Riga, had started to disintegrate. Then, to crown all, on 24th October, at Caporetto, the Italian front suddenly gave way, and the Austro-German armies started to pour into Italy.

The situation was grim indeed, and the only chance of saving it seemed to be to attack the enemy again, and at once. But only the British were capable of making any sort of attack; and if their great Ypres offensive, prepared in the utmost detail, and pressed to the farthest limits of human endurance, had failed to prevent the German strokes, what chance was there that another hastily organized attack would do anything more than incur further losses?

This was the impasse from which the British Commander-in-Chief had to find a way out. Only one was possible. Exhausted though the British Army was by its exertions and losses at Ypres, two of its Corps, the Cavalry and the Tanks, which had been out of the battle for some time, were fresh enough and still full of fight. The Tank Corps, moreover, bitterly disappointed at the poor showing it had made in the Ypres fighting, had long been maintaining that they had never had a fair chance; and that if all the available tanks were hurled suddenly at the enemy, on ground over which tanks could move, they would break right through the German trench line, and create an opening through which the Cavalry could pass and roll up the whole German position.

That, then, was the plan of the Cambrai battle. It was, specifically, a test of the tanks. If, after their failures at Ypres and elsewhere, they failed again in conditions of their own choosing, it would show that they would probably fail everywhere; but in that case, their loss would not be an irreparable disaster. On the other hand, if their coup came off, it might well prove to be an irreparable disaster for the enemy. The plan might be a gamble but the rewards of success were good enough, and the situation grave enough, to justify taking risks.

Surprise was vital to the success of the plan, but if the tanks were to have the support of artillery, surprise could not be counted upon. Yet the tanks were pretty sure to need artillery support to dispose of the German guns against which their armour did not give them protection. The choice seemed to lie between a bombardment delivered without registration, or no bombardment at all; a choice which, to artillery commanders, was rather like that between the devil and the deep sea. They urged that a bare minimum of registration should be allowed, hoping that "by centralizing the control of such registration, the enemy might fail to notice that newly arrived guns were in action."[1]

The Army Commander, however, would have none of this. He "intervened personally"[1] to place an absolute veto on any reinforcing gun opening fire before zero hour. This, surely, was a very unusual step, even for an Army Commander, to take. How did General Byng, who was a cavalryman, come to "intervene personally" in order to overrule his artillery experts in the preparation of this most critical plan? It seems most unlikely that he would have done such a thing entirely on his own initiative.

The *Official History* mentions (p. 6) that some months previously, the C.R.A. of the 9th Division had suggested to his Corps Commander that registration might be omitted in order to make a surprise attack; and although the suggestion may have been passed on to General Byng, it is very doubtful if the latter would have acted upon this alone. It is much more probable that the advice upon which he acted came from a Sapper and not a Gunner; to wit, the O.C. of his Field Survey Company, Major B. F. E. Keeling, M.C. R.E.

For some considerable time past the Field Survey Companies had been supplying all batteries with "artillery boards," i.e., specially mounted maps on which the range and bearing of any target plotted on the map could be easily and accurately read off; and Keeling, who had had much experience of this work, had formed the opinion that the prevailing distrust of map data and unranged fire was not justified, having arisen because artillery officers, accustomed to rely entirely upon ranging, and untrained in the use of maps, had never tried to make their map measurements any more accurately than was necessary to enable ranging to begin.

He had good reason to believe that if guns were properly aimed at their targets, the normal, and largely unavoidable, irregularities of shooting would distribute the shells along the line through the target and secure a fair proportion of hits even when the elevation was not exactly right. He had himself supplied survey "data" to a long-range "railway" gun which had had to open fire during the Somme battle in 1916 without ranging, and explained how this could be used to align the gun on its various targets. The procedure he had then devised had proved most successful, and he knew that it could be applied equally well, and with equal success, to all other sorts of gun. Unfortunately Keeling was wounded during the Somme battle, and had no opportunity to make further use of this knowledge until he returned to duty in 1917, to take over the com-

[1] *Official History of the Cambrai Operations*, pp. 12, 13.

mand of the 3rd Field Survey Company, R.E., shortly before the preparations for the Cambrai battle began. Keeling thus had special knowledge of, and very decided views on, artillery procedure, which he would have had no hesitation, in the circumstances, in expressing; even to the Army Commander.

The *Official History* records that when the Army Commander intervened to veto all registration, " Major B. F. E. Keeling undertook that the data required should be forthcoming," and that, with his two assistants " working almost day and night," they tackled their last job at two o'clock in the morning of the battle.

Keeling's advice and methods were abundantly justified by their results. Just after the tanks and infantry started their advance in the dim light of the dawn of 20th November, 1917, the bombardment—delivered simultaneously by more than 1,000 guns—opened " with a deafening roar," utterly dumbfounding the enemy, who, " stunned by the devastating precision of this storm of fire," were then " confronted with a new terror, the clattering onset of the tanks plunging through the gloom."[1] This was too much for the German infantry. " Here and there, amid the general confusion and alarm, the stouter-hearted manned their weapons and maintained the fight, but most of the survivors in the outpost zone either surrendered or broke and fled,"[1] and more significant still, the German artillery, at which most of the reinforcing guns had been aimed, was, for once, almost silenced.

Admirably though the bombardment had done its job, it was not the artillery but the tanks upon which all eyes were fixed. The bombardment had been only a makeshift; and it was not the artillery but the tanks that were being put to the test. Their coup had succeeded beyond the wildest hopes, and, in the general jubilation, it is not so very surprising that the unusually good effects of the bombardment should have attracted less attention than they might otherwise have done.

There was, however, no mistaking that the new method of bombardment had helped to secure a great surprise; and that, by itself, was enough to ensure that the methods would be used again at the first opportunity. That being the case, their other effects, on the accuracy of fire, followed automatically, even though they were neither intended, nor realized at the time.

The opportunity to try the new methods again did not occur until the next year, when, on 8th August, at Amiens, the Cambrai operation was repeated on a larger scale, and with exactly the same results. Again the enemy was taken completely by surprise, and again his artillery was silenced so effectively that the tanks and infantry were able to make their advance without serious interference from the German guns. But again, as soon as the artillery

[1] *Official History of the Cambrai Operations*, p. 50.

had been left behind, the Germans managed to bring the British advance, tanks, cavalry and all, to a halt.

This time however, Earl Haig could not risk any repetition of the Cambrai sequel, with its heavy losses and meagre gains. At the first check, therefore, he decided to give up any attempt to exploit his victory further, great though it had been, and to make another Cambrai-style attack in another part of the line, selecting, as the venue for this, a part of the original German trench line, because there " an attack seemed unexpected by the enemy " and " the ground was favourable for tanks." (Dispatches.)

Whether the tanks really gained any significant advantage from having to attack a strongly fortified position, instead of an improvised one in the derelict trench area of the old Somme battle, is rather doubtful; but on the other hand there is no doubt at all that the artillery did so. In a temporarily static sector the survey preparations for an unregistered bombardment could go on, ammunition be collected, and targets located, before any guns arrived. Then, when the guns had taken up their positions, fire could be opened without further delay, and with an actual gain in accuracy.

Moreover—to quote from the *Official History* (p. 23)—" Map shooting without registration was admirably suited to the support of a rapid advance, for a wide choice of battery positions had thus become available. As flash cover was no longer necessary, guns could come into action close to the front line, with a range extending deep into hostile territory. All the known enemy gun positions could be dealt with, as well as O.Ps., places of troop concentration, main routes, telephone centres, rest billets, command posts, and approaches along which counter-attacks might develop against the flanks." Hardly any of these targets could be engaged effectively on the old " ranging " basis, but with the new survey methods of aiming all could be well and truly plastered. This, coupled with the much greater accuracy attainable especially against distant targets, made the bombardments of 1918, all of which were delivered in this way, many times more effective than those of previous years.

The policy, initiated after the Amiens battle, of attacking always in a static sector, and making no attempt to exploit the success, or to press the advance, beyond the limits of effective artillery protection, was continued up to the end of the war. It might not have been the mobile warfare which every one believed to be the best way of defeating the foe, but it did the trick; and did it, moreover, without much loss of time, and at low cost in lives.

With artillery able to attack the enemy with " devastating precision " whenever and wherever he elected to make a stand, even surprise lost most of its importance. " Such was our superiority " wrote Field-Marshal Montgomery-Massingberd afterwards " that it would be positively to our advantage if the enemy could be induced to increase the number of the troops holding the line, as his losses would be heavier, and the results of the attack all the more decisive."[1] The German Command, however, evidently seeing in the British tanks an excuse for failure which did not reflect upon their military capacity, continued to proclaim, in their communiqués, that the cause of all the German defeats had been the inability of their soldiers to resist tank attacks.[2] And as no special claims were put forward by the artillery for the new methods, which, as explained, had been a Sapper, and not a Gunner invention, and worked entirely by a few specialists under the nominal direction of the Intelligence branch of the General Staff, it is not really very surprising that the British High Command never knew enough about them either to assess correctly their tactical effects, or to query the German claims.

