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PRESENTATION OF THE FREEDOM OF THE BOROUGH OF GILLINGHAM TO THE CORPS OF ROYAL ENGINEERS

EVER since the arrival in 1812 of the R.E. Establishment (later called the S.M.E.) at Brompton Barracks, Gillingham has been the nearest village or town. The Borough of Gillingham was incorporated on the 8th September, 1903. For some mysterious reason the postal address of the S.M.E. remained Chatham although Brompton Barracks lie in the Borough of Gillingham. In 1953, the Jubilee Year of the Borough, the Gillingham Corporation sitting in council, magnanimously overlooked this slight to their civic pride and decided unanimously to confer the Freedom of the Borough on the Corps of Royal Engineers to commemorate their life-long association.

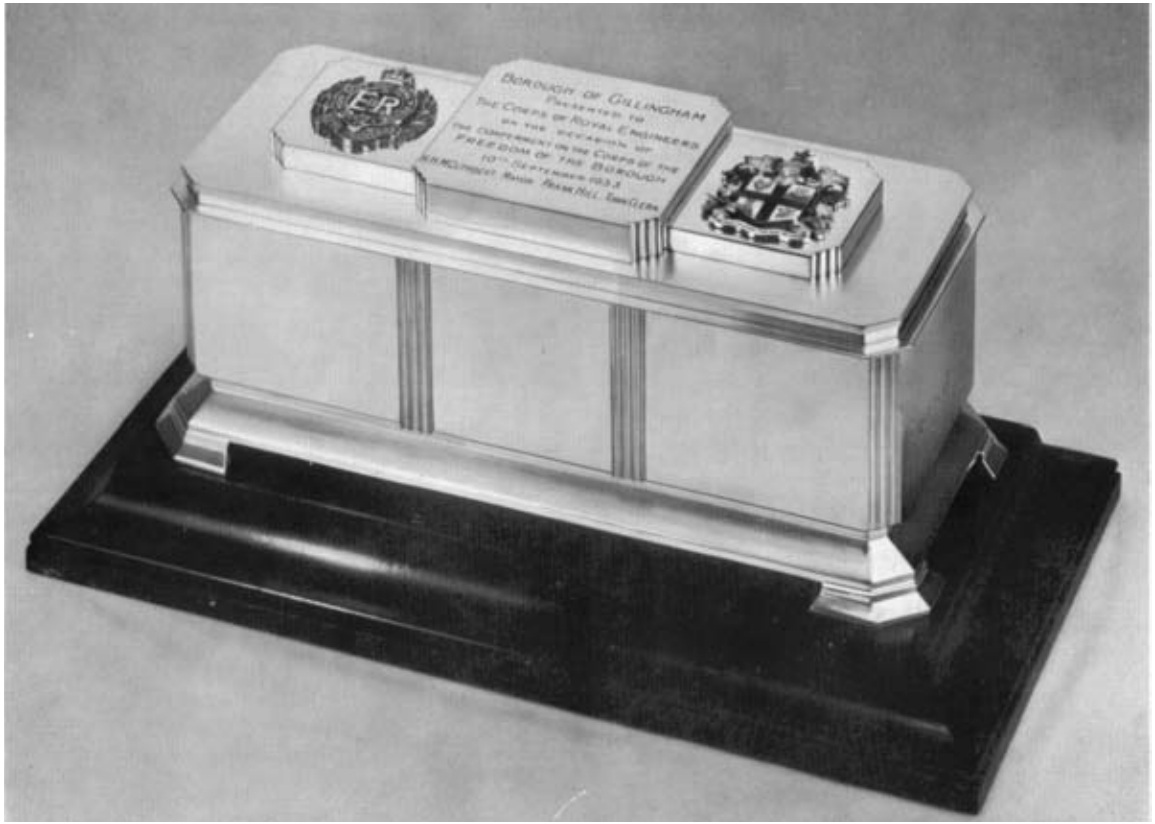
Then ensued weeks of hectic staff work, which was complicated by the commitments in connexion with the Coronation and by a request from the Corporation to organize a Tattoo during their Jubilee Week. The Corporation had arranged for the B.B.C. to take a television film of the Freedom proceedings, which meant even more care in the ceremonial planning.

Precedent for this type of ceremony was slender and so the details had to be worked out and checked to ensure that no ceremonial rule was broken. In addition to this there was a need for inviting the proper people, erecting stands, arranging car parks, practising forgotten drill, fitting clothing, and a hundred and one other details to be meticulously examined.

Owing to the lack of a suitable open space in the town of Gillingham, it was decided that the presentation should take place on the Square in Brompton Barracks during the week of celebration marking the Golden Jubilee of the incorporation of the Borough, and that the Corporation should entertain their guests in the R.E.H.Q. Mess. This produced the curious situation of the Corporation being hosts to the Corps in their own Mess. However, in the event it all worked admirably.

The rehearsals for the parade extended over three weeks and were made more difficult by the absence of the Band on an engagement which had been accepted long before. The erection of the stands conflicted with the necessary work in preparation for the Tattoo, consequently 71 Field Squadron, who were working on a film production, had a complicated work table to get everything ready in time.

The troops on parade, under the command of Lieut.-Colonel P. A. Adams, R.E., included a Casket Party of one Subaltern and three S.D.Is., escorted by the Officer Cadet Squadron, R.E. The



Presentation of the freedom of the Borough of Gillingham to the corps of Royal Engineers 2

main body of the parade formed up behind them in four squadrons of a hundred men each, made up from the regiments at Chatham. These regiments are, in fact, representative of the whole Corps since they consist largely of students on courses from regiments all over the world.

At 3 p.m. on the 10th September, 1953, after the guests and spectators had assembled and General Sir Brian Robertson, representing the Chief Royal Engineer, had inspected the Regimental Guard, His Worship the Mayor of Gillingham, Alderman H. H. M. Cuthbert, arrived at the Crimea Memorial Arch. It was particularly appropriate that the Mayor, who was a regular sapper, the son of a sapper and the grandson of a sapper, should be in office on this occasion. He was welcomed by General Sir Brian Robertson who accompanied him to the dais, while a fanfare was played on the ceremonial trumpets. Sir Brian accompanied by the Mayor received a General Salute and they proceeded together to inspect the Guard of Honour. After returning to the dais, the Mayor addressed the parade and the assembled spectators as follows :—

" The Chief Royal Engineer, General Sir Brian Robertson, Officers, Warrant Officers, Non-commissioned Officers and Men of the Corps of Royal Engineers :—

This is a great and proud moment in the history of Gillingham, for on this day, we the Mayor, Aldermen and Burgesses of the Borough desire to pay tribute to your splendid Corps which was cradled and nurtured within our boundaries.

It was in September fifty years ago that the Borough of Gillingham was given its charter, and this year we are celebrating the Golden Jubilee of our incorporation. What could be more fitting, therefore, than we should choose this time to link ourselves more closely with the Sappers !

For interwoven in the story of our civic heritage and tradition is the story of the Royal Engineers who, by their conduct, example, integrity and valour, have so richly merited the honour which we now seek to confer upon them.

And let me now proclaim that the highest and most honourable distinction that the Borough can bestow upon you is that of admitting you to the Roll of Freemen.

We shall symbolize this honour by presenting to the Corps a Scroll and Casket, but the especial significance of this ceremony, and indeed of the honour itself, must be spiritual, something intangible which is not manifest in material things.

Here, to-day, we do so honour you—amidst memorials and surroundings, which though they of themselves be mute, bear such magnificent testimony to the glory of the Corps. We may remind

ourselves at this moment that, in the making of history, headstones count as much as heads.

In the many years of our association with the Corps, the relationship between the civil and military authorities, has been all that could be desired.

I should, therefore, like to pay tribute to past commanders and to the present Commandant of the School of Military Engineering, Brigadier Browning, and his staff, for the way in which they have joined in with us in fostering this very happy partnership.

In these days when nearly all men do duty in the service of the nation it is a fine thing that we should, by ceremonies like this, seek further to bind together and strengthen the ties between the civic administration and the armed forces of the Crown, for in essence we are one.

And I now, therefore, command the learned Clerk to our Authority to read the Scroll admitting the Corps of Royal Engineers to the Roll of Freemen of the Borough of Gillingham in the County of Kent.

To you sir, representing the Corps, I, Henry Cuthbert, Mayor of this Borough, present unto you this Casket and Scroll, and invite you, on their behalf, to sign the Book of the Roll of Freemen."

The Town Clerk of Gillingham, Mr. Frank Hill, then read the Scroll, which was to be presented to the Corps as Freemen of the Borough. The Scroll is a magnificent example of the modern illuminator's art. The photograph accompanying this does not in any way do justice to its beauty.

FREEDOM SCROLL
BOROUGH OF GILLINGHAM

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 Burgesses of the BOROUGH OF GILLINGHAM in the County of Kent fully realizing and appreciating the great record and glorious traditions created by the Corps of Royal Engineers in loyal and devoted service to our beloved Queen and Country in all theatres of War since your most distinguished Corps was formed and with a view to recognizing your long and historical association with this Borough do by these Presents order upon you THE FREEDOM OF THE BOROUGH and thereby the right, privilege, honour and distinction of marching through the streets of the Borough on all ceremonial occasions with bands playing, drums beating and bayonets fixed.

Presentation of the freedom of the Borough of Gillingham to the corps of Royal Engineers

In witness whereof we have caused our Corporate Common Seal to be hereunto affixed this First day of July One thousand nine hundred and fifty three in pursuance of a Resolution unanimously passed by the Town Council on the Third day of March One thousand nine hundred and fifty three.

Henry H. M. Cuthbert, Mayor. Frank Hill, Town Clerk.

The Scroll was then placed in a silver casket which was handed to Sir Brian Robertson. The Casket has the Arms of the Borough and of the Corps carried out on the lid in enamel work of very fine craftsmanship. It will be kept in the H.Q. Mess at Chatham where it will be on view to all ranks of the Corps and will be prominently displayed on the high table in the Mess on important occasions. General Sir Brian Robertson then signed the Freedom Scroll of the Borough, and, on behalf of the Chief Royal Engineer and all ranks of the Corps, thanked the Mayor and Corporation as follows:—

" Mr. Mayor, Aldermen, Burgesses, and Citizens of the Borough of Gillingham :—

On behalf of the Chief Royal Engineer and all ranks of the Corps of Royal Engineers, both past and present, I thank you for the very high honour which you are conferring upon us all to-day. We are conscious that this honour is offered to us in recognition of long years of association and friendship between your old Borough and our Corps. This association began when the School of Military Engineering was first established here in 1812, three years before the Battle of Waterloo. Our friendship grew strongly during two World Wars when we shared many tasks and trials together.

To older generations of Sappers, this honour will be a deep source of pride ; to future generations, an abiding inspiration.

It is indeed fitting that this ceremony should take place on this old square in the same month when the Borough of Gillingham celebrates its Golden Jubilee.

The welfare and good conduct of soldiers is much affected by the attitude of the civil population. The interest shown by the citizens of Gillingham in our affairs, their kindliness, hospitality and tolerance, are remembered by all ranks of the Corps who have lived and trained in these barracks in your borough.

I attended my first parade as a Royal Engineer on this square and this is likely to be the last military parade in which I shall take part while still on the active list. Like most fellows in the Corps I look upon these barracks in Gillingham as my military home.

To-day's ceremony is further clear evidence of the extent to which the civil population of our country has taken the army to its heart.

It was not always so in the past. Even in the days of my boyhood soldiers were often regarded as a rough, uncouth lot. National Service has brought the armed forces into every home. The Army to-day is an intimate part of the social structure of the nation and good understanding and co-operation between the Army and the civil population from which it is drawn become as natural as they are necessary.

We, in the Royal Engineers, do our best to stimulate the good qualities to which you, Mr. Mayor, have referred, and to return young men to their homes stronger physically, more developed mentally and with a deeper sense of citizenship than perhaps they had before. In making us Freemen of your Borough you have shown that you accept us as partners in this high endeavour.

The very beautiful illuminated scroll and exquisite casket are indeed worthy outer symbols of the deep inward meaning implicit in "The Freedom of the Borough." We shall treasure them profoundly, and house them in the Headquarter Mess of our Corps, where they will be seen by all officers passing through the School of Military Engineering. Moreover I have spoken to the Commandant to-day and he has readily agreed that they shall also be seen from time to time by all ranks who serve here, because of course they have been presented to the Corps and not only to its officers.

The developments of modern scientific warfare are steadily increasing the responsibilities of the Corps of Royal Engineers. The School of Military Engineering, if it is to succeed in the task that lies before it, will increasingly need the co-operation, help and understanding of the Borough of Gillingham. We know that this will be forthcoming in full measure. We, on our part, will always endeavour to justify the special confidence which has been reposed in us to-day by Gillingham, the home of the Corps."

Then followed the Ceremonial Parade, which consisted of a March Past in column, followed by an advance in review order, which was carried out with commendable precision. After the advance in review order Lieut.-Colonel P. A. Adams advanced to the dais and asked the Mayor, "May the Corps of Royal Engineers have the privilege, the honour, and the distinction of marching through the streets of your Borough, with bayonets fixed, drums beating and bands playing?" On being graciously accorded this permission the parade marched off through the Crimea Arch to Gordon Barracks. The route is familiar to many generations of Sappers marching to and from the old Field Works Training Ground on which Gordon Barracks now stands. The route looks the same as ever, save for the disappearance of the tram lines.

After the departure of the troops, Sir Brian Robertson, the Mayor, Councillors and the Mayor's invited guests walked in procession,

headed by the Mace Bearer and Casket Party to the Officers' Mess. The Mess had been lent to the Corporation for the afternoon, to enable them, in their generosity, to entertain the official guests after the ceremony.

On arrival at Gordon Barracks, the troops went to the Gymnasium, where an excellent tea had been provided for them by the Corporation. The Mayor, receiving information of their arrival, bade farewell to his guests at Brompton and went to visit his guests at Gordon Barracks.

One cannot add to the words of the Mayor in his speech, to emphasize the importance of the occasion and the good which this gesture and ceremony have done in cementing the excellent relationship which has always existed between the Corps and the people of Gillingham.

In addition to the ceremony in connexion with the Presentation of the Freedom, the combined Services performed a Searchlight Tattoo as part of the Jubilee Celebrations. The Tattoo was organized by the S.M.E., who received invaluable help from the Royal Navy, Royal Marines, "Q" Battery 564 L.A.A./S.L. Regiment R.A. T.A. and the Kent Regiment R.E., Army Cadet Force. It was a great success and we are happy to feel that we were able to help in quite a large way in the Borough's Jubilee Week. The Tattoo had to be prepared with the minimum of effort and rehearsal owing to the number of activities in progress. The individual turns were, therefore, as ready made as possible, consisting of various manœuvres by the Royal Marine, Royal Engineer and A.C.F. Bands, a meet of the R.E. Drag, Bridging by 71 Field Squadron, a mock action against low flying aircraft by the Royal Artillery, Cutlass Swinging and a P.T. Display by the Royal Navy, a pageant of Watling Street by all the Y.Os. and J.Os. at the S.M.E. and a finale which included the Sunset Ceremony as carried out by the Royal Marines. It was generally voted a great success and 11,000 people evidently enjoyed themselves if applause is any criterion.

The R.E. Association Week-end was held on the 12th and 13th September. The Mayor and Corporation were invited to the Service at the Garrison Church and to drinks in the Mess afterwards.

So ended a week of notable ceremonies, which will never coincide again. As a small gesture of thanks to the Corporation for their compliment in conferring their freedom on us, the Corps will present two links for the Mayoral Chain. These take the form of the Royal Engineers monogram and, according to design, they will be a very fitting symbol of the link between the Corps of Royal Engineers and the Borough of Gillingham.

The blocks for the photographs of the Scroll and Casket were kindly loaned by the Council of the Gillingham Corporation.

R.E. PLANNING AND OPERATIONS FOR THE RHINE CROSSING

By Brigadier F. C. Nottingham, D.S.O., O.B.E.