Still less surprising is it that contemporary historians should have said nothing about them. Earl Haig's dispatches gave no clue which they could have followed up, and it was not until the publication of the *Official History of the Cambrai Operations*, in 1948, that the nature, and indeed the existence, of this Sapper secret weapon was officially disclosed. By that time, of course, Cambrai, and the campaign of 1918, had long since passed into history as a saga of the tanks.

If further evidence is needed of the potency of this Sapper secret weapon, it can be found in the interesting fact that the Germans, working along different lines, had evolved very similar artillery methods, and with their aid, broke through successively the Russian front at Riga, the Italian front at Caporetto, the British front at St. Quentin, and the French front on the Chemin des Dames. And finally, perhaps most convincing evidence of all, when the weapon was used in the second World War, after a long series of reverses, it had the same effect as it had had in the first, of suddenly, and dramatically, turning defeat into victory.

"Alamein" says the *Royal Artillery Commemoration Book* "was the first great artilleryman's battle in the second World War. For the first time it was possible to put into practice the principles governing the employment of artillery which played such a decisive part in the later stages of the war." But these principles were not new principles. They were the very same principles which had played such a decisive part in the later stages of the first World War also; and which, applied for the first time at Cambrai, had been sponsored by Keeling and his handful of Sappers.

[1] *The Story of the Fourth Army*, p. 151.

[2] The preface to the *Official History* of the 1918 Campaign says that "This excuse will not bear examination."

THE JERRICAN FACTORY, M.E.L.F.

By CAPTAIN D. BURTON, A.M.I.E.E., R.E.

INTRODUCTION

DURING the last war, factories for the manufacture of Jerricans, supervised by the "Sappers" and staffed by locally employed civilians were operating in Egypt, Palestine and India. The last of these military factories closed in 1947 and the manufacture of Jerricans was then carried out entirely by civil firms, principally those whose normal product was sheet steel pressings for gas stoves and motor vehicles.

It was subsequently decided, however, to install a Jerrican factory in the Canal Zone, capable of producing 1,000 new and 1,000 repaired cans per shift of eight hours. The building construction was to be executed by contract and the plant installed by the Royal Engineers.

The unilateral abrogation of the treaty in 1951 by Egypt unfortunately brought all work to a standstill. In July, 1952, the gradual return of Egyptians to the Canal Zone permitted work to proceed and by January, 1953, the production section of the factory was completed. The complete factory for production and repair is housed in a standard, five-bay, low Marston Shed and the plant is that previously installed in the war-time factories.

Scope of Work

With the exception of the neck assembly and vent tube, the complete can is made in the Jerrican Factory. Owing to the number of operations required in the production of the neck assemblies, it is more economical to have these sent out complete from U.K.

The factory is a costed installation and returns indicate that the production of Jerricans is economically sound.

LABOUR

The "Production Section" of the Jerrican Factory can be broadly classified into four categories:

(i) Press Operators
(ii) Welders
(iii) Painters
(iv) Maintenance

A few applicants for employment had previously been in the factories in Egypt and Palestine, so it was at once possible to form a nucleus of reasonably skilled press operators, welders and painters. With these men as instructors, small schools were set up and eventually about half of the required staff were got together. The non-availability of sufficient suitable local labour, coupled with their inherent absenteeism, made it essential to employ a substantial number of East African troops.

It is of course well known that East African troops are most amenable to task work, but the manner in which they adapted themselves to press operating, welding and painting has been little short of amazing. Their ability to work under extremely trying conditions, quite oblivious to the heat, especially in the welding booths, has been rewarded with much favourable comment from many a senior officer on tours of inspection. They have been kept together and the competitive spirit developed, and have turned out to be most reliable. An inherent cheerfulness while they are working at their respective tasks is certainly a major contribution to the daily production figures.

Skilled tradesmen to carry out maintenance and repair of plant are provided by the British ranks.

Production Processes

Press Lines

Two complete lines of presses for making the body of the can, and one for handles, were installed, the sizes ranging from 10 to 200 tons each.

The metal forming the body of the can is 20 gauge, extra deep, drawing steel, which is brought into the factory by fork lift truck in two ton bundles, and placed ready beside the guillotine for cutting to the correct size. From here it is taken to the blanking presses, whose 100-ton presses, worked by an average operator, produce six blanks per minute. The blanks are then lubricated in preparation for drawing. Drawing is done on 200-ton presses, each press dealing with two blanks at a time. Lubricated chutes have proved more efficient than roller conveyors between the draw and rebate presses, owing to the rebate press having a working speed of sixteen panels per minute. The rebate is put in principally for strength, and to allow the final seam to be welded, and not stand proud of the sides of the completed can.

The panels (this is the name given to a blank after drawing) are then passed to 100-ton trim presses, where the surplus edges are removed. In order to make provision for the neck assembly, the left-hand panel is passed to a small 10-ton pierce and plunge press, the hole and shoulder being formed in one operation.

Handles for Jerricans are made from 18-gauge, deep, drawing steel, each handle requiring six separate operations. The steel passes from the guillotine to the handle presses, six 45-ton machines each worked by one operator. Being relatively small, press operators can be seated at their work and pass their product to the next operator down a lubricated chute, where it lands in a basket adjacent to the press.

All presses are fitted with regulation safety guards. They are constantly inspected and adjusted, the rigid enforcement of safety precautions has kept all operators free from accident to date.

Degreasers

Before any welding can be done, all traces of oil and grease must be removed from the panels.

Two degreasers, capable of handling 272 cans per hour were installed. The degreasing medium, trichlorethylene, was originally heated electrically but due to the high loading (120 Kw. for both machines) they were changed to steam heating. A small still is provided with each degreaser and it is thus possible to distil the trichlorethylene for further use prior to cleaning out. Due to the sludge coating the steam coils, it is necessary to clean out rather more frequently than with electric heating. Panels are placed in baskets and are rotated in the vapour; on removal they are ready for welding.

Welding, Water Testing and Annealing

The gas consumption in a factory of this nature is relatively high and to avoid bringing oxygen and acetylene bottles to the operators, a manifold house was constructed and connected to a low pressure gas grid situated at high level in the factory. From the overhead grid, sixty-eight welding points are taken and spaced uniformly down the welding line.

The success obtained in welding Jerricans depends to a large extent on the accuracy of the jigs and to this end one man is constantly employed on repair and maintenance of all jigs in the welding line.

Neck assemblies are first tacked and then completely welded on to the left-hand panel, by oxy-acetylene welders. The right and left panels are sent down the roller conveyor to the carbon arc welding booths, where the two panels are tacked together and the seams finally welded. The Jerrican is now complete, except for the handle, and is tested under water with air pressure at 5 lb. per sq. in. to ascertain whether or not it will leak. Any leaks are marked by a special cosmetic chalk and passed to a repair welder.

The handles are tacked and finally welded by oxy-acetylene, the complete can being subject to a further air test to ensure no pin holes have occurred during the handle welding operation.

To relieve any internal stresses due to pressing and welding, the can is put on a motorized conveyor where four oil-fired burners play on the corners. The can is then de-scaled internally by tapping with a mallet and blowing out with air at 80 lb. per sq. in. After a reasonable cooling period, the can is ready for painting.

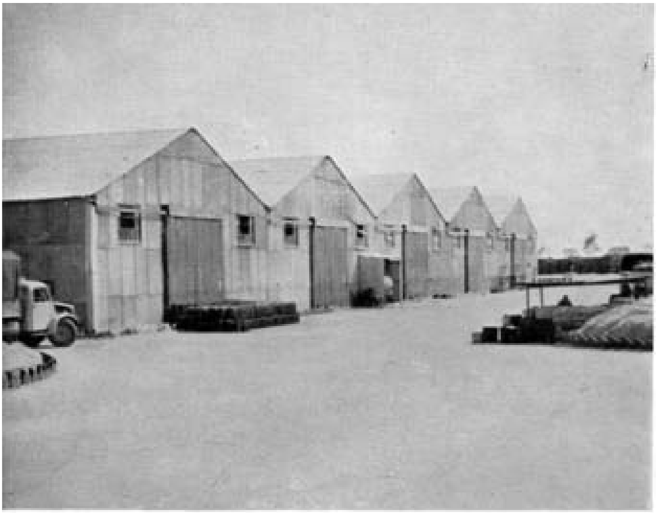


Photo 1.—Front view of factory.

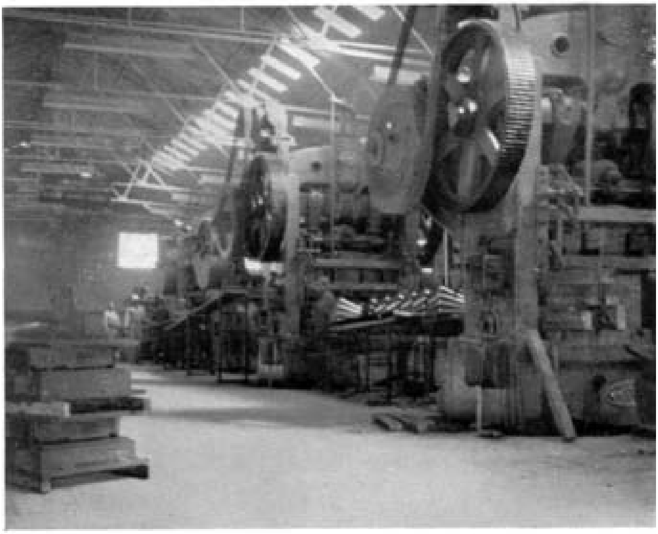


Photo 2.— The heavy press line.

The Jerrican Factory, MELF, 1,2

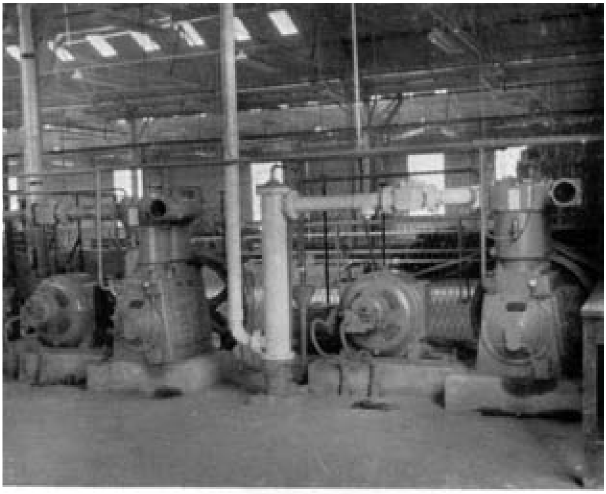


Photo 3.—The compressor room.

Photo 4.—Cans emerging from the stoving oven.

The Jerrican Factory, MELF, 3,4

Painting

The Jerrican has one internal coat of petrol resisting paint, one external coat of red oxide and finally an external coat of olive drab. Paint viscosities and stoving temperatures must be carefully controlled to produce a satisfactory Jerrican. In Egypt the temperature during the working day in summer-time may vary from 75° F. to 100° F. and the absence of fine thermostatic control on the ovens considerably adds to the difficulty of the painting processes.

Many methods of internal painting have been tried with varying degrees of success, but by far the most simple and effective method is to pour a gallon of paint into one can, close the filler cap and twist it round by hand. The filler cap is opened and the paint poured into another can and the process repeated. Cans are then inverted on properly sloped racks where they drain out. The draining time is approximately ten minutes per can and it is advisable not to try to cut this down.

Cans are then sucked out by vacuum pump, to which is attached a low voltage lamp in order that the operator can see to remove effectively all surplus paint.

The next operation is to invert the can on a hot air drier for about ten minutes, when the internal coat will have become "fixed."

From the hot air drier the can is closed and passed to the red dip tank. It is immersed in a tank of red oxide, given a few seconds to drain and suspended on a hanger on the oven conveyor. Then it passes on its way to the stoving oven. Just prior to entering the oven, the filler cap is opened to prevent pressure build up and allow the vapour to escape.

The stoving time is twenty-two minutes and, on leaving the oven, a jet of warm air is blown into the can to ensure all vapour has been expelled.

By this time, the internal and external coats should be set. To ensure this, each can is inspected internally.

Cans are then passed to the olive drab paint tank where they are dipped and passed through the stoving oven as before.

The can is given another internal inspection, it is essential that no blisters occur on the internal coat. A new sealing washer is fitted and the can is then subject to a hot water test.

For ten minutes it is totally immersed in hot water, when the internal rise in pressure would indicate any leaks. Cans that pass the final test are stacked ready for dispatch.

Maintenance

To ensure continuity of production, breakdowns must be few and far between. The importance of a planned and efficient maintenance cannot be over emphasized. Due to the various military duties which must be performed by the Sapper staff of the factory and the shortage of tradesmen, adherence to a definite maintenance routine has been seriously impeded.

To simplify maintenance as far as possible, a comprehensive chart was drawn up detailing the frequency with which various tasks would be carried out. This preventative maintenance has paid dividends and serious break-downs have, to date, been avoided.

Wear on tools, due to the unavoidable ingress of sand, is excessive. When tools are badly worn they are returned to U.K. for reconditioning.

A generously equipped tool room is able to supply most of the urgent needs.

Conclusion

At the time of writing, only the production side of the factory is in operation. The repair section is now scheduled for early completion.

Great interest has been shown in the factory by visiting officers and this has been largely responsible for the high moral of the unit.

Credit for increased output goes to the military staff of the factory, who are constantly putting forward new ideas for improving the production lines. The Sappers are encouraged to time and motion study particular operations, and on their findings, all feasible suggestions are tried out.

Dropping a Jerrican full of water from a height of 35 ft. on to a concrete roadway, without producing leaks, is a test performed on every two-thousandth can and particularly for the benefit of incredulous visitors.

It is hoped that this article written from the general interest point of view will throw a little more light on another of the various works undertaken by the " Sappers."

CONCEALMENT

By Major M. M. Martin, R.E.

ANY offensive weapon is of little use unless the attacker knows either accurately, as in the case of a rifleman, or approximately, as in the case of an atomic weapon, where his enemy is. The purpose of concealment is to keep secret from the enemy not only where the target is, but how it got there and who supports it.

Concealment consists basically of two principal components, namely camouflage, where the target is itself hidden by artificial and natural means, and deception in which dummy positions, vehicles, or installations are erected to draw enemy fire.

Before we deal in detail with these two components it is necessary to stress that no form of concealment will attain its object without strict discipline on the part of the individuals making use of it. Among the principal aspects of concealment which must be considered are those of track discipline, movement by day, noise, lights by night, and indiscriminate firing which may give away the position before the concealment has achieved its object.

The art of camouflage can be again divided under two main headings—natural and artificial.

Probably one of the most obvious means of natural camouflage is to go underground, thus disturbing the contour of the terrain to the minimum extent and giving the occupants of the position maximum freedom of movement, subject to the limitations of the size and amenities of the position. Extensive digging or tunnelling naturally assumes virtually static warfare, as was the case in Korea. It also involves the time element, the question of soil disposal, and possibly ventilation.

In mobile warfare a well-forested and steeply-contoured terrain is the best ally of concealment. In the present war in Malaya both sides appreciate this only too well. There is here a possible tactical use for an atomic weapon in destroying such wooded regions and denying their use to the enemy for concealment purposes.

Foliage, earth, and indeed any indigenous material, are the aids available to the individual soldier. Here again discipline must be stressed. Earth dries out, foliage withers, and cut grass turf will fade unless transplanted. Whatever the form of concealment in open country it must blend with the countryside, show little change of colour and none of texture, and have no visible man-made outline.

Artificial aids to camouflage are more limited in their application, since it is not easy to copy nature. We can reproduce the colour of grass fairly simply, but to incorporate the texture of each blade, which incidentally differs on each side, to make a convincing final product is a very different matter. It is the texture of the subject which tells the tale in air photography to a far greater extent than the colour.

The logistical side must also be considered. The artificial aid must find its way to the battlefield at the expense of other stores. For the individual the camouflaged suit and ground-sheet have provided the obvious answer since these perform the dual function of aiding concealment and protecting or clothing the man, but roll upon roll of green scrim brought up in valuable transport may be useless if the surrounding country is drought-parched, a circumstance which might well be unforeseen in long-term planning. Against such a problem enemy troops in Korea included in their winter clothing a jacket which is reversible, being white on one side and brown on the other. This allows the individual to blend at least partially with either snow or earth. A Russian garment for use in temperate climate is broken green and brown on one side and fully green on the reverse.

The time factor, and again transport, normally preclude the use of camouflage paint in forward areas and its employment is usually limited to static or semi-static installations and the camouflage of armour, vehicles, and similar equipment. The correct use of paint requires the attention, if not of experts, at least of those experienced in its use. The layman tends to be too formal in his design and the man-made result may have the very opposite effect to that desired. Camouflage paint whether on a building or a vehicle is at its best when partially weathered, but the rôle of the paint as a protective agent must be taken into account.

Screens may be used in one of two rôles. They may be camouflaged to merge in with the countryside to prevent the enemy knowing that operations are going on behind them, by giving the impression that the profile of the terrain is unaltered. Alternatively they may be used as "shock" protection against an advance by concealing from the enemy the extent of the defences immediately behind them. In this latter rôle their life is short, but valuable time may be gained for the defence while the enemy destroys the screen to enable him to determine what opposes him. Screens are used also in the deception rôle.

There is a considerable art in obtaining the right degree of deception and it requires the application of a psychological approach to see the proposed deception through the eyes of the enemy. It must be applied to exactly the right degree, as both over-obvious deception and a deception target which is too successfully concealed will fail in their purpose.