THE assault crossing of the River Rhine in March, 1945, was one of the major engineer operations of the 1939–45 war. Although, in other parts of the world, many other rivers just as wide and as formidable an obstacle were successfully crossed, the scale of planning, and the degree of resistance to be overcome, were very much greater in the case of the Rhine, and it is for this reason that the details of the engineer planning, and the story of the actual battle are of such interest to the military engineer.

This account only deals with one part of the operation, that on the front of XXX Corps near Rees. It should be remembered, therefore, in order to obtain a full appreciation of the total effort of the Engineers in this vast operation, that somewhat similar events were being duplicated by XII Corps, who crossed near Xanten and Wesel. It should also be borne in mind that the weather was kind during practically the whole of the period, in the course of which very few, if any, enemy planes were seen in the sky during the hours of daylight.

The Obstacle

By mid-March, 1945, the Rhine floods, which had given such trouble during the early months of the year, had subsided. The level had fallen from a peak of some seventeen metres above N.A.P. (Nieu Amsterdam Point) to 13.3 metres, and was still falling. The width on the XXX Corps front varied from 1,200 ft. minimum to 1,800 ft. maximum. The current was estimated at 3 knots, but was in fact a little more than 2.5 knots. In order to limit the extent of flooding, the Germans had built bunds on each bank, at distances which varied from a few yards to nearly one kilometre from the main stream. These bunds were about four metres high and three metres wide at the top, with sides sloping at an angle of 20 deg. In places on the German side a small subsidiary bund—the "Summer" bund—had also been constructed, about 2.5 metres high, but inside the main bund. Behind the bunds, grazing and arable land intermingle with scattered villages and small groups of houses

and occasional groups of trees, which gave some cover. Between the bund and the river, however, the land is grazing land only, with a tendency to form mud even after slight rain, and cover was non-existent. This was the obstacle that faced the Army after the Germans had been cleared from the west bank, formidable enough in all conscience, one saving grace perhaps being that some genius in the back areas had worked out that the odds against flooding occurring during the time of the operation were at least three to one.

The Situation

After the German offensive through the Ardennes had been successfully dealt with, 21st Army Group resumed its operations to clear the left bank of the Rhine of all the remaining German forces which were still holding out there. Accordingly, the Canadian Army struck out from Nijmegen on the 8th February in a south-easterly direction. In extremely bad weather, and in most adverse conditions against most bitter resistance, it succeeded in joining up with the 9th U.S. Army in front of Wesel early in March. This operation was one of the most fiercely fought actions of the campaign, and it was found necessary at one time or another during its course to employ in it nearly every division in the British and Canadian Armies. But, by the end, the weather had improved, the flooding of the Rhine had subsided, and the armies turned to face the river. Meanwhile, XII Corps H.Q., who had been in reserve, had done considerable work on the planning of the actual crossing. A few R.E. units had been given their rôle, and were engaged in training for their tasks in suitable areas behind the battle line. Many other R.E. units who were to take part in the crossing, were, however, still actively employed, as late as the 10th March, on the Canadian Army operation.

The Plan

The plan of the 21st Army Group was to assault with the British Second Army in the Rees–Xanten area with the Ninth U.S. Army conforming on the right. The Canadian Army was to cross on the left after the initial assault and protect the left flank of the British Second Army. The object was to isolate the north and east sides of the industrial area of the Ruhr from the rest of Germany, and thus to make the successful end of the war a foregone conclusion. The British Second Army decided to assault two corps up, XXX Corps on the left opposite Rees, and XII Corps at Xanten-Wesel. The Canadians were to pass through XXX Corps, take Emmerich and strike out northwards, and Airborne Divisions from England were to drop in front of XII Corps.

"D" Day was fixed for the 24th March, but XXX Corps were to assault on the evening of D – 1, i.e., 23rd March, and "H" Hour was to be 2100 hrs. Sunset was 1915 hrs. local time.

XXX Corps were given three Infantry Divisions—the 51st, 43rd, and 3rd Canadian, and also the 8th Armoured Brigade (a rather weak brigade equipped with "DD" tanks) and the Guards Armoured Division. The "holding" division on the left bank, the 3rd British Division, was to join VIII Corps after the crossing was successfully accomplished. XXX Corps, therefore, planned the assault with one division—the 51st—as the assaulting division, followed by 43rd Division, who were to take over the left sector of the bridgehead as soon as possible after the assault. Later the Canadians would come in still further to the left so as to clear the way for their advance to Emmerich. Once the 51st and 43rd Divisions were across, and the bridges built, the Guards Armoured Division was to cross, and strike north-east for Rheine and the Dortmund-Ems Canal.

The assaulting division—the 51st Highland Division—were given a considerable number of extra formations in order to help them perform their task. They had under command, or in support, therefore :—

8 Armoured Brigade with "D.D." tanks.
Two Regiments L.V.Ts.
Sixteen Field Regiments.
Ten Medium Regiments.
13 A.G. Royal Engineers for bridging.

In addition, a "Pepperpot" consisting of two Armoured Regiments, three Anti-Tank Regiments, four L.A.A. Regiments, and three M.G. Battalions, was to drench the right bank with bullets until just before the leading troops in their L.V.Ts. were due to touch down there.

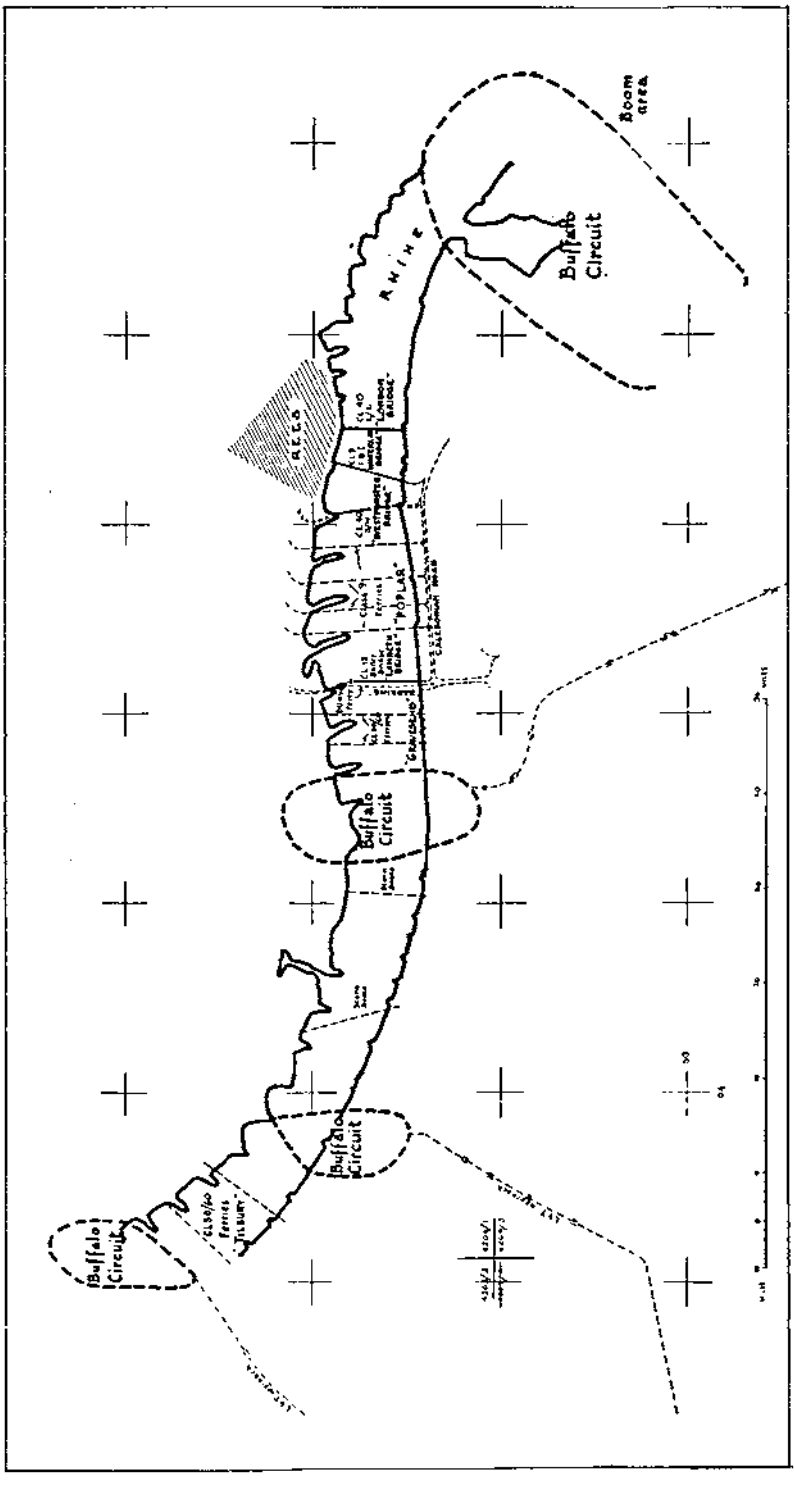
The divisional attack was to take place on a two-brigade front. 154 Brigade on the left was to capture Speldrop and to clear and hold the right bank, while 153 Brigade was to capture Rees and block its eastern approaches. Behind 154 Brigade was 9 Canadian Brigade, who were to follow them and to take over the left sector of the divisional front. 152 Brigade of 51st Division was to follow 153 Brigade and exploit northwards.

43rd Division was to cross and eventually take over the left of the 51st Division between them and the Canadians.

The Engineer Plan—XXX Corps Front

(*a*) 13 A.G.R.E. was entrusted with the task of constructing and operating all rafts and ferries and bridges on XXX Corps front

PLATE 1



RHINE CROSSING THE BRIDGE AND FERRY PLAN. 23 MARCH 45.

with the exception of the L.V.T. ferries. They were also to be responsible for the construction and maintenance of booms.

(*b*) The bridging requirements had been worked out by XII Corps and Second Army as :—

	To be ready by	*Time actually ready*
(i) L.V.Ts. (96 L.V.Ts. per brigade)	H Hour	
(ii) Storm boat ferry for reserve brigades	H + 3	
(iii) L.V.T. ferries for small vehicles	H + 9	
(iv) D.D. tanks exits	H + 9	
(v) Close support rafts (Class 9/12) —four per brigade	H + 9	
(vi) 50/60 rafts (two per brigade) and DUKW Ferry	H + 12	H + 13½
(vii) Class 9 F.B.E. bridge	H + 36	H + 52
(viii) Class 15 Bailey	H + 48	H + 59
(ix) Class 40 Bailey	H + 60	H + 74
(x) Class 40 Bailey—high level	H + 120	H + 141

Later an additional Class 40 Bailey was to be provided on a site to be decided on, according to the tactical situation. The provisional site was on the line of the DUKW ferry, and this was the site on which it was actually built.

(*c*) 13 A.G.R.E. were allotted the following Engineer formations, with tasks as shown. The code names of the various bridges and ferries are also given and their sites—as planned—are shown on Plate 1.

Under Command

(i) 5 Assault Regiment—Class 50/60 rafts (GRAVESEND and TILBURY).
(ii) 2 Canadian Corps Troops Engineers—Class 40 Bailey (BLACKFRIARS).
(iii) 30 Corps Troops Engineers—Class 40 Bailey (LAMBETH).
(iv) 6 Army Troops Engineers—Storm Boats and Class 40 high-level Bailey (WESTMINSTER).
(v) 8 G.H.Q. Troops Engineers—Class 40 Bailey (LONDON).
(vi) 18 G.H.Q. Troops—F.B.E. (WATERLOO).
(vii) 50 G.H.Q. Troops Engineers (CALEDONIAN RD. and DUKW FERRY).
(viii) 59 G.H.Q. Troops Engineers—Close Support Rafts (POPLAR).
(ix) 147 Bomb Disposal Platoon—Mine Clearing.

In Support

23 and 58 Mechanical Equipment Platoons.
Royal Navy—Detachment for operating towing craft boom construction.
R.A.S.C.—128 Bridge Company.
Three General Transport Platoons.
Pioneer Corps—Four Pioneer Companies.

The whole of this force under 13 A.G.R.E., consisting of approximately 8,000 all ranks of the Royal Engineers, was therefore under command of 51st Division for the assault. The R.E. of 51st Division were passengers as far as the actual crossing was concerned, but took over from 13 A.G.R.E. on the right bank, and from thence were responsible for all engineer work on their divisional front. R.E. 3rd British Division were given the task of preparing tank tracks and opening gaps in the winter bund to enable L.V.Ts. to reach the water's edge.

The Preliminary Planning

It was not until late on the 6th March, 1945, that 13 A.G.R.E. had any inkling that they were to be employed in this operation. They were working at that time with the Canadian Army in the Reichwald, and the first indication was the arrival of a signal at about 8 p.m., placing them under Second British Army forthwith. Early next day the Intelligence Officer paid a visit to Second Army to find out the new task and came back with the news that the A.G.R.E. was to be used under XXX Corps on the Rhine. Next day, 8th March, the Commander and the Brigade Major went to see Chief Engineer XXX Corps and were given the details of such planning as had been done by XII Corps, while the latter were in reserve. Some of the formations coming under command already knew their rôles and were busily engaged in training for them. The A.G.R.E. Commander was then told that, for the assault, he would be under command of the 51st Division in the initial phases, and that traffic to and from the bridges would be controlled by a Bank Control Group, found by the Royals, with whom there would have to be close liaison. The first problem facing him was one of time and space. The formations who were doing their training were scattered over an area from Nijmegen to Maastricht, about a hundred miles, and 51st Division was some fifty miles to the south of XXX Corps H.Q. which was at Goch. The Royals were twenty miles from 51st Division. With only fifteen days to go, the position of H.Q. A.G.R.E. was of some importance, and it was settled by moving it to 51st Division for two days (10th–11th March), liaising with the Royals during that time, and then moving back to Goch

next door to the office of the Chief Engineer for the final planning period. This worked very well and there were no last-minute changes or misunderstandings due to lack of previous liaison.

On 12th March, the Commander A.G.R.E. and his Brigade Major accompanied the G.O.C. and G.S.O.I. 51st Division on a reconnaissance along the river bank, during which the river and its approaches and exits were thoroughly studied.

From the 12th–15th March, the A.G.R.E. Staff worked overtime, getting out the details of the concentration of all the R.E. formations taking part in the battle, with all the administration problems involved. For instance, some 300 lorry loads of materials needed for the operation were being used on the preliminary training, and their collection, loading and moving had to be arranged for. The moving of the formations into forward concentration areas across the main front meant close liaison with Movement Control, and had to be arranged to fit in with similar movements of formations of the other arms.

On the 15th March, A.G.R.E. held a conference with all the Cs.R.E. concerned, and issued a draft "Method" paragraph of the operation order. This was taken away by the Cs.R.E. to be studied, and they were told to come in and clear up the outstanding details by the 18th. They were also told to produce three lists of stores required.

(*a*) A consolidated list of stores required for their particular bridge or rafts.

(*b*) A list of vehicles by loads required at the bridge site in order of priority.

(*c*) A list showing the number of lorry loads and types by bulk, i.e., so many panel, so many decking, etc.