Three basic points are: the timing of the deception, its position, and the ability to maintain it. The maintenance of deception usually requires the inclusion of a proportion of "real life" equipment to make it effective. A dummy anti-aircraft position, to take an obvious case, must be able to make at least a token resistance to enemy aircraft. Roads and tracks must have the appearance of being in use to a degree consistent with the size of the deception position.

The siting of the deceptive position must be considered in relation to all the forces involved and their tactical rôles, and a similar principle applies to the timing.

Full use may be made of natural resources, such as foliage, earth, shadow, etc., in the construction of deception positions. A shallow depression of the appropriate shape may be made to resemble a trench, gun-pit, or whatever may be required, by judicious disposal of the spoil with regard to shadow, and darkening the excavated portion. Natural camouflage must be skilfully, but not too skilfully, employed. Foliage, for example, might be allowed to fade slightly more than it would in true camouflage. Dummy footpaths must be constructed by hand and given the appearance of being in use, and signs of activity maintained; for example, by the raising of artificial dust clouds where these might be expected.

Noise simulation may be a necessary adjunct to deception in certain cases. Small arms fire may be simulated by a device made for the purpose, but in practice the presence of an actual L.M.G. or a few riflemen will probably be called for. Simulation of the noise of armour massing was effected during the last war by several means, varying from scrap iron towed behind soft vehicles to the use of gramophone records and loudspeakers.

In general no effort must be spared, from such resources as may be available, to give the deceptive position every indication of occupation and activity, and a proportion of manpower allotted to this duty will seldom be wasted.

The artificial aids applied to camouflage find an equal use in the deception rôle. Even more care in the use of nets, scrim, etc., must be taken, as the deception position will for the most part be unoccupied and maintenance will tend to suffer.

The services of tracked and wheeled vehicles will be necessary to produce convincing tracks where required, and these must be developed and maintained in the case of a long-term deception. It is a feasible but lengthy job to reproduce tracks of armour by hand and the reproduction of duplicate tracks of the right width, the correct pattern of skid turn, and similar peculiarities, requires a degree of skill.

Stores to simulate trench excavations, gunpits etc., may be available, but local materials are more likely to be available for use as required.

During the last war portable dummies of many types were developed, from dummy men to dummy tanks of inflatable balloon canvas. The "sticks and string" type of deception equipment is likely to be the most readily available, and has the advantage that much of it can be improvised on the spot.

Screens may be used in the deception rôle. The attention of the enemy may be casually drawn to them with the suggestion that activity is taking place behind them. This use of screens naturally depends on the tactical situation allowing of their erection as a relatively long-term policy.

To summarize: concealment-mindedness, discipline, and ingenuity are the essentials for successful concealment. Simplicity, as in all branches of tactical planning, should be the major guide and this implies the use and improvisation of local materials, rather than dependence on prefabricated aids.

DEWATERING

By Major T. W. Tinsley, R.E.

Introduction

"DEWATERING" is the name given to a well-tried and well-found engineering technique. The aim is to remove the water from a selected volume of ground to such a degree that the soil behaves at its best, and can be dug out, usually by machinery, leaving the sides of the excavation at their optimum slope with a minimum of shuttering. This aim is achieved by surrounding the soil on all sides with " well points," each of which is protected by a gauze filter and about six inches of coarse sand. Vacuum pumps are then set to work to remove the water from the ground without removing any of the soil itself. The diagram and photographs attached to this article will make these points clearer. They are reproduced by permission of Millars Machinery Ltd., who are acknowledged experts in this field of engineering.

This paper cannot cover all aspects of the use of dewatering equipment, as no two problems are ever the same. The paper represents a summary of comments and practical hints which have been collected after conversations with several members of the firms of Millars Machinery Ltd. and W. & C. French Ltd. The latter firm specializes in work in bad ground and has found that, under suitable conditions, the technique provides an economical, quick and, indeed, perhaps the only solution to a difficult problem of muck shifting, particularly in " running sand."

There are many ways of improving the operation of the system, and hence this report.

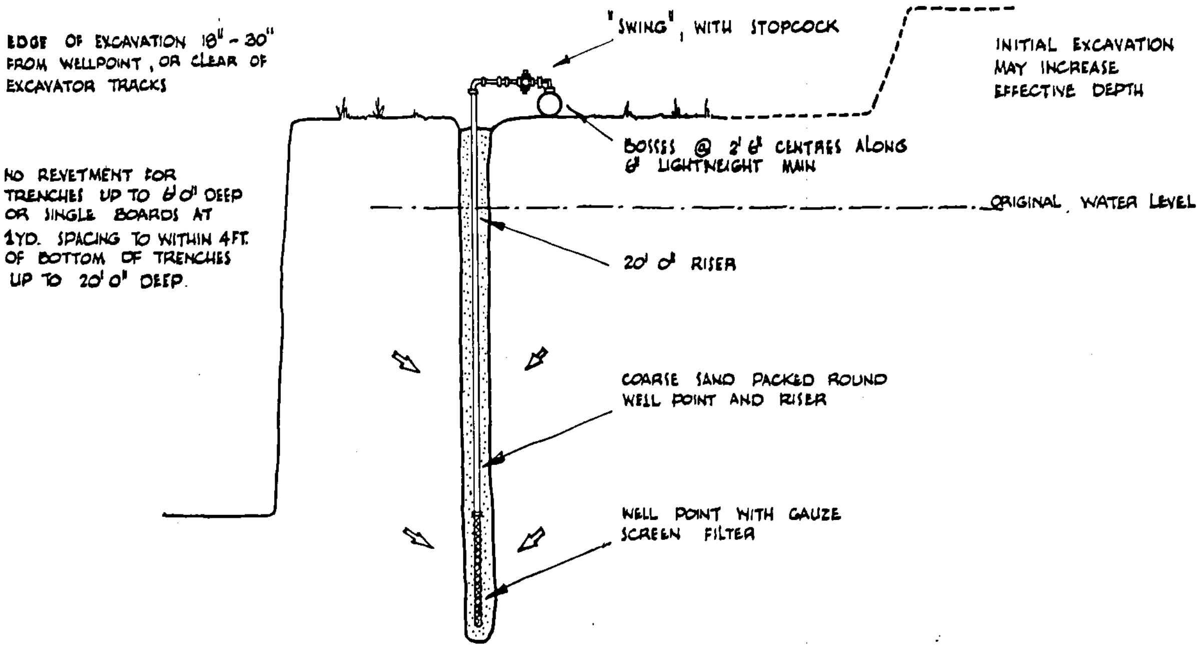
Factors Affecting Efficiency

(*a*) The following factors affect the use of the technique:—

(i) Soil type—or types—at varying depths.
(ii) Water table level.
(iii) Scope of project.
(iv) Suction head.
(v) Run off for water extracted.
(vi) Supply of jetting water.
(vii) Hydraulic gradient and flow of water to well points.
(viii) Effects of a breakdown.

(*b*) When considering whether the soil is suitable to be dewatered, two main aspects must be borne in mind.

Firstly, the well points may be difficult to sink. While it is possible to use an auger, in some cases, to lower the well points through a strata of difficult material, this is laborious and costly. The well points are most easily sunk by jetting them in, and therefore rough gravel which has not enough fines to enable the jet to displace the particles is not a suitable material for this technique.



MILLARS DEWATERING SYSTEM

Photo 1.—A trench excavated 11 feet deep in heavily water-logged ground after dewatering by means of the line of well points shown on the left of the trench.

Photo 2.—Jetting in a well point.

De-Watering 1,2

Photo 3.—Permanent water level on a site in South Australia before dewatering.

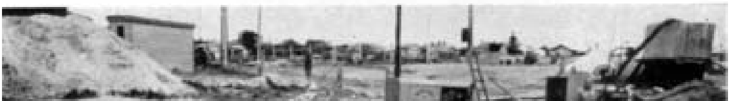


Photo 4.—The same site after dewatering.

De-Watering 3, 4

Photo 5.—A site in Wales close to the sea, which has been dewatered.