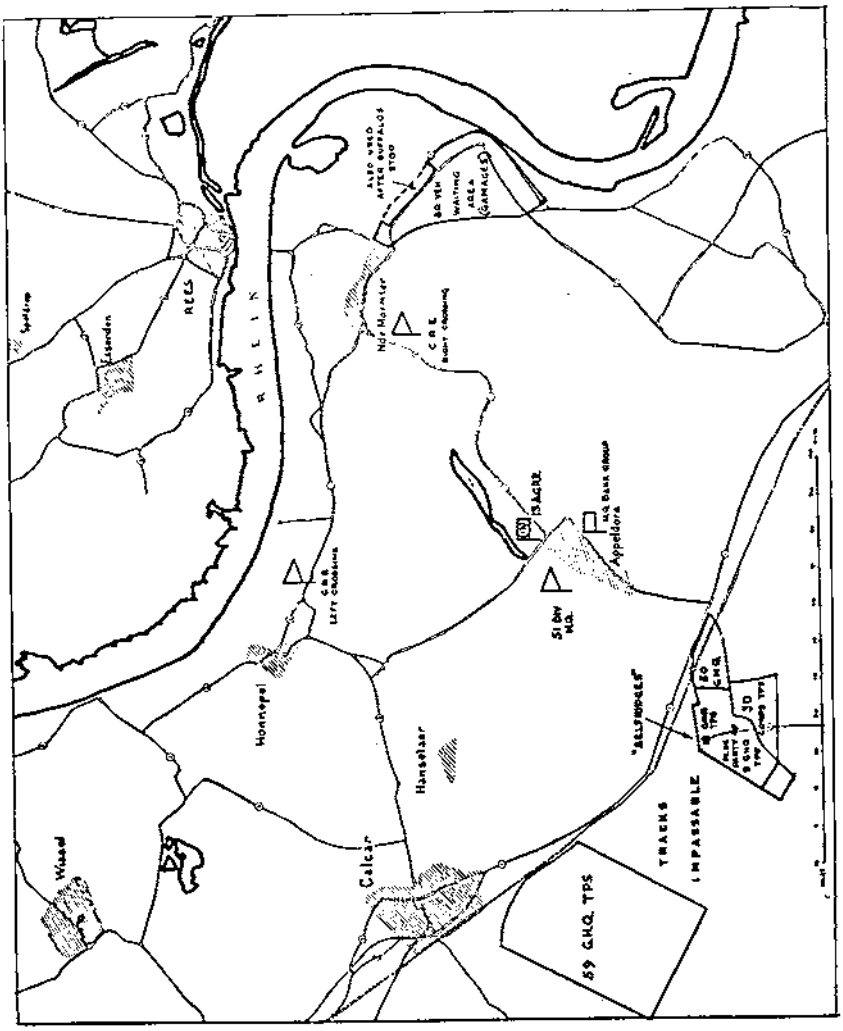
Of these, the first lists were consolidated by H.Q. A.G.R.E., checked and handed to XXX Corps who arranged for a bulk release from the bridge dump. The other lists were required by H.Q. A.G.R.E. for checking the progress of the operation.

The final conference, under Chief Engineer, XXX Corps, was held on 18th March and all outstanding points were cleared up then.

Control of Bridge Stores and Vehicles

Meanwhile Second Army had chosen a site for the main bridge dump at Goch and had made the necessary arrangements for stocking it. Work began on 4th March, while the area was still under shell fire. During the next fifteen days some 25,000 tons of stores were moved in, checked and stacked. This was a really magnificent effort. The R.E. (Tn.) managed at the end of this period to get the railway working, which helped the build-up considerably.

PLATE 2



RHINE CROSSING ENGINEER DEPLOYMENT. 23 MARCH 45

The requirements of 13 A.G.R.E. were 1,500 loads, for which 500 odd vehicles were available. Close control of the loading of these vehicles at the Bridge Dump was obviously going to be a necessity, and some method of keeping up to date with the lorry position at any time during the battle would have to be worked out. It was, therefore, decided to make two main checking points for vehicles after they left the Bridge Dump—there would be a Forward Assembly Area and Bridge Vehicles Waiting Area. It was thought that these names would be confusing to the uninitiated so they were named respectively "Selfridges" and "Gamages." "Selfridges" was run by the Field Park Company of 50 G.H.Q. and "Gamages" by the Field Park Company of 59 G.H.Q. Troops, the C.R.E. of which was C.R.E. Right Crossing.

Control was ensured by 13 A.G.R.E. phoning the Bridge Company of the next requirements, i.e., name of bridge and types of load, worked out from the lists supplied by the C.R.E. These were loaded, each lorry being labelled before it left with the code name of the bridge for which it was intended, and the type of load it was carrying, i.e., "Lambeth Decking." The driver was also told verbally in case the writing on the lorry was washed off by rain. As far as possible, convoys left the Bridge Dump in groups of thirty vehicles. At each place—Goch, "Selfridges" and "Gamages"—"bins" for each bridge were laid out and lorries as they were loaded, or as they arrived, were marshalled into the bridge bin and checked. Forward movement from "Selfridges" to "Gamages" was arranged by 13 A.G.R.E. through Bank Control. Cs.R.E. called for their vehicles direct from "Gamages," and arranged their own guides.

The schedule of vehicle loads referred to previously were in the hands of the Commanders at Goch, "Selfridges" and "Gamages" and it was, therefore, possible to check exactly at any time the actual vehicle and load state.

Concentration Areas

13 A.G.R.E. had also to arrange for the Unit concentration areas and their own H.Q. for the battle. The area shown on the map was called "The Pig Hotel" and a booking office was opened in XXX Corps H.Q. where one went and literally "booked one's room." This was to ensure that there was no overlapping between different units and formations going for the same area at the same time. H.Q. 51st Division was to be at Appledorn, with A.G.R.E. and Bank Control next to them, and the R.E. concentration area was near "Selfridges." Bank Control clamped down on all entrances to, and movement in, the "Pig Hotel" area and permission and a pass had to be obtained from them before anybody went inside it. This effectively cut down movement and stopped the "Swanners" giving the show away.

It was decided to allow Cs.R.E. to recce, in conjunction with 3rd Division protection, and under their control, during the night hours, and although no one was allowed over the river, the home bank was properly reconnoitred. Towards "D" Day the whole area was thoroughly smoked, so reccos by day (again under strict control) were possible. The weather was fine, the ground was dry, and everybody hoped for the best, and that the fine weather would continue over the period of the battle.

Telephone circuits, which were extensive, were laid and buried by mole plough during the nights previous to the assault. These worked excellently throughout, so that the wireless communication which had been provided as a stand-by, was never used.

The Final Plan

(*a*) *C.R.E. Right Crossing—C.R.E. 59 G.H.Q. Troops* (Lieut.-Colonel R. E. Lloyd, O.B.E.).

Responsibilities

"Caledonian Road"—50 G.H.Q. Troops.

"Poplar" Close Support ferries—59 G.H.Q. Troops.

"Gravesend" Class 50/60 ferries (two rafts)—Detachment 5 Assault Regiment.

"Caledonian Road" was to start before H hour under orders of A.G.R.E., other tasks as the situation permitted in conjunction with Commander 153 Infantry Brigade. C.R.E. 59 G.H.Q. to cease to act as C.R.E. Right Crossing after Brigade moved across river and all formations would revert to under command A.G.R.E.

(*b*) *C.R.E. Left Crossing—C.R.E. 6 Army Troops* (Lieut.-Colonel T. D. Oborne).

Responsibilities

Storm Boat Ferries—6 Army Troops.

"Tilbury" Class 50/60 rafts—5 Assault Regiment, R.E.

When 154 Brigade moved forward C.R.E. Left crossing to cease to act as such and formations to revert to under command A.G.R.E.

On completion 6 Army Troops to Reserve in order to plan construction of "Westminster" high level Bailey bridge, Class 40.

(*c*) *XXX Corps Troops* (C.R.E., Lieut.-Colonel R. E. Black, D.S.O.).

Under command A.G.R.E. Class 15 Bailey bridge ("Lambeth").

Launch two L.C.V.P. tugs.

When finished to revert to XXX Corps.

(*d*) *18 G.H.Q. Troops* (C.R.E., Lieut.-Colonel J. H. Boyd, O.B.E.).

F.B.E. Bridge Class 9 ("Waterloo").

Two Arrow Booms upstream of bridges.

Launch 4 L.C.V.P. Tugs.

(*e*) *8 G.H.Q. Troops* (C.R.E. Lieut.-Colonel C. A. O'B. Compton, M.C.).

Class 40 low level Bailey bridge ("London").

(*f*) *50 G.H.Q. Troops* (C.R.E., Lieut.-Colonel R. W. Ewbank).

Initially under C.R.E. Right Crossing. To construct "Caledonian Road".

Construction of DUKW exits both sides of river.

(*g*) *5 Assault Regiment* (C.R.E. Lieut.-Colonel E. Hall).

Detachments at start under C.R.E. Right and Left Crossings.

To construct two ferries each of two Class 50/60 rafts.

(*h*) *2 Canadian Corps Troops* (C.R.E. Lieut.-Colonel Hamilton, R.C.E.).

One Class 40 Bailey bridge ("Blackfriars").

Site of this to be chosen depending on tactical situation.

(*j*) *Royal Navy Party.*

To be under 5 Assault Regiment for construction of submarine booms and ASDIC loops, downstream of bridging site.

The final operation order was issued at 1530 hrs. of 20th March. It was a comprehensive document, as indeed it had to be, summarizing the results of the discussions of the previous days.

It included the tasks for each formation, orders for move to the concentration area, a forecast of move from this area forward to the river, the orders for organization of Bridge Dump at Goch, and for "Selfridges," and "Gamages." It also included orders for moving the equipment from the training area, the allotment of plant and tugs, and gave details of the wireless and telephone layout diagrams.

The Final Touches

On 21st March, Commander XXX Corps had his final briefing at which all the senior officers in XXX Corps were present. After running through the plan of the battle and its expected course, he told his listeners that this would, in his opinion, be the last time it would be necessary to call a conference of this nature. "Get across the Rhine and into Germany and the war will be over in no time," was his cheerful pronouncement. But the Sappers were only too conscious of the terrific responsibility which lay on their shoulders in this operation, and later on that day the Commander A.G.R.E. issued the following order to all the Engineers under his Command:—

"The British Army is shortly going to undertake the Assault Crossing of the Rhine. This may well be the last major operation in which the British Army and its Allies are engaged in the war against Germany. Every Sapper, whatever rank he may hold, will

realize the major part that must be played by the Corps in this operation, and also that its success will depend upon the work done by the Engineers.

"As far as possible the necessary arrangements have been made to ensure that you will get the materials at the right times and places to enable you to perform your tasks. The rest must be left to the individual determination of every man to get the Army across the Rhine. If all ranks are imbued with this spirit, this will be done successfully. Good luck to you all."

And so, in the lovely spring weather, the last finishing touches to the plan were made. Under the smoke screen which was now continuous along the whole front of 21 Army Group, the assaulting troops and the supporting Engineer units took up their positions on the night of 22nd/23rd March (D—2). Thirty-five storm boats and 500 yards of Channel track were dumped behind the main bund, carefully camouflaged, and strongly guarded by the infantry of the 3rd British Division so that no enemy patrols would find them. The necessary explosive charges were got ready for the gaps in the bund which would have to be made, to allow the L.V.Ts. with the assaulting troops to go through and enter the water.

The Battle

At 1700 hrs., 23rd March, the barrage started, gradually increasing in intensity as the "Pepperpot" started up. Until the amount of enemy reaction could be gauged, it was thought prudent not to allow any bridge vehicles further forward than "Selfridges," but after 1700 hrs. angledozers were allowed up separately, and reached their parking areas in "Gamages" without incident. The area chosen was an extremely lucky choice for scarcely a shell fell in this area during the whole operation, in spite of its proximity to Rees. There were, in fact, very few casualties to vehicles caused by enemy action.

5 Assault Regiment were moved to Wissel in the afternoon so as to be nearer their tasks on the Class 50/60 ferries, and as the light failed C.R.E. 50 G.H.Q. Troops, was allowed to infiltrate his sappers to the head of "Caledonian Road." At 1930 hrs. he was, to quote the words of a U.S.A. general on another occasion, "a'raring to go," and was, therefore, allowed to start work on his road, provided he kept to our own side of the bund until H hour.

At 2000 hrs.—one hour before H hour—R.E. 3rd Division blew up their charges in the bunds and started in to doze proper gaps for L.V.Ts. These were all ready by H hour.

At H hour, Lieut.-Colonel Robin Ewbank and his sappers from 50 G.H.Q. Troops started work on "Caledonian Road" through the bund to the river and then right-handed towards Rees. This

was a service road of Channel track to be used as an approach for the "Poplar" and "Gravesend" ferries. In spite of heavy fire and many casualties, this was pushed through with great determination and practically finished by first light—a fine effort. Behind, the first vehicles for 59 G.H.Q. ("Poplar" ferries) and extra vehicles with Channel track were on their way to "Gamages," with three lorries of Bailey bridge for 18 G.H.Q. Troops, who had to bridge a crater on the approach to the F.B.E. site at "Waterloo," before they could start building the bridge itself. The Bailey was not completed by first light and a platoon of 74 Field Company was imprisoned under heavy fire in the crater all next day in full view of Rees. They amused themselves trying to build a Bailey bridge from below, but reported afterwards that it was not a particularly good method of bridge construction.

At 2250 hrs., the Assault R.E. started their recce at "Tilbury," and the storm boats were being placed in the water. About six boats were casualties due to mortar fire but this had been anticipated and reserves had been arranged. At midnight (H+3) the "Caledonian Road" had reached the river bank and a service road for bridge vehicles was in hand along a track just on the enemy side of the bund. Orders were given to 59 G.H.Q. Troops to start and the first vehicles got on to the site, for work on the first of the ferries. At "Tilbury," there was trouble due to mortar and spandau fire and also to the grounding of some 13 D.D. tanks at the chosen site of the far exit, which made a quick re-alignment necessary. This meant a most uncomfortable hour for the recce officer—Captain Stafford—as the far bank was littered with schumines. He decided to wade in the river, but was hampered by his equipment including a 38 set, as well as by the presence of groynes, and some accurate sniping. (He discovered that the accuracy was due to the fact that every time he stooped down, the torch on his belt at the back flashed a green light !) He found suitable sites downstream, got in touch with his squadron and work started in earnest.

Owing to the confused situation at Rees, the equipment for the Class 50/60 rafts at "Gravesend" was kept back from the river as there were no reserves of this equipment available, but the recce parties made their preliminary arrangements.

The situation during the rest of the night, therefore, was that in front of Rees, 18 G.H.Q. Troops had finished the diversion to the first crater, and were trying to erect a Bailey over the second one, which was the last obstacle stopping them getting down to their F.B.E. site ; while slightly downstream 59 G.H.Q. Troops had made a start on the Close Support rafts at "Poplar." The equipment for the "Gravesend" Class 50/60 rafts was handy to the site, and near by the "Caledonian Road" was progressing well in spite

of casualties. "Lambeth" was being reconnoitred and the storm boats were doing all that was expected of them. Still further downstream, work on the "Tilbury" ferry was going on well, in spite of difficulties caused by enemy action and the occasional L.V.T. drifting downstream on to their cables.

By 0730 hrs. next day, 24th March, there was a river mist half hiding Rees and work was proceeding steadily without much interference. But Rees had not yet been captured, and it seemed that if the enemy still held it in strength, it would be preferable if the mist lifted, to change the "Poplar" ferry site downstream. Three rafts were, therefore, diverted to "Tilbury" and the Storm Boat ferry site was reconnoitred for a Close Support raft ferry. By 0830 hrs. the DUKW ramp, by "Lambeth" Bridge, had been started, the storm boats had ferried four battalions across, and "Tilbury" reported that they would be ready for Class 50/60 loads by 1030 hrs. Any change of rafting or bridging sites would seriously interfere with the carefully thought out traffic plan, and as 51st Division were so optimistic that Rees would soon be cleared, it was considered preferable not to commit all the Close Support rafts to the downstream site. By 1130 hrs. there was still no sign of enemy reaction, so work went on according to the original plan. The equipment for "Gravesend" ferry was allowed down to the river. By 1150 hrs. one Class 9 raft was accepting vehicles, but the mist was showing signs of lifting and smoke was asked for. Unfortunately this did not materialize quickly enough before the mist disappeared, and enemy observers in Rees were able to bring heavy and accurate shelling on the rafting sites, and this occurred at any sign of movement during the rest of the day. Rees was, in fact, proving a very hard nut to crack. Early in the morning, C.R.A. 51st Division had made arrangements for A.G.R.E. to send shell reports direct to 5 A.G.R.A., who from that time were in direct support of the A.G.R.E. and took a tremendous interest in the sapper progress. The latter were cheered to know that anything they received would be paid back with interest. Work went on in spurts during the rest of the day, but by 1900 hrs. the shelling intensified, and one Close Support raft suffered a direct hit, killing most of the party on board. A R.E. recce party under Lieutenant Grace of the 18 G.H.Q. Troops was, therefore, sent into Rees to find out the real situation, but they, too, returned with optimistic reports about the prospects of clearing the town. At dark, the party of 74 Field Company were withdrawn from their crater, but it was still not possible to start on the F.B.E., so Lieut.-Colonel Boyd, C.R.E. 18 G.H.Q. Troops, was told to find another site for this bridge near "Tilbury," which, by now, was fairly quiet. All Close Support rafts were cast off and allowed to drift down, on

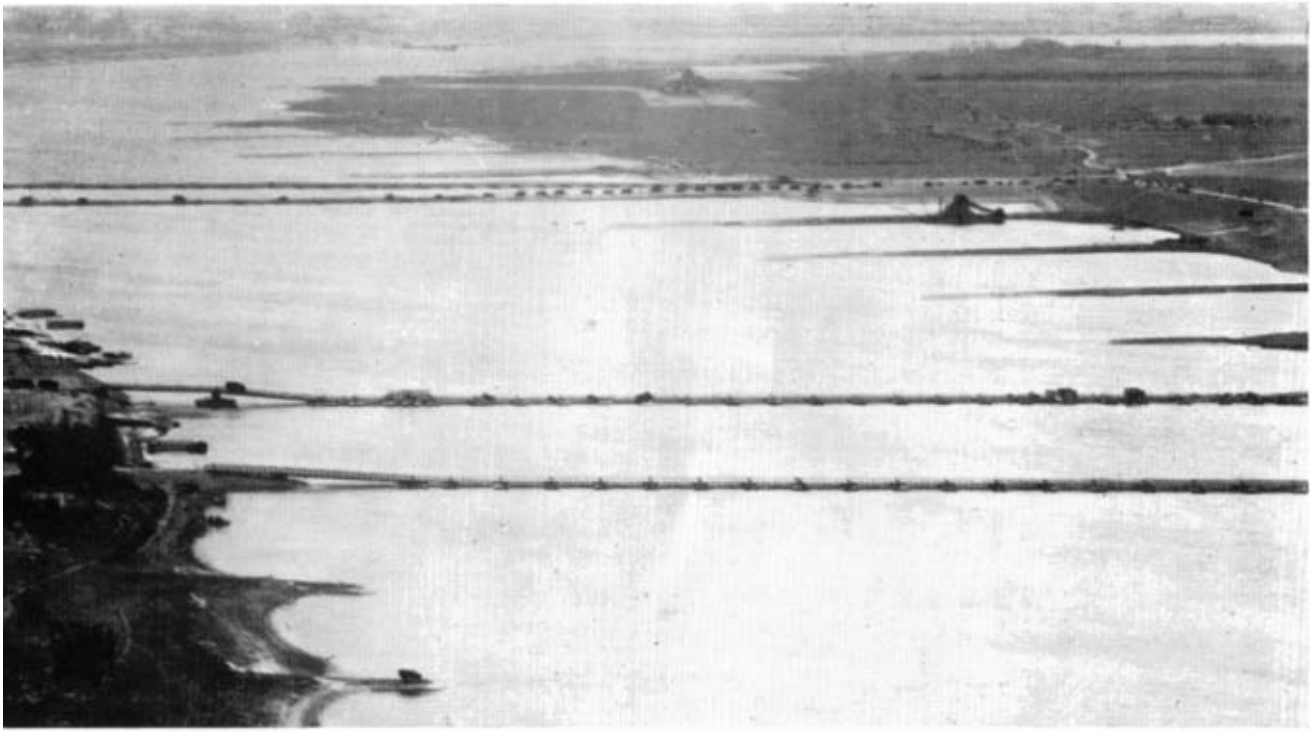


Photo 1.—London, Westminster, Lambeth, Blackfriars in that order.

The Rhine Crossing,rees 1

Photo 2.—*Left*—Lambeth. *Right*—Blackfriars.

Photo 3.—Westminster.

The Rhine Crossing,rees 2,3

their own, to the Storm Boat site. They started working there at 0500 hrs. but were once more heavily shelled, and it was, therefore, decided to move them all to "Tilbury," where they organized their ferries and did much useful work.

The "Gravesend" Ferries had better luck and worked through the night, taking some fifty-three heavy vehicles over.

In order to hasten work on the "London" bridge, the first Class 40 bridge, 8 G.H.Q. Troops were told to try and build rafts on the lagoon just upstream of Rees, where it was thought they could remain hidden until they were required.

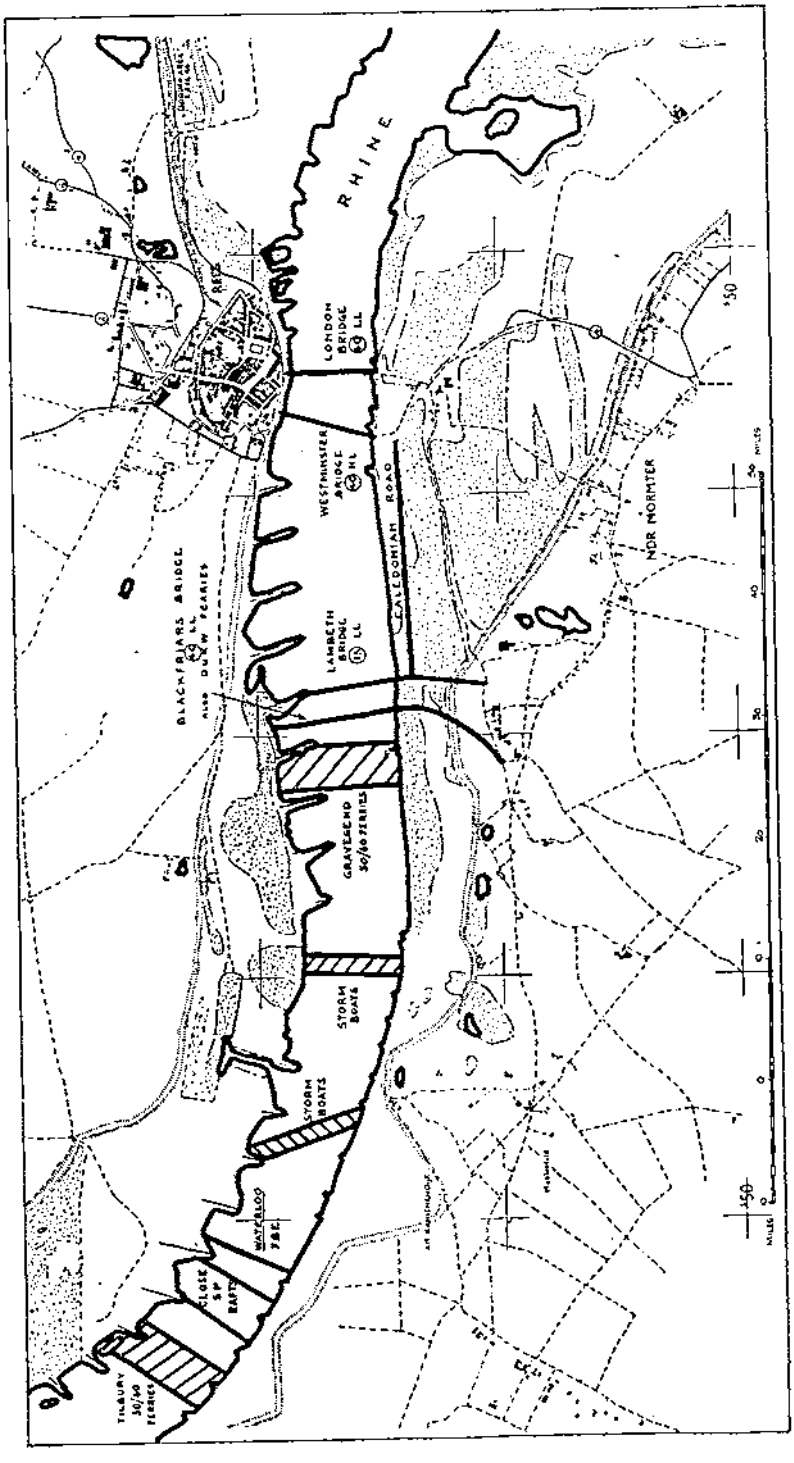
At 0800 hrs. on 25th March, as Rees had still not been captured, Lieut.-Colonel Boyd was told to build the F.B.E. Bridge on a site he had found near "Tilbury," and work started there at 1000 hrs., that is one hour after it was due to be completed in the original plan. Bank Control had, of course, been told of these changes in plan and had altered their own arrangements to conform. About 1030 hrs., 51st Division had finished with the storm boats, so 6 Army Troops went into reserve, waiting to start the preliminary work on "Westminster" when stores would be available, and the situation allowed.

By this time, too, the DUKW ramps were finished and the DUKWs had begun to ferry supplies across the river. Smoke was now being laid on to Rees in sufficient volume to hide the bridge sites and the shelling gradually ceased. By the afternoon, 25th March, the Rees waterfront was clear, although a small packet of enemy held out in the middle of the town until nightfall.

The evening of the 25th March (H+48) saw both "Waterloo" and "Lambeth" bridges well under way and both gave 0100 hrs. 26th March as their estimated time of completion, so it looked like a race as to who would finish first. "Waterloo" bridge won, as "Lambeth" had bad luck owing to the inexperience of the Royal Navy ratings manning the tugs. "Waterloo" opened at 0100 hrs. 26th March (H+52) and "Lambeth" at 0830 hrs. the same morning (H+59). Being Class 15, "Lambeth" bridge could take all medium regiments, which was most useful.

Once these bridges were opened, with the field and medium guns pouring across them and the Class 50/60 ferries working more quickly, as their crews became more experienced, enemy action ceased, and the remainder of the operation was routine. Provided the supply of vehicles to the bridges was sufficient to keep things going, work was not held up. "London" bridge was started during the night 25th/26th March, after the waterfront at Rees was cleared and was completed at 2345 hrs. the same day. During the 27th, work went on steadily on "Blackfriars," on the site of the DUKW ferry which was now no longer working, and "Westminster" was

PLATE 3



RHINE CROSSING. BRIDGES AND FERRIES AS BUILT.

started. The upstream and downstream booms were constructed and put in position. The Close Support rafts were dismantled, and once "London" was open, the Class 50/60 ferries ceased to operate, after having passed 390 armoured vehicles and fifty-one others over the river.

"Westminster" bridge was the last bridge to be finished and was actually completed by 1800 hrs. 29th March (H+141). The last bridge was, therefore, ready some twenty-one hours after the time laid down in the original planning, but it should be remembered that one extra Bridge—"Blackfriars"—had been built and that its completion time was H+117 so that by the time originally laid down, the number of bridges across the Rhine and taking traffic was according to the initial plan.

The above was not done without losses. The casualties to the Royal Engineers on this part of the front were five officers and 150 other ranks killed and wounded. One unusual feature was that of the officers—all were of field rank, with the exception of a Chaplain who was a captain.

In a letter attached to the operation order, the Engineers were told that the operation might not go entirely as planned, but that as long as the main outline was followed, the details could be changed as the situation demanded. In the actual event, the operation did not, in fact, go exactly to plan (cf. Plates 2 and 3). With complicated traffic control, and other administrative arrangements to consider, plans were not changed until it became evident that such changes were absolutely necessary, and it speaks a great deal for the liaison and close co-operation which existed between the Royal Engineers and the other arms, that the changes, when they were made, did not impede the rate of build-up across the river to any appreciable extent.

In a letter to the R.E. units afterwards, the Corps Commander pointed out that the main problem was not to get the assaulting troops across but rather to get tanks, guns, and ammunition across quickly enough after the assault so that the Corps could be built up rapidly to withstand counter-attack, maintain pressure on the enemy, and break out.

This was the sapper object in this battle and one which they successfully attained.

CORONATION CAMPS, 1953

By Colonel R. N. Foster, D.S.O., O.B.E.

IN July, 1952, London District was given the task of making all military arrangements for the Coronation of Her Majesty Queen Elizabeth II. This promised to be a complicated assignment requiring planning and organization equivalent to a small operation of war, with the disadvantage of having no enemy to blame if the plans miscarried.

Since all operations involve the engineers, and no clear record came to light of the engineer activities in the 1937 Coronation, it may be of value to describe briefly how this task was tackled on the engineer side in 1953.

A very considerable movement problem faced the staff in the concentration of troops from all parts of the Commonwealth and Empire and in their dispersal, but the Engineers had to provide accommodation for 31,750 Army, Air Force and Police personnel within easy range of the Coronation route for a short period. Some work was also required for Naval accommodation.

The policy was laid down to concentrate overseas detachments in areas near to London ; for the final assembly, to fill existing barracks near the route to capacity, to transport a limited number on Coronation day from concentration areas outside the Metropolitan area, and to erect temporary camps for the remainder.

These temporary camps were our real problem.

Planning

Staff

Since there was plenty of time we asked for no officer increment to the C.E's. staff and the S.O.II G. & P. took over the planning, assisted by S.O. III (E. & M.), three civilian and three military draughtsmen.

Sites

First thoughts went to camps in the royal parks, but there were ministerial objections to be overcome. Then negotiations were opened to secure Olympia and Earls Court, which were estimated to take 14,000, leaving 17,750 to be accommodated in the parks.

Through the early autumn we carried out reconnaissances and produced tentative plans for varying numbers, in Hyde Park, Regent's Park, Kensington Gardens and some thirty football stadiums and other similar places to suit the latest whims of planners and objectors !

Interlude

In the middle of this, " Q " War Office rang up and said " We want to know what the cost of the camps will be ! " The answer was required in two hours' time to tell the Treasury. This resolved itself

into an interesting equation with a startling number of indeterminates.

The Victory March camps in 1946 were constructed by contractors and prisoners of war on a lavish scale for 17,200 troops in Kensington Gardens at £7 per head.

The Coronation Camps in 1953 would be constructed by military labour at summer tented scales for 17,750 in an undecided park and for 14,000 in Olympia and Earls Court (if we could hire them) for how much per head? Say too much and the scales would be cut to fearful austerity. Say too little and write letters for years in explanation of excesses. We said £4 per head and rang off quickly.

Back to Sites

The Royal Navy agreed once again to go underground, so a standard plan for facilities at Clapham Deep Shelter was developed. Stepping carefully round dairy cattle and cages of rabbits, mice, etc., our draughtsmen made plans of Olympia, while those at Earls Court, in the middle of a motor show, produced plans of all five floors and managed to unravel and tabulate the entry and exits of the ninety-eight staircases, totalling 13 miles of tread, which all appear to decant one on to the floor one does not wish to reach.

Kitchen areas, ablution and latrine blocks, dormitories with detailed bed layout, offices, band instrument stores, M.I. room, etc., were all fitted in, agreed with the staff branch concerned and checked with the resident engineer in each establishment. It was agreed to hire gas or electric cooking gear for these places from the Ministry of Works and for the local engineers to connect up. Military solid fuel cooking equipment was not suitable in the confined and overpopulated space.

It was decided that we had better concentrate on Kensington Gardens for the camp. It was accordingly surveyed for aboveground drainage in victaulic piping (to save damage). A block layout of six camps for 3,000 Police, 2,250 Army Reserves, 4,500 R.A.F., 4,265 street lining troops, 1,300 Commonwealth troops, a central administrative battalion of 1,100 and a C.S.D. were prepared, and amended a few times.

In the end ministerial agreement was achieved for this camp.

It was a tight squeeze to fit all the tentage required into the area and pitching trials were held to see how much tent guys could be interlaced, whether six or eight men should go to a 160 lb. tent, could they have wardrobes for their No. 1 dress or not.

It was decided to attempt the scale per tent of one senior officer or three junior officers, or four W.Os. and sergeants, or six O.Rs. Wardrobes, which were issued one to two men in Olympia and Earls Court for processional troops were *not* agreed for the street liners in Kensington Gardens.

o

Briefly the task consisted of the following requirements :—

At Clapham Deep Shelter.—Certain work for the Royal Navy.

At Regent's Park Camp, latrines, ablutions, water supply and lighting for 350 R.A.S.C. who were an overflow from the barracks.

At Earls Court, about fifty eight-bay latrines and the same number of ablution structures, with 250 yds. of internal screening.