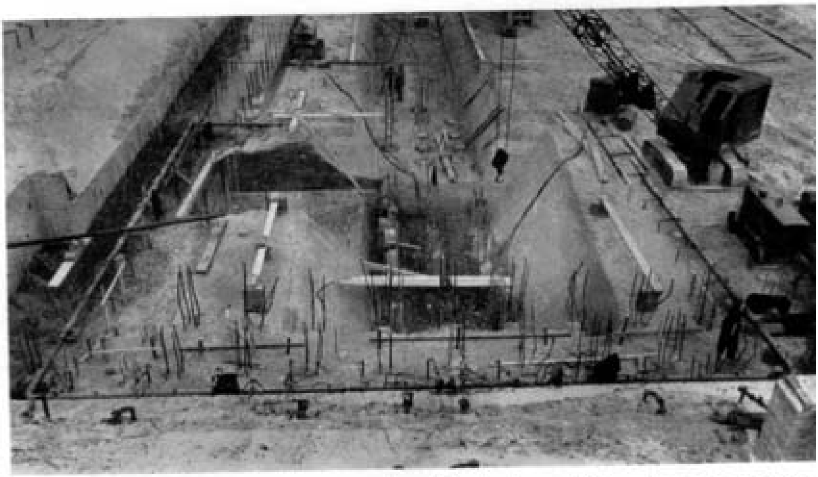
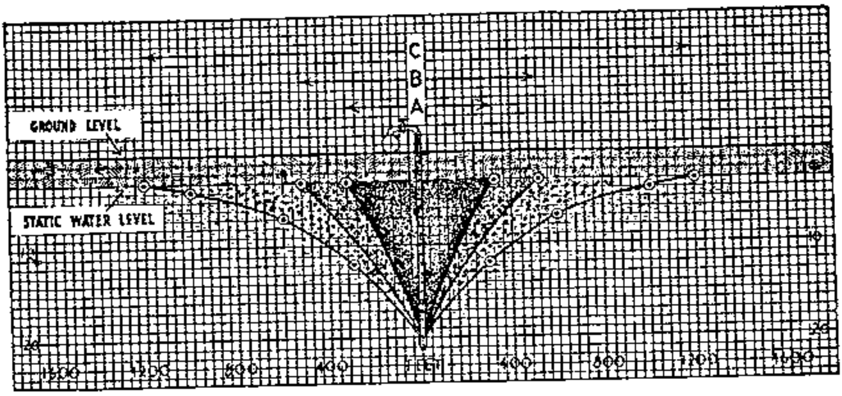


Photo 6.—The same site showing dewatering points in the top left-hand corner and in fore ground and an auxiliary ring dewatering to a further 16 feet.



Secondly, once the well points are sunk, it is essential that the water in the soil should be able to flow to them. Water will flow through sand and some silts, but *not* through clay.

It may be noted that a thin stratum of impervious material may entail double the effort (i.e. two layers), unless the stratum can be punctured sufficiently for water to flow to the well points.

These considerations are summed up in the following table which is based on the Casagrande classification of soils, details of which are given in *R.E. Supplementary Pocket Book 5D.*, Chapter III.

Consideration	*Unsuitable Soils*	*Difficult Soils*	*Suitable Soils*
Sinking well points	Rock GW		
Removing moisture content	GC SC CL CH OH	GF (with clay) SF (with clay) ML OL MH Pt	GP SW SP GF (with little clay) SF (with little clay)

(*c*) Under good conditions a normal ring of well points can lower the water table 15 ft. in 24 hours (these figures are very approximate—they simply illustrate that the technique *can* achieve startling success).

It is good practice to excavate as much as possible using standard methods until the water table is reached, so that the ring main can be set as low as possible, thus reducing the suction head of the vacuum pump.

After one ring main has lowered the water table to a certain depth, it is possible to excavate to this level and extend the effect of dewatering by means of a second and successive rings of well points.

(*d*) The capacity of the pump limits the number of well points that can be connected in one ring, and this limits the scope of the effort for each pump. The job must therefore be broken up into parts, depending on the spacing and the depth of the well points. A typical " Ring " may be a hundred well points set out at 5-ft. intervals to a depth of 18–20 ft.

(*e*) The vacuum pump cannot overcome a suction head of more than 21 ft. The filter end of the well point is 3 ft. long, and therefore one should aim at a maximum depth of 15–20 ft. below the Ring Main level.

(*f*) It is essential that water, once removed from the soil, does not percolate back into the ring, and the pump is limited as to distance or height to which it will deliver the water. A Booster pump will overcome this difficulty.

(*g*) It seems an " Irishism " but, before dewatering can commence, it is necessary to arrange for an adequate supply of water to jet the first ring of well points into the ground. After dewatering has commenced there will be adequate supplies of water for future " jetting " from the initial well points, but in the first instance a supply of 200–300 gallons will be needed for each well point.

(*h*) The principal factors affecting the spacing of the well points are the depth of excavation required and the flow of water to the well points from the areas farthest away from them. Provided the water can flow to the well points there seems to be little limit to the quantity that can be removed, since dewatering has succeeded at 42 ft. below sea level in sea-borne gravel and sand—a truly remarkable feat. While laboratory tests may show a figure for the gradient required to pass water through the soil, there seems to be little to beat practical experience, coupled with a trial ring and bore holes to show the actual effect on the water table. When excavation has started it may be impossible to jet in extra well points in the " Ring " without damaging the work, but initially it is a fairly simple matter to put in extra well points. After work has commenced extra well points can be installed inside the excavation.

(*i*) When excavation is under way it is essential that no breakdown should occur. If the moisture returns to the soil, the sides of the excavation will collapse, cavitation will begin and the last state of the work will be worse than the virgin state of the soil. It is most necessary, therefore, to have a stand-by pump ready for instant action.

Hints for Operation of Dewatering System

(*a*) Ensure that the well points are all level throughout the job: this ensures that all the points are equally effective and prevents any length of pipe, which might otherwise be stagnant, from silting up.

(*b*) Test the circuit regularly and do not be guided solely by the flow at the discharge or the gauge on the pump. Test each point and see that it is actually working, either by the noise of its flow, or the fact that if water is flowing it will cool the pipe below the ambient temperature above ground, and may even make a visible condensation. Also, test joints for leakages and ensure that valves are properly closed and not blocked in their action by silt.

(*c*) Stop the pump occasionally, perhaps once every twenty-four hours, when working in very fine silt or clay, let the water "back flush" and restart: this helps to keep the system of pipes and valves clear without disturbing the sand round the well points.

(*d*) Withdraw well points by jetting and not by brute force, to avoid damaging the expensive filters on the end of the well point.

(*e*) Make full use of valves in the circuits: replacement of pumps, faulty well points, etc. is then easy while keeping up the flow of water from the rest of the circuit. Valves will also enable the "stand-by" pump to be used in the next circuit along the line of march so that work can "leap frog" without loss of time. If a breakdown does occur in the primary circuit, the "stand-by" pump can be switched into it by changing the valves.

(*f*) Ensure the pumps are in good condition before they are operated—for instance, there is a cork float valve in one type of pump which may get saturated in time if not replaced or dried out, and may cause inefficient working.

(*g*) As the well points are jetted in, they should be worked by hand with a clockwise screwing motion to give a hole about 12 in. diameter. Once in position it is essential to have about $\frac{1}{3}$ yd. cub. coarse sand ($\frac{1}{8}$–$\frac{3}{16}$ in.) ready to fill the hole right up as the jetting water is turned off. This gives a good filter at the bottom of the well point and prevents it from silting up and pumping silt out, which would cause subsequent cavitation and collapse. Men *must* be trained to do this most important task properly.

(*h*) Flexible hose must be handled carefully and dried out before storage, as replacement of hoses is one of the items which frequently occur on the bill for daily running. There may be scope for the inclusion of a pressure safety valve in the pipe line to prevent pressure from building up suddenly and bursting the pipes.

(*i*) The ring main should be set back about two feet from the edge of the excavation, but ensure that the width is sufficient for the tracks of any mechanical excavating machinery to pass.

(*j*) Keep all the parts clean, ensure that they are stored and handled carefully, and make repairs early.

(*k*) Fill the header pipe with water before starting up, and watch that the pumps do not gain on the rate of water percolating through to them.

(*l*) It is inadvisable to dewater during excessively cold weather due to the danger of freezing up. Pipes may have to be warmed if frost conditions are encountered.

CORRESPONDENCE

"B.R. or B.M."

(*R.E. Journal*, June, 1954)

The Editor,

Royal Engineers Journal.

SIR,

It is indeed gratifying to see a Sapper answering so promptly the call to engineers of vision to set the world to rights. I feel, though, that "Monstroviam" is in danger of blinding himself with the brightness of his particular vision. A slightly deeper study of his scheme for British Motorways will I think expose, if not fallacies, at least weaknesses.

It does not follow that because high speed bus services are efficient transport between Tulsa and Oklahoma or indeed between Chatham and London that they are necessarily universally suited for steady and continuous operation over wide variations of traffic density and type. Nor does it follow that because road transport is more efficient in land use and route capacity than rail that it is possible or desirable to convert one to the other.

May we consider first the problem of maintenance and replacement? We are told that British Motorways could do with 110,000 vehicles what British Railways now do with 1,242,000. This comparison I must first modify since it is not in accordance with the supporting figures. At least 44,000 B.R. vehicles are not concerned with movement along existing rail routes and would, presumably, be also required by B.M. to perform their present task. B.M. will then require 146,000 prime mover vehicles to do the work for which B.R. requires 57,000 prime mover vehicles and at least 19,000 of these last are robust, long-lived machines requiring little maintenance. To perform the tasks allotted to them each B.M. bus and lorry must travel 26,000 miles a year, even if never moved a mile unless full to capacity. Suppose we are more realistic and assume 50 per cent load factor, a not unreasonable figure since much freight traffic at any rate is one way. Each vehicle must then travel 52,000 miles a year. Many people may consider that the vehicle will be past its best by then and no machine to travel at 60 m.p.h. with a heavy load. But let us assume that superlative design and maintenance will give a life of 100,000 miles. B.M. will require then to renew its entire rolling stock every two years—a thousand new vehicles a week—surely a sizable and costly problem even if only to dispose of the worn-out items.