At Olympia, about thirty eight-bay latrine structures, and the same number of ablution structures, with 1,400 yds. of internal screening between dormitories, offices, etc.

At Kensington Gardens, eight-bay latrine structures totalled ninety, with the same number of ablution structures, a total of twenty-four cookhouses, mostly of the 1,000-men type, 4 miles of victaulic piping for drainage and nearly five miles of piping for water supply. The electrical supply required a total of 15 miles of cable, some armoured, with switches, meters, fittings, etc. In addition there was the supply of duckboards, fencing for C.S.D., etc.

Maps

"G" and "A" branches required large-scale maps of the Coronation route for planning the processional routes, street lining, forming up, etc., and there were many calls for sketches for briefing conferences.

Route Latrines

There appeared to be a large requirement for temporary latrines along the route for the troops. This involved much discussion with local authorities and police on siting, but in the end it was found that local authorities were constructing so many for civilians that the military requirement was reduced from a list of forty-five to seven latrine stations only.

Route Marking

All streets used by the troops were to be marked at the head and tail of each marching detachment or street lining platoon with lines and serial numbers. An officer of the Engineer Regiment was briefed for this task by the staff representatives concerned. Land Rovers for street painters were laid on and special white road paint was indented for.

Notice Boards

Provost Corps took on the signing of routes, but it was evident that a comprehensive scheme of sign posting would be required for each camp.

By Christmas, camp commanders had been appointed. These were A.A. brigadiers with their staffs and we pressed them for tabulated schedules of the notices they required, giving dimensions, colours, etc. We found their ideas a bit expansive, particularly for internal notices in the buildings, but once we had scaled down a

requirement of a 6 × 3 ft. sign to the size of a car number plate and demonstrated its efficacy all went well.

The S.M.E. took on the construction of all the exterior notices which required painting, while internal notices were drawn by our own staff, printed, coloured and issued to camps, stuck on to plain or hardboard to be attached to walls, posts or bed-ends as required.

Electricity

Lighting and power were required for Kensington Gardens and Clapham camps for cookhouses, dining-rooms, officers' and sergeants' messes, canteens, offices, guard rooms, medical, mobile laundries and for television and radio in welfare clubs.

Two districts of the London Electricity Board were concerned with the supply. Cables could not be laid in trenches since the park officials would not agree to our cutting up the ground. Internal feeders had therefore to be of a special type and arrangements made to protect these at the many road crossings. Personnel trained in paper insulated cable jointing would be required.

It was decided to centralize all electrical work under the S.O. III E. & M. who would take executive charge of construction.

Labour

36 Army Engineer Regiment with its Park Squadron was made available for the whole operation. Based on figures for construction of 1,000 men and 250 men camps, obtained from Eastern Command, we reckoned they could do the construction in four weeks and dismantle in two. They would need loading parties of unskilled men.

Electricians.—Two W.Os.(E) were demanded and twelve out of fifteen sapper electricians of the regiment were given a course of paper insulated cable jointing at the S.M.E.

Accommodation

Advance Squadron would be accommodated in the camp adjoining 6 C.E.S.D. and build a camp for the rest of the regiment.

Stores

By November we had completed a full stores list based on summer tented scales, and C.E. Eastern Command undertook to have these stores into 6 C.E.S.D. at Wormwood Scrubs by 31st March, 1953. The Engineer Regiment would then take over all stores until dismantling was complete.

Transport

The Engineer Regiment were to bring their own personnel and workshop transport to London. R.A.S.C. transport to carry the 2,000 tons of stores to camp sites and return was demanded from "Q."

Time

Various factors affected the time available. Earls Court and Olympia could only be used four days before the troops came in.

From the time the last troops left Earls Court we had to be clear in twenty-four hours so that the Royal Tournament could start and we had only two days in which to clear Olympia.

Due to ministerial pressure the construction of Kensington Gardens camp was reduced to ten days and we were pressed to clear in six days, of which troops would still be in occupation for four days.

Camp administrative battalions had to be catered for early in the construction so that they could live in and erect tentage. All margins of time allowed in our planning were thus removed before we started and it was obvious that the engineer troops would have to work long hours and fast.

Programme

By the end of September a programme had been made and is given at Appendix "A." Subject to small modifications this programme was carried out.

Preparation

Detailed drawings were now made to the number of one hundred different master copies, with adequate prints to give exact layouts and details of each construction to hand to the N.C.O. in charge of each job. Detailed estimates were completed and forwarded to War Office for approval by the end of December.

Reconnaissance

The reconnaissance by the regiment was somewhat piecemeal since they were fighting the floods in Lincolnshire, but the C.O. and his staff visited his own camp site and the Coronation camp sites on several occasions, and the squadron commanders responsible for each camp visited their sites, met the camp staff and were briefed at London District.

Orders

Finally, orders and complete sets of drawings and stores lists were sent to the regiment in April.

Additional Works Services

Subsidiary tasks carried out by the normal works services were :—

(*a*) Camps at Pirbright for Commonwealth troops to the number of 269 officers and 2,099 O.Rs.

(*b*) Construction of a horse camp in Hyde Park—Knightsbridge.

(*c*) Repairs and maintenance of sanitary accommodation at Woolwich for ninety-six officers and 410 O.Rs. of the Colonial Forces and 2,000 civilian police housed by the Garrison.

(*d*) Temporary latrine structures for Coronation Day use at Millbank, Chelsea and Wellington Barracks.

The Operation

On 30th April, the advance squadron arrived at Gunsite camp, Du Cane Road, where they were welcomed by the Railway Home Group, R.E.

They completed the transport camp at Regent's Park by 4th May and the camp for their own regiment by 9th May. During this time a section of twenty-five Pioneers joined to act as duty men in the camp so as to free every available sapper for work.

10th May.—The main body of the regiment arrived, settled into camp and started taking over stores, setting up a workshop area and prefabricating certain structures for the Coronation camps.

11th May.—A working party of two officers and ninety-six gunners of 70 H.A.A. Battery joined the regiment. This unit was invaluable. They worked with tremendous energy and were soon adapted to construction parties working on the camps with the sapper squadrons, in addition to their loading and unloading tasks.

R.A.S.C. transport, consisting of forty-five 3-ton lorries, were put at the disposal of O.C. Regiment and were also accommodated in the sapper camp.

Clapham camp for the R.N. was completed between 12th and 15th May, and on 14th May the regiment got a flying start at the drainage and water supply of Kensington Gardens.

An unexpected difficulty arose in the ramps over the drainage pipes where they crossed camp roads. Those designed did not work and bigger ramps of sleepers and flexboards had to be undertaken.

On 18th May, the administration battalion arrived to live in the camp and caused some immediate demands, but by 23rd May, Kensington Gardens camp was complete.

The sappers had been working till 9.30 p.m. each night and on one occasion were paid at 11 p.m. in their own camp. The route painters had no sleep at all for the two nights prior to the Coronation.

In Earls Court and Olympia we were also fortunate in being able to start early. The resident engineers had beaten the pistol and had all service connexions ready by 17th May. On the 19th cooking equipment started to arrive and was all connected and working by 24th May. It was brand new equipment and the huge kitchens manned by A.C.C. were an impressive sight.

Starting two days early, by a gentleman's agreement with the two managements, the squadrons, at reduced strength (Kensington Gardens was still going full bore) got a good start and completed their tasks by the correct time, 28th May.

Incidentally, it was impressive to see the camp administrative battalions erect the 9,000 and 5,000 beds on an exact layout in 24 hours starting 2 a.m. on 25th May.

Thus the construction job was done. Maintenance parties were kept at instant call, but otherwise during the Coronation week-end

36 Engineer Regiment had a break to rest themselves. Some of them marched in the procession and an officer and forty O.Rs. joined the R.E. street-lining detachment.

Dismantling

For the dismantling it had been agreed with Eastern Command to make Ashford the R.S.D. for camp structures, and "Q" (M) managed to lay on enough railway trucks and loading bays at the stations to compete with this back-railing of stores. This saved double handling at 6 C.E.S.D.

A fork-lift was obtained for loading heavy cooking gear and proved invaluable. Earls Court was internally clear by midnight on 3rd June and completed the next day. Olympia was completed by mid-day 5th June. The route latrines vanished on the 3rd.

Kensington Gardens clearance needed very close liaison with the camp staff, since troops were being moved out over a period of three days and the administrative battalion required full scale amenities till midnight of 7th June.

One squadron dismantled what was possible on the first two days, ably assisted by one hundred men of the R.E. Training Brigade who had been in the R.E. street lining detachment and were impressed into the dismantling party for the two days before their time of dispersal. On the 6th the whole regiment was concentrated on the task and by tea-time on the 8th nothing remained in the park other than one plumber's bench close to the Statue of Physical Energy!

Cookhouses were dismantled as men ate their last meal and the tables and benches were removed as they cleared their plates. An unexpected indication of the speed of backloading stores was given to Ordnance storemen at Osterley when they unloaded from a 3-ton lorry a Soyer stove still alight, and another containing a stockpot, which was still bubbling!

Clapham and Regent's Park camps came down in the next three days and the main body of the regiment departed for Ripon, leaving a rear squadron to clear their own camp.

Conclusion

The whole of this operation from start to finish had a good atmosphere. It held a great incentive. Despite the very severe test made on the Sapper Regiment during construction and dismantling, the tasks were efficiently completed within the hard limits of time imposed. They will be the first to give credit to the cheerful co-operation they received from all with whom they had to work.

They may also feel proud of having had the privilege of carrying out a task in the best traditions of their Corps, as part of the larger team which made such a success of the Coronation of Her Majesty, our Colonel-in-Chief.

APPENDIX "A"

SERIAL	SITE	NUMBERS TO BE ACCOMMODATED	ERECTION: PROGRAMME OF WORK MAY 1953	TRANSPORT REQUIRED: 3 T	TRANSPORT REQUIRED: 10 T	TRANSPORT REQUIRED: Days Required	TRANSPORT REQUIRED: Eng. stores to be collected from	TRANSPORT REQUIRED: Time	LOADING PARTY: No	LOADING PARTY: Req on	LOADING PARTY: Rep to	LOADING PARTY: Time	DISMANTLING: JUNE DISMANTLING PROGRAMME	DISMANTLING: TRANSPORT REQUIRED: 3 T	DISMANTLING: TRANSPORT REQUIRED: 10 T	DISMANTLING: TRANSPORT REQUIRED: Dates req.	DISMANTLING: TRANSPORT REQUIRED: Time req.	DISMANTLING: TRANSPORT REQUIRED: Report to	DISMANTLING: TRANSPORT REQUIRED: Stores to be returned to	DISMANTLING: LOADING PARTY: No	DISMANTLING: LOADING PARTY: Req on	DISMANTLING: LOADING PARTY: Report to	DISMANTLING: LOADING PARTY: Time	REMARKS
a	b	c	d	e	f	g	h	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
1	REGENTS PARK	250																						ONLY WASHING & SANITARY FACILITIES REQUIRED THIS IS A SMALL OVERFLOW CAMP FOR RASC DRIVERS FROM REGENTS PARK BKS
2	WORMWOOD SCRUBS	400																						TENTED CAMP TO ACCOMMODATE OVERFLOW OF REGT FROM HOME RLY. GP ACCOMMODATION TENTS TO BE ERECTED BY ADVANCE SQN 'A'
3	F U POINTS & LAT STATIONS	2000 + *		8		12	Nº 6 CED	0745	20	12	OC 6 CED	0745		8	-	9	0745	OC 'B' SQN	Nº 6 CED	20	9	OC 'B' SQN *	0745	TONNAGE INVOLVED 40T APPROX * REPORTING RV TO BE ARRANGED WITH OC 'B' SQN
4	KENSINGTON GARDENS	17,096 (8587 ARMY, 5319 RAF, 3190 POLICE)		24 OR 42 x 3 Tons	6	15 TO 18	Nº 6 CED	0745	90	15 TO 18	OC 6 CED	0745		28	-	5 TO 8	0745	OC ENGR. REGT	Nº 6 CED	45	5 TO 8	OC ENGR. REGT	0745	TONNAGE INVOLVED 1560 T APPROX
5	EARLS COURT	8,500		25	-	24-26	Nº 6 CED	0745	60	24 TO 26	OC 6 CED	0745		25	-	2-4	1745	OC 'C' SQN	Nº 6 CED	60	2 TO 4	OC 'C' SQN	1745	TONNAGE INVOLVED 458 T APPROX
6	OLYMPIA	5,500		10	-	25-26	Nº 6 CED	0745	30	25 TO 27	OC 6 CED	0745		10	-	2-4	1745	OC 'A' SQN	Nº 6 CED	30	2 TO 4	OC 'A' SQN	1745	REGT. TO STAND BY FOR DISMANTLING AT MIDNIGHT 2/3 JUNE EARLS COURT MUST BE CLEARED BY 3 JUNE MIDNIGHT TONNAGE INVOLVED 255T APPROX

THE ABOVE REQUIREMENTS ARE BASED ON 3 ROUND TRIPS

THE ABOVE REQUIREMENTS ARE BASED ON 3 ROUND TRIPS

DEMOLITIONS

By MAJOR A. H. W. SANDES, R.E.

INTRODUCTION

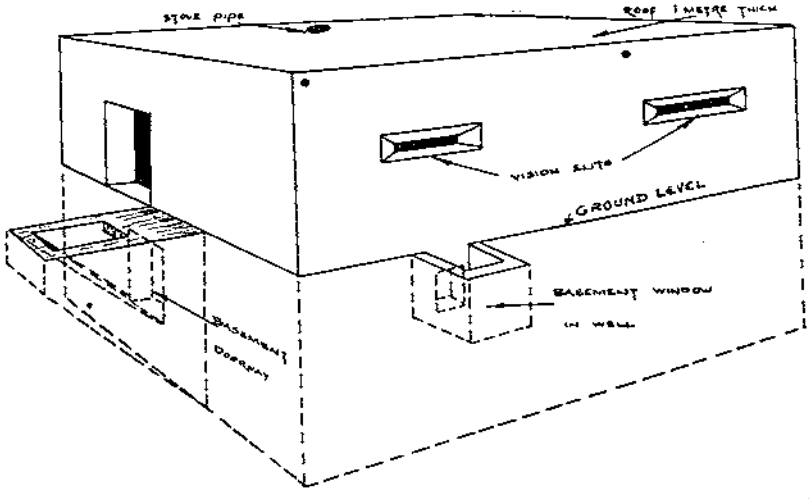
DURING the winter of 1947–8, at No. 1 Engineer Training Establishment, B.A.O.R., I took over the instruction of Demolition Teams of the Control Commission for Germany. My predecessor, "Paddy" Irish, had already reduced the course to an efficient routine, and I was fortunate to find myself with keen and experienced Q.M.S.Is., plenty of explosives, and a variety of suitable demolition targets, thoughtfully provided by the Third Reich at the Unterluss Ranges. The small town of Unterluss lies hidden in a wide belt of heath and pine forests, which extends open and desolate for mile upon mile, and is, I believe, a part of Lüneburg Heath. The ranges, which lie northwards of Unterluss, are about ten miles wide by thirty miles long, and except for an occasional forester's house are almost deserted. They were used by the German firm of Rheinmetal-Borsig as a testing ground for weapons of every description. We saw there V-1 launching ramps, V-2s, guns of every size from 20-mm. to 16-in., tanks, aircraft and bombs. The whole range was dotted with shell-proof observation towers, concrete pill-boxes and bunkers, underground shelters, gun emplacements, workshops and a variety of specialized buildings for testing armaments.

It was our practice to spend several days during each course on practical demolitions at the ranges. The targets available to us were those structures scheduled for demolition by the Disarmament Branch of the Control Commission, from which we could take our pick to teach whatever aspect of demolition technique we wished. Seldom can a demolition instructor have had better facilities.

Our demolition methods differed in one major respect from the technique normally employed by military engineers. The Control Commission Demolition Teams often had to work in thickly built-up areas with the object of destroying one particular target while preserving from damage the surrounding buildings and their occupants. Hence our aim was to teach our students to calculate their charges so as to produce exactly the required effect on the target while avoiding damage to the surroundings. This involved the adoption of the general principle that, for such restricted targets, the absolute minimum of explosive should be used, in marked contrast to the usual military technique of doubling the charge when in doubt. In fact, our slogan was "When in doubt, halve the charge." I might mention in passing that insistence on this policy was really important; there was one ex-naval student who liked to take his basic unit of explosive as one depth-charge.

TARGET ONE

Fig. 1. General View



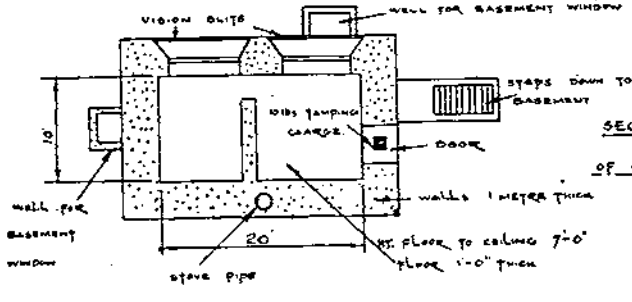


Fig. 2

SECTIONED PLAN OF GROUND FLOOR

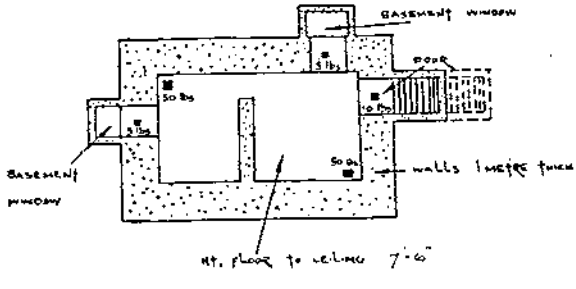


Fig. 3.

SECTIONED PLAN OF BASEMENT

It must be emphasized that in the cases quoted here our object was only to make each building unusable and not to carry out a complete demolition.

I kept a personal record of a number of our demolitions which seemed of particular interest at the time. The rest of this article describes four targets and how they were attacked, with the lessons we learnt. Opportunities such as we then had for full scale demolitions have almost vanished in Europe, and those who are limited to blowing not more than ten pounds of explosive on a piece of steel girder in a demolition pit may be interested in our experiences. To those on the other hand, who may be demolition experts and to whom such minor jobs would be not worth recounting, I apologize. Perhaps they may care to cap this article with tales of bigger and better bangs.

Target One

This target was a small, lightly reinforced, two storeyed concrete shelter. The top storey was at ground level, with a basement beneath. The north face contained two vision slits 6 ft. long by 2 in. deep fitted with armour plate glass. The slits could be further protected by steel shutters inside the shelter. The east face contained two normal sized doorways, one at ground level, the other in the basement reached by a flight of steps. The basement had two windows each about 3 ft. by 1½ ft., one on the north, the other on the west face. These opened into small "wells" to admit air and light. Two small vents 6 in. square in the north face and a 4-in. stove pipe through the roof were the only other apertures. From the general view (Fig. 1) and plans of ground and basement (Figs. 2 and 3) it will be apparent that the shelter was strongly constructed. Close inspection in fact failed to reveal any weak points such as pouring joints.

Owing to the great thickness of the walls and the few apertures, the obvious method of attack was by concussion charge.

Using the formula $C = \frac{KT/\sqrt{T}}{3}$

Where K = 1.1 (the factor for heavy concrete).
T = 3.0 ft. (approximate wall thickness).
V = 3,100 cu. ft. (internal volume of shelter).

The charge required was 105 lb. of explosive. For practical purposes this was taken as 100 lb., and placed in two 50 lb. charges (as shown in Fig. 3) on the basement floor. The two doors were each tamped with a 10-lb. charge which was connected to the main firing circuit. All remaining apertures were blocked with sandbags. All the explosive used was Nobel "808" plastic, initiated by primers from a detonating cord ring main. The main was fired electrically, the firing point being under cover 400 yds. away. About fifteen students took two hours to prepare this demolition.

The demolition was most successful. Concrete debris was thrown in all directions up to about 150 ft. radius, but there was negligible blast felt at the firing point. The shelter was effectively destroyed. The roof, which proved to be a very lightly reinforced concrete slab, not tied into the walls by reinforcement, fell into the basement and broke up. The walls were severely cracked and sucked several inches inwards. The basement floor was destroyed.

The conclusion we reached on this target was that it could have been adequately destroyed with a smaller charge, say about 80 lb. This would have been advisable in a built-up area, to restrict blast and debris.

It should be noted that for all concussion charges we used at this time a basic divisor of 3, giving one-third of the charge as calculated by the normal formula given in R.E.S.P.B. No. 4, $C = KT\sqrt{VT}$. For restricted targets the divisor could be increased to 4 or more.

Target Two

In the demolition area were a number of air-raid shelters of varying sizes, built to accommodate the inhabitants of groups of houses surrounding the military establishments. One of these shelters was selected for attack on account of its special features.

The target, shown at Fig. 4, was a tunnel type shelter, S-shaped in plan, built on the cut-and-cover principle, with about five feet of earth overhead. There was a main entrance at each end, and a small emergency exit shaft near the centre of the shelter.

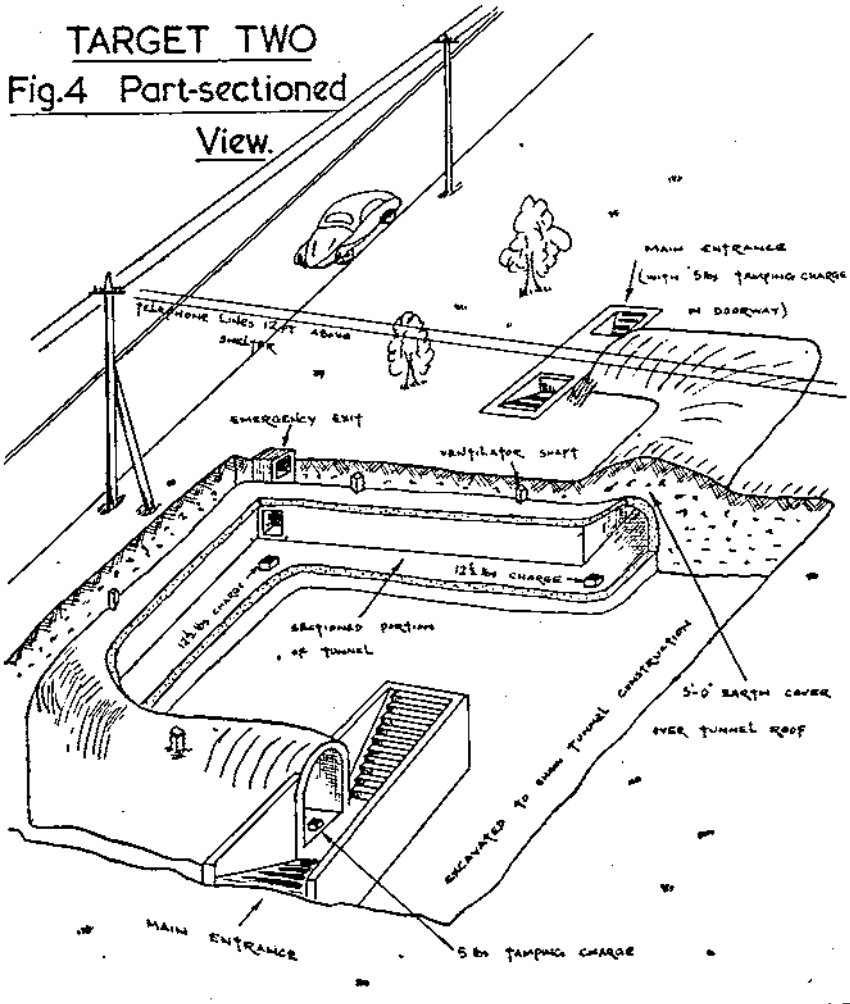
Besides these openings there were a number of small ventilating shafts projecting through the roof of the tunnel. As far as we could make out in the limited time available, the concrete construction was not reinforced. The tunnel lay in sandy soil.

The factors which made this an interesting target were, first, its suitability for a concussion charge attack ; secondly, its location.

The shelter lay within five yards of the main road, along which overhead power cables ran suspended from telegraph posts ; a branch telephone line ran directly across the shelter not more than twelve feet above it ; lastly, inhabited houses almost surrounded the target, the nearest being only twenty-five yards away. In short, this formed a highly restricted target requiring the use of the absolute minimum charge. A concussion charge was decided upon in view of the few openings and the thickness of the overhead cover. Using the same formula

$$C = \frac{KT\sqrt{VT}}{3}$$

and taking $K = 1.0$ (the factor for R.C. tunnels in normal soil)
$T = 1.17$ ft. (wall thickness)
$V = 7{,}254$ cu. ft. (internal volume)

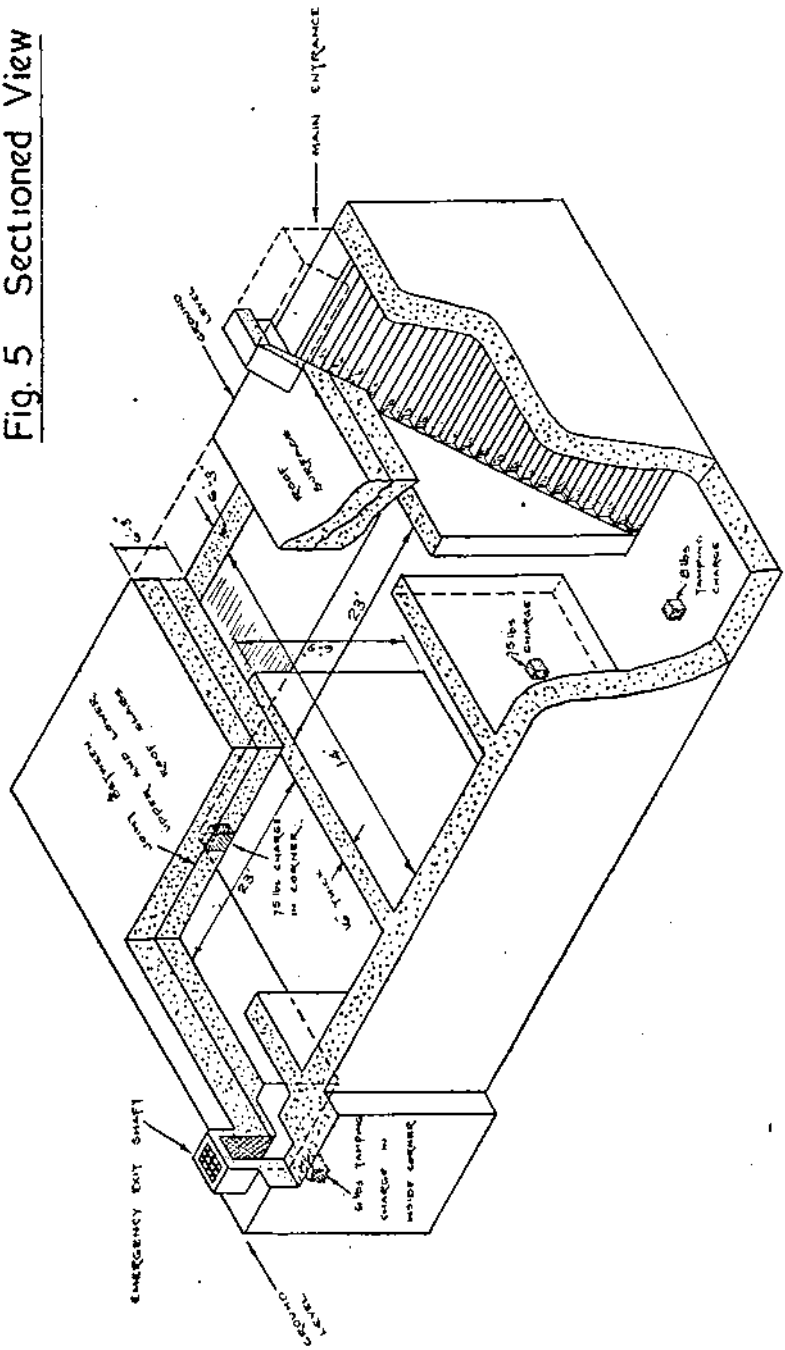


the calculated charge was approximately forty pounds. This, from previous experience we considered too high to ensure safety of the buildings, road, power and telephone cables, so we reduced it to 25 lb., which was equivalent to taking K as 0.7, or, with K as 1.0 the dividing factor would be 4.3.

The main charge was divided and placed as shown in Fig. 4, with a 5-lb. tamping charge at each entrance (the entrances were too large for tamping with sandbags). The emergency exit and all the ventilating shafts were thoroughly tamped with sandbags. The main tamping charges were placed on boxes a foot or two off the floor, on the centre line of the tunnel. The object of dividing the

TARGET THREE

Fig. 5 Sectioned View



main charge in two was that, when the two charges were blown simultaneously, the two blast waves would tamp each other in the centre "leg" of the tunnel. All charges were connected with a detonating cord ring main, initiated electrically. The firing point was about 150 yards away, under cover but in view.

All inhabitants were removed from houses within a hundred yards, after being warned to open all windows. The roads were closed and German police posted to keep the area clear of civilians. A final check by our men proved worth while, as we found that despite the police there were quite a number of interested children lurking around.

We were very pleased with the result of this attack. About half the roof of the shelter collapsed completely in fragments, and the walls caved in. The rest of the shelter was so badly cracked as to be unsafe to walk over and was considered effectively destroyed. There was no debris at all, and the only damage reported was two windows near by broken by blast. Not even the telephone lines twelve feet above the shelter were damaged.

We concluded that our estimate of 25 lb. for the charge was exactly right. A lesser charge might not have sufficiently damaged the shelter ; a greater charge might have caused damage to surroundings. For purposes of calculation it would seem that for a buried shelter with earth cover of four feet or more, K should be taken as 1.0. Normally the divisor should be 3, but in restricted cases, such as this, may be increased to 4 or more.

Target Three

A target presenting somewhat similar problems to those encountered in Target Two, was a large underground air-raid shelter. It was located beside a road, in a thickly built-up area, with a petrol pump within twenty-five yards. We were, therefore, restricted in our attack to methods which would not throw debris and would not risk rupturing the underground storage tank of the petrol pump.

Fig. 5 gives an idea of the design of the shelter. A hasty reconnaissance indicated that the construction was of heavy concrete, and what appeared to be $\frac{5}{8}$ in. diameter reinforcing bars at 3 in. centres were visible through a roof ventilation shaft. As far as could be judged, the roof was at least 6 ft. 3 in. thick, but had a convex upper surface (flush with the ground), so that in the centre it could have been seven feet or more thick. There was a main entrance stairway at one end of the shelter, and at the other end an emergency exit shaft, closed by a heavy steel plate sliding horizontally on rollers. Besides these the only other apertures were four or five small ventilators.

This was obviously a concussion target, and the charge was

calculated at 405 lb. taking $K = 1.1$, $T = 6.5$ ft. and $V = 4{,}480$ cu. ft. Because of the risk to surrounding buildings from debris and to the petrol point from earth shock, however, we used a divisor of 8 instead of 3, giving a calculated charge of 150 lb. This was divided into two 75-lb. charges, one in each half of the shelter and diagonally opposite each other. The charges were kept well off the floor to minimize direct earth shock. The ventilation shafts were tamped with sandbags, the stairs by an 8-lb. charge at the foot, and the emergency exit by a 6-lb. charge at the foot. The steel cover plate was removed in case it should be thrown in the air by the blast coming up the shaft. The firing circuit was a detonating cord ring main, electrically initiated. We took the normal safety precautions, getting the police to evacuate all civilians from buildings within a hundred yards and having all windows in near-by houses opened. The whole job took twenty men one hour to complete.

The demolition, which we watched from a safe distance, was most spectacular and we feared for the safety of some near-by buildings. However, when the smoke and dust had cleared away, we saw that all was as it should be, and the shelter was now a smoking crater, in which lay the remains of the roof and walls. There was practically no debris. On closer examination we found that the roof was cracked everywhere and in many places broken into large blocks, each 1 metre thick and which lay heaped together in the crater. Surprisingly, neither roof nor walls showed reinforcement at all—so our reconnaissance had been misleading. We were rather worried, when inspecting the damage, to hear the sound of gushing water (or petrol?) in the shelter, and found that a water main which ran through one corner had been broken by the explosion. The petrol pump was undamaged.