"Monstroviam" draws an attractive picture of a new life for the city commuter—never waiting for a train—never missing one. But is it really so simple? How many suburban stations in closely built up areas can allow through traffic at 60 m.p.h. while buses unload? How many of these have room not only for these lay-byes but for space for the vehicle to slow down and accelerate clear of the main stream? How many can find space to turn a vehicle and bridge it over or under the main line to the return lane? And why does he assume that he will get 100 per cent load factor from his system? Suppose the average suburban run is fifteen miles. In order to achieve the 5 per cent efficiency supposed by "Monstroviam" each vehicle must run at least one hour a day at 60 m.p.h., that is four suburban journeys. Unless B.M. can persuade their customers to return home for lunch this means each vehicle must make two full journeys morning and evening with one empty return journey in between, a load factor of 66 per cent at its most optimistic.

We are told that drivers can be paid by results and that output will produce attractive pay packets. (" A driver's daily output might be 3,000 ton-miles or 10,000 passenger miles.") This seems to be a fallacy, for the present inefficient " average " engine driver moves 605 ton-miles an hour and the crack express driver may well move 110,000 passenger-miles in five hours! Even if we allow a train crew of three and a bus crew of one payment by results will hardly be attractive to the driver of B.M. vehicles.

There can be little doubt that high traffic densities are possible on roads but in deciding to change from one to the other can we really ignore cost and practical considerations? It is not just a matter of paving the existing formation, though this is a large enough problem (20,000 miles at say £50,000 per mile). Every level crossing must be replaced, no problem in open country, but what of the many in close built areas (the city of Hull has, I believe, thirty). And what of the open decked bridges, all of long span, that must be rebuilt? How will B.M. be affected by weather, will we still be able to travel at 60 m.p.h. in snow or fog? Trains can and do.

How long can we afford for the change over? Ten years? Many will say that that is far too long to disrupt our transport system. But even in that long time we must rebuild 2,000 miles a year—£2 million a week for paving alone. Can we afford to build up a civil engineering industry of this size for ten years' work?

I started to write this letter intending to state facts and have ended asking questions. Though they may be rhetorical, perhaps someone can answer them and *via monstrata* we will all be enthusiastic clients of B.M.

But till then, Sir,
I must remain,
A FAITHFUL IRON HORSE.

24th June, 1954.

Editor's Note.—There has been a considerable amount of correspondence on this subject in *The Times*, and the article in the *R.E. Journal* has been quoted there. " Monstroviam's " article was composed on broad lines, but it is highly probable that more will be heard of this problem in the future.

" PAST AND PRESENT AT THE S.M.E."

(*R.E. Journal*, June, 1954)

DEAR SIR,

I am indebted to Colonel A. H. Bell for pointing out a mistake in the above article. The village of which Sir Francis Drake's father was the parson was not Upnor but Upchurch, five miles farther down the River Medway.

The Rev. Edmund Drake is recorded as having become vicar of Upchurch in 1560.

Yours faithfully,
J. M. LAMBERT.

Minster,
30th June, 1954.

BOOK REVIEWS

THE WAR AT SEA

Vol. I

By CAPTAIN S. W. ROSKILL, R.N.

(Published by Her Majesty's Stationery Office. Price 42s.)

War at Sea is, by long usage, waged in silence and secrecy in an element which obliterates without trace. Thus during hostilities, only a few people have any detailed understanding of the long sequence of violent and locally decisive incidents which constitute maritime warfare. It is only when a connected story is finally pieced together, as in this first volume of the official account of the *War at Sea*, that the barriers of security are at last removed and that fresh fields of naval history are thrown open to the thousands who wish to explore them.

The tale unfolded by Captain Roskill is at once thrilling and agonizing. That evil ruling "No War for ten years," which was the bane of all three services, the squabbles of the Admiralty and the Air Ministry, Scapa Flow dismantled after 1914/18 and insecure in 1939, Malta practically naked of air defences—all these pass under review. The Admiralty, perhaps made over-confident by the "asdig" and better A.A. guns, evidently underrated the dangers which were so soon to come from the submarine and the aeroplane. It was also unconscionably slow in deciding that carefully routed convoys with powerful escorts not only saved ships from isolated destruction, but also enabled U-boats to be dealt with far more effectively than any system of hunting for them separately. Since the convoy system finally triumphed in 1914/18, it is difficult for the layman to understand exactly why it was not at once more rigorously enforced in 1939/41.

That political gestures cannot succeed unless they are backed by effective military force is an axiom which, in time of war, cannot be shaded or qualified. The Government's disregard of this axiom cost the Royal Navy dear both in Greece and the Far East. In the latter theatre the battleship *Prince of Wales* was first sent to Singapore as a political deterrent to Japan and against the advice of the Admiralty.

One of the most interesting features in the book is the detailed account of the German armed raiders, which were directed with boldness and skill. One of them passed into the Pacific by way of the north coast of Siberia and the Bering Straits. Another sank and was sunk by H.M.A.S. *Sidney* off the west coast of Australia. The results obtained by the raiders did not compare with the losses caused by U-boats, but nevertheless they gave a lot of trouble.

In general the Admiralty shouldered its enormous responsibilities slowly but surely. The Royal Navy stood by the Army with its traditional devotion in Norway, at Dunkirk, in Greece and Crete, and in the Far East. In the battle of France the 51st Division was the only formation which could not be evacuated. Early in the war the rescue of several hundred merchant seamen from the *Altmark* in a Norwegian fiord fired the imagination of the whole world. Above all the movement of shipping in millions of tons, to, from and round the British Isles never ceased, in spite of the truly formidable efforts of Germany to prevent it.

Captain Roskill's clear prose is an admirable medium for describing the complications of naval warfare. His comments are few, fair and unprejudiced so that much is left to the judgement of the reader. He most properly pays eloquent tribute to the officers and men of the Royal Navy, whose conduct was never more splendid than in times of adversity. Whatever else failed, they never did.

This fascinating first volume of the *War at Sea* is one of those books that simply must be read. It fills a big gap in the history of World War II which has, until now, been hardly touched. B.T.W.

THE DECISIVE BATTLES OF THE WESTERN WORLD

By MAJOR-GENERAL J. F. C. FULLER, C.B., C.B.E., D.S.O.

(Published by Messrs. Eyre & Spottiswoode. Price 30s.)

To the elderly and perhaps even to those of middle age, the title of this book inevitably recalls Creasy's *Fifteen Decisive Battles of the World*, which is now seldom mentioned. Published in 1851, it ran into forty editions by 1894. At the turn of the century, it was one of those formidable books in resplendent calf bindings but poor print, which started on their long trail to dusty oblivion as prizes for the deserving. Yet the *Fifteen Battles* is nearly a masterpiece. It is not long and for those who have no history, the synopses of events between the battles make it a valuable abstract of warfare from Marathon to Waterloo. Creasy was, of course, a romantic and cast a glamour over war which it seldom deserves. His description of the battles shows little of that understanding of the military art, which is obviously desirable.

Nevertheless it is a little strange that General Fuller makes no reference to Creasy in his Preface, particularly as the outline of his book is not dissimilar, except that full-blooded chronicles replace the skeleton synopses. Perhaps the General thinks little of Creasy's amateur investigations. He certainly makes small use of the outdated book: only in the battles of Arminius and Varus is there any trace of it.

All this does not in the least detract from the grand manner in which General Fuller has set about his task. In three volumes he will have written a unique history of war from Megiddo, 1479 B.C., to the decisive sea battle of Leyte Gulf, 1944. This first volume goes as far as Lepanto 1571. The second will take in Waterloo by next autumn, and the third will appear in the spring of 1955 to finish the work.

In a long history such as this, a pleasing style helps much to carry the reader along contentedly over the rough ground, which he has to cover. In the *Decline and Fall of the Roman Empire* on almost every page some tremendous sentence whets the appetite for more. Yet where war is in question, Kingslake's *Crimea* often shows that decorative writing can border on the ludicrous. General Fuller's clear cut prose is, therefore, admirably suited to his purpose. His battles have a tactical reality which must be new to history. The battle of Hastings is particularly good in this respect.

Volume I seems to suggest that two " leitmotivs " underlie the history of war. One is the unending desire of mankind for empire and the other is the ceaseless urge of eastern peoples to press towards the fairer and more temperate lands of the west. Movements in the other direction were, in the ultimate analysis, defensive. They did not consist of nations on the march with their wives and children, goods and chattels, seeking new abodes. No doubt these two dominant ideas will be further developed in Volumes II and III, which will be eagerly awaited. B.T.W.