We concluded that the job had been very successful, though if we had known that there was no reinforcement we might have used a 100-lb. charge, equivalent to calculating on a divisor of 12 for $K = 1.1$ or 4.4 for $K = 0.4$. For the actual charge used (150 lb.), with the normal divisor of 3, K works out at 0.41, that is, the figure normally taken for light reinforced concrete.

We learned from this operation just how effective a concussion charge is when used on a buried target, even when that target is of heavy concrete. We were also reminded that water mains should not be forgotten.

Target Four

This article, so far, will perhaps have given the impression that the concussion charge is the way to demolish all buildings. The demolition here described should make it quite clear that this is not

the case. On the Unterluss Ranges there was a considerable number of surface type ammunition bunkers, consisting of a reinforced concrete frame with thin concrete walls and roof, protected on three sides by banked earth and on the roof by earth cover 2 ft. thick. The concrete columns and roof beams were of a uniform 12 in. square section, well tied together with medium reinforcing. The floor was of about six-inch concrete, and the side and rear walls of 4-in. slab concrete with mesh reinforcement, lined with a 4-in. breeze-block skin. The front wall, however, was of breeze only. The roof was of four to six-inch concrete with mesh reinforcement. The main member of the structure was the lintel beam of the front wall. This proved to be a Portal type beam, integral with the corner columns of the front wall. The beam was 2 ft. 3 in. deep by 1 ft. 3 in. wide and the columns were about 2 ft. 6 in. square in section. Two porches, for the two entrances, were set partly beneath the lintel beam and being of fairly solid concrete construction gave added strength to the front wall structure.

The construction is illustrated in Fig. 6. The soil in which the bunker was constructed was of light sand. There were no restrictions to be considered in carrying out the demolition, as the bunkers were well away from houses. Several previous attempts had been made to demolish bunkers of this type, and had been largely unsuccessful. A study of the results showed that failure was due to attempting to economize on explosives by cutting only a proportion of the R.C. frame members. This had resulted in only a partial collapse of the bunker, due to the extraordinary strength of such members. In many cases for instance, a single charge on each column had stripped the concrete but left the reinforcement intact, so that the whole structure had merely subsided a few inches and remained supported by the steelwork. In other cases the Portal beam had not been attacked, and the roof members which tied into it, had not given way completely even when the remaining columns were cut.

We accordingly decided that our method of attack should be to cut the R.C. framework at every vital point, to blow in the walls, and thus collapse the bunker. In addition we would crater the floor to render it unusable for any new building.

We used the following types of charges :—

(*a*) Breaching charges, on the six central columns and on the three columns set in the front wall.

(*b*) Mined cutting charges, dug into the earth bank behind the seven intermediate columns of the side and rear walls, and behind the upright members of the Portal beam.

(*c*) Borehole charges, beneath the footings of the six central columns, to shatter the footings and crater the floor.

(*d*) Pressure charges, over the top of the six central columns, on the centre of the Portal beam and on the Portal beam over the centre of the two porches.

The placing and size of the charges is shown at Fig. 6. The total explosive used amounted to 232 lb. of Nobel "808," plus six 6-lb. Beehives (C.D. No. 1) to form the boreholes under the column footings.

The procedure involved two separate "blows." First the Beehives were blown to form boreholes under the column footings. The detonation completely removed the front wall and brought down a large amount of the breeze lining, but otherwise did not affect the structure. The remaining charges were then placed and the demolition was fired, having involved about two hours' work for twenty men. The firing circuit, as usual, was a detonating cord ring main, initiated electrically. The roof was disrupted and collapsed completely, together with the walls and the lintel. The floor cratered ; debris was thrown up to about a hundred yard radius.

We concluded that the demolition was successful and that our method of attack had been right in principle, but that we might have reduced the charges on the columns from 5 to 3¼ lb. (the correct calculated value), or even omitted them from the central columns altogether since each central column had in addition a pressure charge on top and a borehole charge beneath.

Conclusion

Perhaps the most striking feature of the various demolitions described is the apparently casual way in which we altered the calculated charges to suit various conditions, and yet achieved success, often with far smaller charges than those given by the formulae. Our guide in this was practical experience only. It must be emphasized again, however, that we only required a partial demolition, whereas the formulae are based on more complete destruction.

The second main lesson to be learnt from these demolitions is, I think, the absolute necessity for thorough reconnaissance before tackling the simplest target. Particularly with reinforced concrete, it always pays to blow off a piece with a small charge and have a look at the reinforcement. An incomplete reconnaissance is the worst possible basis for a restricted demolition.

Acknowledgement.—The drawings used in this article were "faired" by W.O.II, F. E. Boice, R. E.

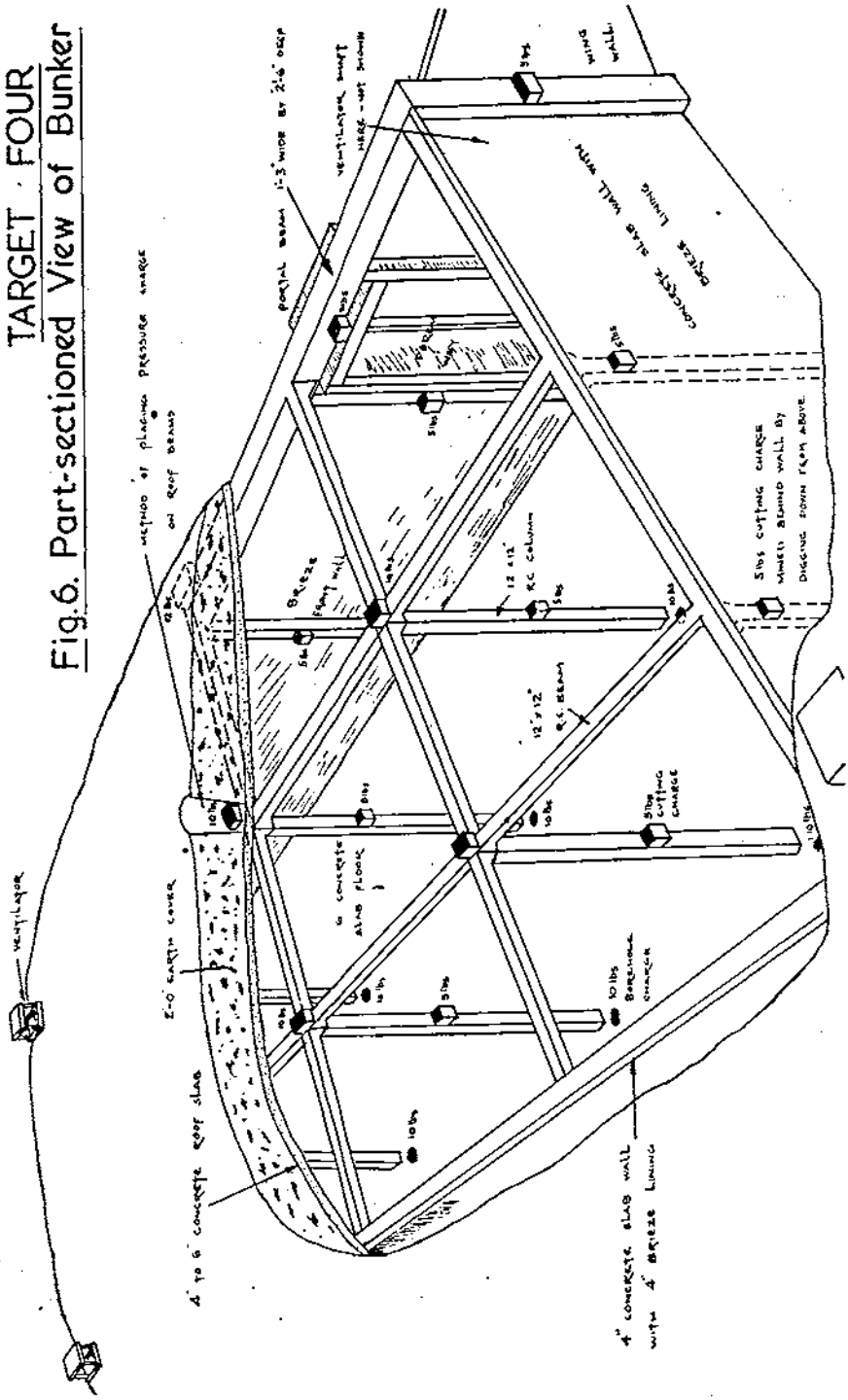


Fig.6. Part-sectioned View of Bunker

TARGET · FOUR

PALLETIZATION OF MILITARY CARGOES

By Captain P. K. A. Todd, R.E.

Introduction

In articles published by Major E. J. Carter, R.E., in the March, 1952, and September, 1952, *R.E. Journals*, the need for a new approach to handling problems in storage and in the field, has been stressed. While the complete mechanization of stores handling on the land is most desirable, the idea of complete mechanization of military stores handling cannot be achieved, unless the problems, which sea transport presents, are solved. The difficulties which face the operator are many and this article points out but a few. To examine all these difficulties is outside the scope of any one paper and discussion is limited, therefore, to palletization and then only in so far as it may enhance the efficiency of ship discharge in ports abroad ; always bearing in mind the implications so far as the Transportation Service is concerned.

The aim of any scheme to introduce palletization in cargo handling is to increase efficiency and this implies a reduction in man-power, a saving in time, an increase in the stowage factors of quays and sheds, a reduction in pilferage and a speeding up of clearance from a port area.

Cargo

The types of cargo that can be readily moved from place to place on a pallet are limited in number. Ideal commodities are such things as small carton goods of uniform shape and size, ammunition and bagged goods. Many other goods of irregular shapes can be bound together into parcels which in themselves can be mounted on a pallet. A good example of this is in the case of combustion heating stoves. Singly, they are a most awkward load to handle ; but, if bound into parcels containing four stoves and mounted on a pallet, handling, stacking and stowage are simplified.

The average military cargo, however, includes many other stores which are not so easy to palletize. Such things include steel rails, vehicles, assorted lengths of baulk timber, pipes and steel reinforcing rods. It seems, therefore, that the complete palletization of military cargoes will rarely be possible.

Complete Palletization

The full benefits of complete palletization can only be gained when ships, specially designed to carry such cargoes, are used. The basic requirement is for side ports and hoists in the ships' holds to allow fork lift trucks to enter the ship with their loads.

In the Great Lakes of the American continent a small number of ships, designed to carry palletized cargo, are in regular use. These ships have side ports and internal hoists, and stowing aboard is carried out by fork lift trucks. The special features of design mentioned above are necessary, because fork lift trucks cannot work on top of stowed cargo. The alternative of carrying from vehicle or stack to the pitch, slinging by crane or ships' gear to the hold and then stowing by means of fork lift trucks, is wasteful in machinery, labour and time. It is interesting to analyse some of the rates of discharge and manning scales for this unique service. As much as 1,400 tons of cargo, the capacity of these vessels, has been regularly discharged in five to six hours, using only eighteen men. When these figures are compared to those applicable to the normal methods of discharge, it is easy to see the benefits of such a scheme.

In the average port in the United Kingdom, the discharge of a similar cargo, by what we might call normal methods, would take approximately thirty hours, employing twice the number of men. The number of machines would, of course, be much less, but a considerable saving in time, labour and cost has been achieved.

It is most important to understand, however, that this service is not deep-sea. There is an acute danger of palletized cargo shifting in heavy seas, thus endangering the ship and her crew, and much research needs to be carried out into stowage methods before this can be rectified.

One of the main demerits of any palletization scheme, in relation to shipping, is the considerable loss of shipping space incurred. This would apply particularly to military cargoes, where it is difficult, if not impossible, to load a ship down to her marks, even without using pallets. In ships carrying palletized cargo, as much as 30 per cent of the space in the hold can be lost. This may seem to be excessive, but not only is there the volume of the pallet to be considered, but the broken stowage between "bricks" and inside the bricks themselves. Palletization does not obviate the need for dunnage.

Part Palletization

The name implies the palletization of only part of a ship's cargo, and this is probably as much as can ever be achieved in the case of military supplies. In a small way, part palletization in one form has been in existence for a number of years. On the majority of cased goods, manufacturers are fixing two or more substantial reinforcing bands, which act as fixed stillages and so permit the entry of the forks of a fork lift truck, without additional aids. In the case of military boxed and cased goods, the provision of such fixed stillages should be made universal.

Palletization of other stores is based on this principle. It is unfortunate that, with the obvious exceptions of ammunition and other dense cargoes, the majority of palletizable goods fall into the category of top stowage. In discharge, therefore, the use of fork lift trucks on board ships will be largely restricted to the 'tween decks.

Without fork lift trucks, the handling of palletized loads in the hold will be most difficult in view of their size, weight and fragility. They cannot be drawn out from the wings without a considerable risk of damage and, in the interests of safety alone, they must be hoisted vertically from the "square" of the hatch. The use of fork lift trucks in a ship's hold also increases the risk of fire. This is particularly so in the case of petrol and diesel driven vehicles. Electric trucks are probably easier to render safe in this respect.

Terminal Palletization

The name, terminal palletization, implies the making up of pallet loads in the hold of a ship, instead of the normal sets. In this way, the pallet remains in the unit or "brick," to facilitate handling and stacking from the ship, to whatever stage of delivery is desired. Where this method is adopted, a delay in building up the "bricks" in the hold must be accepted. This delay will be caused by the additional time taken in bonding the units into a stable whole. The principle of building palletized "bricks" is the same as for building brick or stone walls, i.e., no through joints and plumb sides. The rate at which the "bricks" can be built will increase as the stevedore becomes practised in the art. The multifarious nature of military stores does not allow for long runs in any one class of goods. Set patterns will be required for different commodities, and it will be difficult to incur that vital feature of speedy discharge, namely rhythm.

Size and Weight of Pallet "Bricks"

The size and weight of bricks is governed by one or more of the following factors.

(*a*) The density of the materials.

(*b*) The S.W.L. of the gear and machinery required to handle them.

(*c*) The dimensions of the vehicles in which they are to be conveyed.

The weakest link in the handling chain will normally be the ship's gear, rigged as a union purchase. The generally accepted maximum weight of any set, when this rig is used, is 30 cwt. If one considers a 30-cwt. brick of general military cargo (density 70 to 80 lb. per cu. ft.) its average dimensions would be 6 ft. × 5 ft. × 4 ft., giving 120 cu. ft. These dimensions and weights are well within the

capacity of the smaller range of fork lift trucks (two to three tons) and are convenient for the average rail and road vehicles.

It is neither desirable nor practicable to produce many different sizes of pallet to suit every commodity ; but on the other hand it is not possible to produce one size common to all classes of cargo. In the case of through palletization, where the stores remain on the pallet from manufacturer to consumer, the problem solves itself, as the pallet should be expendable ; and being fixed by the manufacturer, it will be designed to suit that particular class of goods.

On the other hand, should terminal palletization be employed, a supply of pallets suitable for carrying all classes must be provided. If military stores of a palletizable nature were divided into three groups, dependent upon the ruling factor of size, shape and weight, three standard pallets could be designed, each to suit a particular group. This should simplify the problem considerably.

Pallets

Pallets can be considered to fall into one of two categories, viz.

(*a*) Expendable Pallets.

(*b*) Returnable Pallets.

Expendable pallets are considered to apply more to through palletization, where the brick sits on the same pallet throughout its journey from, say, manufacturer to consumer, and where it is uneconomic to arrange a closed circuit working. Thus, in through working, the pallet is a fixture and forms a part of the same load. It is, therefore, less susceptible to damage than a returnable pallet and can be of a lighter construction. American manufacturers, who specialize in the making of pallets of this type, have produced them for as little as 5s. each. The cost of pallets for a regular through type service would not, therefore, be prohibitive.