IWO JIMA—AMPHIBIOUS EPIC

(Published by the Historical Branch—H.Q. U.S. Marine Corps)

This thirteenth monograph takes the story of the U.S. Marine Corps in the Pacific on to the Bonin Islands, which lie about 660 nautical miles south by east of Tokio and 700 miles west of the Mariannas. Iwo Jima was required as an air relay base, from which Mustang fighters could cover the action of B-29 bombers over the mainlands of Japan. Shaped like a leg of mutton, Iwo Jima is only five miles long by two and a half miles wide. At dawn on 19th February, 1945, an armada of 450 ships lay off the island and two U.S. Marine divisions landed successfully the same day. A third Marine division and V Amphibious Corps H.Q. landed on 24th February. By 26th March General Schmidt, the Corps Commander, had concluded the largest enterprise ever undertaken by the U.S. Marine Corps. The fighting was fierce. The Japanese defenders numbered 21,000 and they inflicted 23,156 casualties (of which 5,885 were killed) on the Marines, before they were finally liquidated.

In the *R.E. Journal*'s review last June of the *Recapture of Guam*, reference was made to Admiral King's insistence in 1944 on the main advance to Japan being made by way of the central rather than the south-west Pacific. A somewhat similar decision resulted in Formosa being discarded as an objective for 1945 in favour of Iwo Jima in the Bonins and Okinawa in the Ryukyu Islands. The attack on Okinawa, 740 miles farther to the west began even before Iwo Jima was finally captured. The final operational history of World War II, into which all these monographs are to be integrated, will no doubt show how the main strategy of the air/sea war against Japan was planned. It will be interesting reading.

Land-based U.S. bombers and fighters started using the Iwo Jima air strip early in March so that the main object of the operation was attained with remarkable speed. As usual the monograph is beautifully produced.

B.T.W.

A CONCISE HISTORY OF MATHEMATICS

By DIRK J. STRUIK

Professor Struik has compressed a history of mathematics into under 300 pages and to do this has restricted himself to the unfolding of a few main ideas to the detriment of other advances and new ideas. His treatment of this very large subject has been to trace the evolution of mathematics as far as it is known in early history in the main centres of civilization of Egypt, Babylon, China, India, Greece and Arabia. He has related the development of mathematics to the social and economic conditions of the countries concerned and has selected a limited number of examples to support his conclusions. The influence of agriculture, commerce, manufacture, warfare, engineering and philosophy on the development of mathematical thought and advance are all considered and the best of all the early thought is gathered together in the fifteenth century at the University of Bologna, from whence he traces the modern age of mathematical thought in Western Europe.

The rapid development of mathematics during and after the Renaissance brings into revue such great scholars and mathematicians as Archimedes, Diophantos, Benoulli, Kepler, Galileo, Cavalieri, and Fermat who each are shown to pave the way for Newton to develop the Calculus. The history is taken through the eighteenth and nineteenth centuries but wisely does not attempt to analyse the twentieth century mathematicians.

The necessary brevity and omissions required to keep this book to its small size has led to the author's conclusions and methods of progress being statements rather than logical deductions from facts and examples and the book itself is a little unsatisfying.

Satisfaction can be obtained with further reading, and the author has included excellent bibliographies at the end of each section. The book in itself is less a history of mathematics than an introduction to the history of mathematics and an excellent guide for orderly thought and reading by would-be students of this vast subject. For others it shows the outline of the development of mathematical thought and philosophy and reminds us that the accepted methods and approaches at present in use are by no means likely to be final.

A good book as an introduction to the subject or a guide to further study. C.H.C.Ll.

THE ARMED FORCES OF SOUTH AFRICA

By MAJOR G. TYLDEN

(Published by the Africana Museum, Johannesburg. Price 25s.)

This book of 239 pages (octavo) was originally written in 1947 for the Society of Army Historical Research, but proved to be too long for the society to publish. It was then submitted to the Africana Museum, Johannesburg, which financed its publication. Its chief object is to trace the units which, at one time or another, served in South Africa. Many of these units have long ceased to exist. The present armed forces of the Union are only mentioned in very general terms. The title of the book is, therefore, rather a misnomer. For the general reader, however, the short account of the many wars, which have taken place in South Africa between 1659 and 1946, may be useful. B.T.W.

TECHNICAL NOTES

Notes from *Civil Engineering*, April, 1954

INDUSTRIAL USE OF TELEVISION

Television is being increasingly used in industry for a number of purposes. Its great virtue is that the " eye " of the camera can operate where conditions would be dangerous or impossible for an observer, or alternatively where congestion makes it impossible for a number of people to see simultaneously some small operation. It also makes it possible for a single observer to be in " several places at once." The article describes the equipment available to industry, and some of the uses to which it has already been put with success. Whilst no specific civil engineering applications have so far been listed, it would appear that there might be a wide field for experiment.

Underwater television, which was successfully used to locate the sunken submarine *Affray* and more recently the wreckage of the Comet aircraft off Italy, could well be employed for the rapid examination of marine structures such as bridge piers, wharves, etc, where divers could not operate or because of its greater economy. The article points out that if used by a diver, television would allow the engineers on the surface to see for themselves rather than estimate the situation by question and answer.

A further suggestion is the use of the " eye " on the bucket of a very large aerial cableway placing concrete, etc.

The Owen Falls Hydro-Electric Scheme in Uganda

Last month Her Majesty Queen Elizabeth II, during her Commonwealth tour, formally inaugurated the first of the generating sets in the Owen Falls dam in Uganda.

The ceremony marked an important milestone in the development of central African resources, for it is the first really large hydro-electric scheme in the area.

The article describes the main features of the project and some of the engineering difficulties which had to be overcome during the construction of the main dam which is approximately 2,500 feet long, 100 feet high and contains some 223,000 cubic yards of concrete. Considerable skill and ingenuity was exercised in the design, construction and final placing of some very large coffer-dams for temporary works. One of these coffer-dams consisted of a timber crib 50 ft. in height and lined with a steel cage of ex anti-torpedo netting. The rock fill weighed 400 short tons, and the whole structure was placed in one piece by the felling method.

In other sectors, owing to the rocky nature of the ground, it was impossible to drive steel sheet piling to obtain watertightness so a series of timber cribs, consisting of logs bolted together, were constructed. The cribs so far as possible were made so that their lower faces " matched " the underwater surface of the rock on which they were to sit. The cribs were then filled with rock to anchor them and steel beams were fixed to act as waling spanning between the cribs. Steel sheet piling was then placed as a facing sheet giving watertightness except at the toe, and here " murrum " was dumped in large quantities together with bags of lean mix concrete which set in configuration with the ground. The whole article on the description of the work makes most interesting reading.

Design of R.C. Retaining Walls—Economic Aspects

The second part of this extremely useful article appears in this month's edition. The author discusses the design of counterfort walls and goes into the economical spacing of counterforts very carefully, together with the factors deciding the economical minimum height at which the incorporation of counterforts in a retaining wall is desirable. From the various design equations, some very satisfactory graphs have been evolved; one shows the height above which counterforts are economical and is plotted for three values of soil density, equal to 150 lb./cu. ft., 120 lb./cu. ft. and 90 lb./cu. ft. The graph ordinate is represented by the angle of soil repose, ϕ, with values from 15 to 45 deg. The graph abscissae represent height in feet from seventeen to twenty-five feet, and in this particular graph the prices of concrete, steel and shuttering are fixed. The second graph shows the variation of counterfort spacing with the change in prices of materials and shuttering; the third graph shows the variation of minimum height for a counterfort wall with change in prices of materials and shuttering. The author draws the following useful conclusions:—

(*a*) Length of toe should be 0.45 to 0.65 of base. Lower values should be used when bearing value of soil is high or when shuttering is cheap.

(*b*) " No heel " or " no toe " designs are very expensive.

(*c*) It is more economical to allow release of soil compression under the edge of the heel if there is no risk of water reaching there.

(*d*) If all prices change in the same proportion there is no change in either the economical spacing of counterforts or the minimum height for counterforting.

(*e*) Spacing of counterforts is affected mainly by height of wall, density of soil and prices. It increases with height and decreases with density.

The dearer the shuttering the greater is the spacing. Materials have opposite effect. As the variation in cost is not sharp near the economical values of spacing, an empirical rule to keep the spacing of counterforts between seven and twelve feet is suitable, higher values being adopted for taller walls.

(*f*) The minimum economical height of walls for counterforts decreases with increase in intensity of pressure.

The influence of the change in prices on the economical height at which to change from cantilever to counterfort type walls is considerable. Cheaper shuttering and dearer materials lower this height. For example, in Burma it may be about fifteen feet, whereas in Britain at present it should be about twenty feet. The article brings out the point which is always important in good civil engineering practice, namely that it is not very difficult to design a retaining wall but to design one which is economically efficient requires a certain degree of skill and examination of detail.

The article is to be concluded.

Mechanical Continuous Loader

A new type of elevating loader known as the "Rotary-Loader" is described. It has an output of 30–50 cu. yds./hr. and can handle material up to 6 in. in size, although maximum efficiency is obtained with material up to 3 in.

The makers, David Roberts & Co., Ltd., claim that one operator can operate three of these machines simultaneously.

Soil Stabilization Equipment

Rotary Hoes, Ltd., have manufactured a specially matched soil stabilization equipment consisting of a pulverizer and mixer with which water spraying apparatus is incorporated, a cement spreader which is fitted to the pulverizer and mixer, and a compactor.

The equipment can be supplied either as a complete single-pass outfit, or by individual units. The pulverizer and mixer employ the normal tractor power take-off control.

Notes from *Civil Engineering*, May, 1954

Prestressed Concrete

An unusual grain storage project is described in which the circular or elliptical silos were in prestressed concrete. It is the means of applying the prestress that is of interest. The concrete was of precast blocks with wire wound around the silo with sufficient tension to ensure that it was tight. The separate strands of the coil were then distorted from the straight by a simple lever and held so distorted by wire ties exactly as the base of an army hospital bed is tensioned. The wires were later covered with gunite. The simplicity of such a method of prestress may well find application in other fields of engineering.

Composite Bridge Construction

Undoubtedly the most interesting article to the sapper in this edition is one on composite bridge construction. It is more normal in general R.S.J. span construction to pour a concrete deck over the beams which is merely a means of distributing the load over the beams themselves. However, by securing the concrete to the steel we can produce a composite beam in which the steel takes the tension and the concrete the compression rather like a reinforced concrete T beam. The design calculations are simple and a saving in steel of up to 30 per cent can be achieved.

Mechanical Pointing of Brickwork

A most interesting article appears in this month's edition on new methods, organization and the difficulties encountered during the "top overhaul" on the lining of a large tunnel. A considerable amount of repair work to tunnel linings, especially repointing, together with difficulties in obtaining labour and arranging occupations, necessitated the development of a method which would be economical in men and time. This has been particularly desirable in the Severn Tunnel where general conditions are severe, due to both the physical characteristics of the tunnel and the very heavy traffic which it accommodates. The author points out that it is perhaps an axiom where the two previously mentioned desirable economies are required together, it is necessary to think in terms of mechanization. The problem therefore resolved itself into: (*a*) the mechanical cleaning down and preparation of brickwork (raking of joints, etc.), and (*b*) the mechanical application of fresh mortar into the joints.

The article describes in detail and with illustrations exactly how these two operations were carried out, the cleaning with a high pressure water jet lance and the pointing with a specially designed air blast nozzle. It was found that one lance with a nozzle diameter of $\frac{1}{8}$ in. could clean and rake on an average 1 sq. yd. of brickwork in $1\frac{1}{2}$ min.

Notes from *The Engineering Journal of Canada*, April, 1954

Canada's First Subway

The April, 1954, issue of *The Engineering Journal* (*Canada*) contains three papers dealing with the following aspects of the design and construction of the recently opened underground railway in Toronto:—

(i) Job control.
(ii) Installation of electrical equipment.
(iii) Cars, shops and mechanical equipment.

These papers are of interest in that they describe the planning and construction of a modern electric railway system embodying the most up-to-date equipment and safety devices, and involving the most careful co-ordination to avoid undue interference with established public utilities and road traffic.

It is stated that, as a result of co-operative planning, "consumer complaints" were practically negligible, and the complexity of the problem to be solved in a modern city is simply and clearly set out. Traction and auxiliary power requirements and distribution are discussed, and brief descriptions are given of the control, communications and alarm systems, and of the signal system, including automatic train dispatchers. The design and installation of lighting schemes are particularly interesting.

It is gratifying to know that the rolling stock is British built, and there are many points of interest in the descriptions of the equipment installed for heating, ventilation, escalators and drainage.

Reconnaissance of the Labrador Railway, 1945

This paper, in diary form, shows what can be done by air reconnaissance followed by an apparently haphazard trip through what the author calls "rough country." Unfortunately, his style is so modest as to be laconic and the only guidance given in a very interesting account is that "the technique of railway reconnaissance can only be acquired through years of experience in railway location and construction," that

" aerial reconnaissance can be very deceiving " and that " in estimating yardage quantities it is wise to go over a mile or so of the country, measure the required yardage in that mile, and, proceeding, estimate plus or minus amounts—for each change of terrain."

The reader is left with a feeling of admiration for the author's achievement, but little increase of " know-how."

Notes from *The Engineering Journal of Canada*, May, 1954

Menihek Power Development

The power plant built at Menihek, in Labrador, provides a most interesting example of design and construction at a remote site, under severe climatic conditions, where maximum use had to be made of local and largely unsuitable materials and where, in the absence of stream-flow and meteorological records, precipitation, run-off, maximum flood level, snowfall and ice conditions had to be assessed. The problem was therefore very similar to those likely to arise in war.

An outstanding feature of the project was that almost all supplies and equipment, as well as personnel, were delivered to the site by a 330-mile airlift, since construction started before the Labrador railway was built, and in fact the dam for the power project also serves as the bridge and approaches for the rail crossing over the Ashuanipi River.

This very interesting paper describes the methods used to compute precipitation, run-off and stream-flow and gives a clear and concise appreciation of the factors governing the choice of site. The determination of installed capacity, selection of equipment and methods of construction are also clearly discussed in outline; the special measures taken to utilize local aggregates and fill-material are described; and alternative designs for earth dams, to suit summer and frost conditions respectively, are illustrated. The earth-moving plant used is listed, work being done on a twenty-four-hour basis to construct a total of nearly four miles length of earth-fill dam, containing 650,000 cu. yds. of compacted material. The power-house accommodates two 6,000 h.p. turbines, power being generated at 6,900 volts by two 5,000 k.v.a. generators.

Rotary Wing Aircraft Development

Recent military operations have proved the outstanding value of helicopters, which also have some remarkable achievements to their credit in the field of civilian reconnaissance and survey. Civil application for airport to city-centre operation and for short journeys from congested areas is likely to develop rapidly.

This paper, which is primarily a review of the history of rotary wing aircraft, also describes present machines in general terms and classifies their types into five categories:—

1. Single rotor—tail rotor.
2. Dual rotors—lateral arrangement.
3. Tandem rotors.
4. Dual rotors—intermeshing.
5. Co-axial rotors.

The salient features required by civilian operators are listed, and general specifications of existing types and comparisons of performance with that of fixed wing aircraft are clearly set out. The author forecasts that convertible aircraft, having both a fixed-wing and a rotary-wing system, are an inevitable development, and makes some cautious predictions of the likely trend of future design.

"THE MILITARY ENGINEER"

(Journal of the Society of American Military Engineers)

March–April, 1954

"Military Water Supply and Sanitation Symposium",
by John S. Williams

A well illustrated account of a symposium held in October, 1953, at the Naval Civil Engineering Research and Evaluation Laboratory, California. The particular subjects considered were techniques, methods, and equipment for advanced bases in the field. Both military and civil engineers from the research and consulting fields were represented.

Current Army water supply equipment being developed includes a family of new field water purification units employing prechlorination, continuous coagulation, and diatomite filtration. The first unit is a complete water purification plant assembled in a rigid, insulated and heated van body mounted on the standard 2½-ton truck chassis. A 10 kW. generator mounted on a 1½-ton towed trailer provides the electric power for pumps, chemical feeders, and all other powered components, including lighting for night operation. A small portable pump located near the raw water source delivers water to the equipment within the van body where it is coagulated, filtered, disinfected and then stored in collapsible fabric tanks adjacent to the truck for final distribution.

A new type solids contact clarifier, the "Erdlator," designed to make maximum use of pulverized limestone as a coagulant aid, provides continuous chemical pretreatment and clarification of raw water, which then passes to two diatomite filters in parallel. These can be backwashed in one minute by an "air bump" method using only water contained in the filter shell. An excellent illustration of the diatomite filter has erroneously been entitled "The Erdlator."

Truck mounted units in 3,000 g.p.h. and 1,500 g.p.h. sizes are being developed, and also a 600 g.p.h. unit on a 1½-ton trailer. A semi-permanent 10,000 g.p.h. unit is in the design stage.

It is unfortunate that the author, who has been engaged on this type of research since 1951, makes no reference to the efficiency of these units when called upon to deal with radio-active contaminated raw water.

May–June, 1954

"Atomic Power Reacter for Military Use"—News and Comment

It is reported that at the request of the Department of Defence, the Atomic Energy Commission is investigating the possibility of building a small nuclear power plant for military use. Army Engineers are collaborating in the project.

The purpose of building a prototype plant is stated to be to demonstrate that the design selected is suitable for military requirements, to study economic and operating characteristics of the plant, and to provide training facilities for military engineers, operating and maintenance personnel.