The returnable pallet, such as might be used for terminal palletization, is required to be more robust, to enable it to remain in constant use under field conditions. The initial cost of pallets in a scheme of this sort would undoubtedly be high, and an effective scheme for returning pallets to the port is essential. This should not be difficult where there is a regular flow of traffic between a port and its surrounding base depots. Under these circumstances, the flow of supplies is generally one way, and empty vehicles returning to the port area could carry used pallets.

Where it would be desirable for palletized loads to remain as such, forward of base depots, it would be better to resort to the use of expendable pallets, as the arrangement of a return service would prove extremely difficult, if not impossible. Each port will, however, present its own particular problems, and it is unwise to attempt to outline a standard system of control.

Whatever the size and shape of pallets used, they should be designed so as to be capable of being slung by crane and lifted by fork lift truck.

It is not considered feasible to return pallets by ship to the U.K. in peace or war, as in the former instance the cost of shipping would outweigh the cost of the pallet, and in the latter the continuous loss of vital shipping space would be intolerable.

Palletized Cargo—Discharge Rates and Manning

Cargo Stowed on Pallets in the Ship

The average rate of discharge of cargo stowed on pallets should be very high, provided that fork lift trucks, or similar equipment, can be used in the hold and 'tween decks. The operation of "breaking out" will, however, cause an initial delay, until such time as fork lifts can be worked on board and a rhythm established in the work. By working two purchases to each machine, it will be possible to increase the output from each hold without the addition of extra men in a gang, and so at least double the normal discharge rate for hand labour of ten to twelve tons per hour.

Tables showing comparative manning scales, based on these assumptions are given below :—

Direct Discharge to Rail, Road or Lighter

	Palletized Cargo			Loose Cargo		
	Road	Rail	Lighter	Road	Rail	Lighter
Hold	2 Slingers 1 F.L.Dvr.	2 Slingers 1 F.L.Dvr.	2 Slingers 1 F.L.Dvr.	6	6	6
Deck	1 Crane Dvr. 2 Winch Dvrs. 1 Hatchman	as for road	2 Winchmen 1 Hatchman	1 Crane Dvr. or 2 Winchmen 1 Hatchman	as for road	2 Winchmen 1 Hatchman
Shore	4 Plus Dvr.	6	2 Plus Crew	6	6	2 Plus Crew
Total	11	13	8	15 or 16	15 or 16	11

Discharge to Transit Shed or Quay

	Palletized Cargo	Loose Cargo
Hold	3	6
Deck	1 Hatchman 1 Crane Dvr. 2 Winchmen	1 Hatchman 1 Crane Dvr. or 2 Winchmen
Shore	3 Minimum	9 Minimum
Total	10 Minimum	17 Minimum

A typical sequence of operations in discharging palletized cargo is given below.

(i) Fork lift truck in the ship's hold draws out cargo to the square of the hatch.
(ii) Two men slinging and clearing dunnage.
(iii) Fork lifts or mobile cranes and one man receiving on the quay.
(iv) Fork lifts or mobile cranes deliver to stack.

The capacity of sheds and quays will be considerably increased by the use of mechanical stacking.

Terminal Palletization

Where this type of working is put into operation, a deceleration in the output rate from the ship must be accepted, for reasons already outlined. This will be more pronounced in the early stages, when the work is new ; but a steady improvement should set in as the work progresses. Ships' gangs may even have to be strengthened to keep up with the rate of receiving and delivery on shore.

It is difficult to quote figures to substantiate this view, as much depends upon the skill and experience of the gangs. But it is considered safe to assume that the additional labour required in the ship will be met from the saving of labour elsewhere. The exception will be in the case of direct discharge to road, rail or lighter, where the shore gang strength will be the same as for loose cargo.

Even so, there is bound to be an over-all saving in manpower and time, as the forward movement of the supplies will be executed more efficiently than otherwise. The main advantages of such a system lie in the possibility of the shore being able to keep pace with the ship, and for the normal sixteen hour ship working period in every twenty-four hours to be increased to a minimum of twenty hours. This will be brought about in two ways, i.e., by increasing the capacity of sheds and quays, and by speeding up delivery to rail and road vehicles. The saving in stevedore manpower opens up interesting possibilities. It might then be possible for the Port Operating Troop, which normally forms five gangs, to provide extra labour in the larger holds from its own resources. Alternatively, the size of the troop could be reduced. But as it seems unlikely that palletization will ever be more than part or terminal, a considerable proportion of the work done by an operating unit will be by more conventional methods. This being so, the Troop would still require to be at its present established strength.

Rail and Road Vehicles—Methods of Loading

Direct Loading ex Ship

The direct loading of palletized cargo into rail and road vehicles can be carried out by using ship's gear or cranes. In either case,

the operation demands the use of flat topped, drop side or open type vehicles, to enable the operator to lower sets into or on to them. Direct discharge of loose cargo is often done direct to vans ; but this involves the use of stages at van doors, on to which sets can be lowered. The cargo is then stowed into the body of the vehicles piece by piece. This is obviously impossible in the case of pallet loads, as they cannot be manhandled. Loading of pallet loads from upper floors in quay sheds by means of jiggers is also restricted to the open types of vehicle.

Loading ex Quay or Shed Floor

This operation can be carried out by means of mobile cranes or fork lift trucks. But again, only flat topped, open and drop side types of vehicles can be used. Fork lift trucks can only load flat topped and drop side vehicles, as they are unable to place their loads in such a way as to fill the other types. There is an exception to this rule. The more bulky cases and packages can be lifted over the sides of side door vehicles and lowered into the vehicle body, keeping the forks within the limits of the door opening. Such cases, however, are comparatively rare.

From the foregoing statements, it would seem that mobile cranes are more versatile than fork lifts. But it must be remembered that the fork lift trucks can operate in less space than a mobile crane of similar lifting capacity, that it can make fuller use of a given area for storage purposes, and that it does not suffer from the same restrictions on headroom, as does a mobile crane. In addition, of course, they can be worked in the hold of a ship to speed up discharge. The ideal availability condition of mechanical handling appliances would appear to be a mixture of the two types, depending on the nature of the task.

Transport—Design of Road Vehicles

No palletization scheme can operate at maximum efficiency without an adequate supply of suitable vehicles. In practice, as has already been stated, this means that canopies must be off, sides down and wheel boxes either dispensed with or their nuisance effect nullified by the use of packing and false floors. For closed circuit working between a port and base depots the employment of mechanical horses of the 6-ton variety should be given careful consideration. The introduction of this type of vehicle into circuit working immediately establishes a saving in driver manpower and vehicle standing time. Normally, each prime mover is allotted a total of three trailers, which are of a type ideally suited to palletization. The distribution of trailers is such that one is loading, one is in transit and one is off-loading at the point of delivery.

If these vehicles were put into military service, however, a

modification of design would be essential to allow the prime mover to tow its three trailers at the same time. This would facilitate the transfer of vehicles from port to port in a campaign.

Supply and Maintenance of Handling Plant and Equipment

The demand for mechanical handling equipment in any future military port, will vary considerably according to the scale of palletization in operation. It will vary from ship to ship and even from day to day. It seems, therefore, that the most economical method for the provision of such equipment, will be to form a central pool, from which the demands of all units can be met. Such a pool could be formed within the Port Operating Squadron ; but this would tend to be wasteful and costly. Another important consideration is the effect that the constant switching of personnel would have upon the efficiency of an operating unit.

The Port Operating Troop is designed to provide five ship-working gangs and the training of personnel is centred around this gang system. Any scheme which tends to break down this organization is bound to have a detrimental effect on the unit's operational efficiency. There may also be varied and conflicting demands for plant in a port, and it would therefore, be desirable to have all plant under the control of the senior Transportation Officer. There again, there is the problem of maintenance and minor repairs ; implying the need for a body of skilled tradesmen, equipped with the right tools and equipment.

All these factors point to the need for a new Plant Troop within the establishment of a Port Operating Regiment, under the direct control of the Regimental Commander. This unit would be responsible for the provision of mechanical handling equipment and operators, routine maintenance and inspection and first-line repairs. Its establishment should be designed to be flexible according to the demands for its services.

The control of pallets in circuit working has been discussed. The manufacture and repair arrangements, however, present further problems. It is felt that as there will be a demand for large numbers of expendable and returnable pallets, a small factory would be required to provide the necessary quantities, in the same way as jerrican factories were formed in the 1939-45 war. The repair of pallets could be carried out by the Port Maintenance Squadron, provided that the establishment were increased to include a larger number of carpenters and blacksmiths. These tradesmen could man a small pallet repair shop in the port area. The normal establishment of cranes and other equipment in the Port Operating Squadron should not be altered even when a mechanical handling equipment troop

forms part of the regimental organization. It will always require the use of its own equipment, whether or not palletization is being carried out.

Summary

The main points arising from the foregoing discussion of palletization, as it might affect the discharging of ships carrying military cargoes, are summarized below under the headings under which they have been considered.

Cargo

(*a*) Although many commodities can be palletized, the average military cargo will include a large number of items which cannot be stowed on pallets.

(*b*) The complete palletization of a military cargo will therefore rarely be possible.

Complete Palletization

(*a*) To work at maximum efficiency, complete palletization demands the use of ships fitted with internal hoists and side ports.

(*b*) Where it has been put into operation, complete palletization has reduced ship discharging time by 80 per cent of normal and halved the labour force required.

(*c*) Heavy seas are liable to cause shifting of palletized cargo.

(*d*) As much as 30 per cent of the total shipping space can be lost when a cargo is completely palletized.

Part Palletization

(*a*) Probably the maximum attainable with general military cargoes.

(*b*) The universal application of fixed stillages on cases should be insisted upon.

(*c*) Fork lift trucks cannot work over stowed cargo.

(*d*) The use of fork lift trucks in the ship's hold increases the risk of fire. Electrically powered trucks are probably easier to render safe in this respect, than petrol or diesel models.

(*e*) Pallet " bricks " cannot be drawn out of the wings by means of purchases and must be hoisted vertically from the " square " of the hatch.

Terminal Palletization

(*a*) Where this method of discharge is put into operation, a delay in the ship's hold must be accepted.

(*b*) The multifarious nature of the average military cargo means the making up of many different pallet bricks and it will be difficult to maintain any form of rhythm in the ship working.

Size and Weight of Pallet Bricks

(*a*) These are governed by :—

(i) Density of materials.

(ii) S.W.L. of gear or machines.

(iii) Dimensions of vehicles.

(*b*) The weakest link in the handling chain will normally be the ship's gear rigged as a union purchase (S.W.L. 30 cwts.).

(*c*) A 30-cwt. brick of 70 to 80 cu. ft. per ton density would have approximate dimensions of 6 ft. × 5 ft. × 4 ft. and would be a convenient load for handling in all stages of its journey.

(*d*) 30 cwt. should be the maximum weight of pallet bricks.

(*e*) Military stores of a palletizable nature should be divided into three categories according to their respective densities and each category should be provided with its own standard pallet.

Pallets

(*a*) Expendable pallets can be manufactured cheaply and should be applied generally to through services.

(*b*) Returnable pallets should be used in closed circuit working, such as will exist in the terminal palletization of stores from ship to base depots.

(*c*) Where palletization is required to operate from the ship to any point forward of base depots, expendable pallets should be used.

(*d*) All pallets should be designed for slinging by crane and for lifting by fork lift truck.

(*e*) The return of pallets from overseas to ports in the U.K. is not feasible in peace or war.

Palletized Cargo—Rates of Discharge and Manning

(*a*) The discharge of palletized cargo from an ordinary supply ship of present-day design may be carried out at double the normal rate and with a reduction in manning of between 25 and 50 per cent, depending upon the method of delivery.

Supply and Maintenance of Handling Equipment

(*a*) A new Mechanical Handling Equipment Troop should be introduced on the basis of one per Port Regiment employed in the handling of palletized cargo. Such plant should be supplementary to that on the establishments of units.

(*b*) The troop should be responsible for :—

(i) The provision of equipment and operators.

(ii) Maintenance, inspection and first line-repairs.

(*c*) The troop should come under the direct control of the Regimental Commander.

(*d*) Its establishment should be flexible according to the demands for its services.

(*e*) Where possible, pallet factories should be formed locally.

(*f*) The Port Maintenance Squadron should be responsible for the repair of returnable pallets, and its establishment of blacksmiths, welders and carpenters increased to allow the squadron to provide a pallet repair shop in the port area.

The Application of Palletization to Military Cargoes in Peace and War

In so far as the stevedore is concerned, the introduction of palletization is a revolutionary step and demands a completely new approach to the problems of ship working. The fruits of this method are only available to those who accept this and who enter into it wholeheartedly.

Palletization cannot be nibbled at and, therefore, it is essential that, before it is introduced, it is proved that the scheme can be worked efficiently and that the enormous capital outlay required to put it into effect will be outweighed by the economies incurred in its operation. From the military point of view, complete palletization can be discounted ; but part palletization of stores from manufacturer to consumer is a distinct possibility.

In peace-time, part palletization is not considered to be worth while, as military stores do not normally make full cargoes, and individual items are in such small lots that its use is unwarranted. Civilian agencies, who are generally responsible for the handling of military stores in peace-time, are hampered in their efforts to introduce palletization in any form by the reluctance on the part of the dock workers to accept mechanization.

In war, palletization could be insisted upon in the national interest, and it is felt that this should be done, to the extent of introducing through palletization of those stores which can remain on pallets from manufacturer to consumer. If this is carried out, it will be " Q " Movements responsibility to ensure that these stores are loaded as bottom or 'tween deck stowage. This will enable handling machinery to be employed in the ship at the receiving port.

Terminal palletization in war is felt to have many more possibilities. It should be introduced as standard practice in all military controlled ports. This implies the provision of suitable plant, equipment and transport in sufficient quantities to ensure success. If it is done in this way, not only will the turn-round of ships be accelerated, but the capacities of ports for receiving cargoes will be considerably increased. In addition, there will be appreciable savings in manpower.

Palletization in peace-time is not considered to be essential or worth while, but the training of both regular and reserve units should be largely devoted to the development, for the purposes of palletization, of new techniques in stowage, discharge and general handling of cargoes. This will ensure that in the event of war, units are ready to play their respective rôles, without having to spend an unnecessary length of time in training.

THE CONSTRUCTION OF EIGHT PRESTRESSED CONCRETE TANKS*

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GENERAL REQUIREMENTS

IN 1950 the Ministry of Works called for competitive designs and estimates for eight prestressed concrete tanks, each tank to have a capacity of 430,000 gallons, with a maximum depth of liquid of 33 ft., giving an internal diameter of 50 ft.

Owing to the nature of the liquid to be stored in the tanks, it was a fundamental requirement that they should be impervious to liquid of a specific gravity of 1.03, under all conditions of loading and weather. For this reason, it was specified that the walls must be designed and constructed so as to be monolithic with the floors, and the usual form of sliding joint was not permitted.

The decision to use prestressed concrete in one form or another was due to the fact that it was considered to be a suitable form of construction to meet the requirement of watertightness.

Although the original specification did not require the concrete floor to be prestressed, this was later incorporated in order to guard against cracks at the joints due to shrinkage, temperature or differential settlement of the base.

DESIGN

With "fixity" between the walls and floors, as with traditional reinforced concrete tanks, a large part of the load in the bottom section of the tank wall is carried by cantilever action instead of by direct hoop tension. This increases the bending moments carried by the wall, hence increasing the number of vertical prestressing cables, and reduces the hoop tension near the base, thus reducing the number of horizontal prestressing cables at this point.

The difficulty from the design point of view with a "fixed" joint at the base is to decide exactly how much restraint the base slab offers to the wall. A cylindrical wall is a very stiff member compared with a circular flat slab, therefore the condition of full restraint may not be achieved. If a condition of full fixity at the base of the

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wall were adopted in the design too many vertical prestressing wires would be required. In this design, sufficient vertical prestress was provided to allow for the estimated degree of restraint at the base, and additional reinforcement was provided in the form of mild steel stirrups projecting from the floor slab into the wall, to take the difference between the fully fixed moment and the moment provided for by the vertical prestressing cables. Another governing factor for the amount of vertical prestress is the bending moment, of opposite sign to the " fixed " moment, which occurs higher up the wall. This moment, from the horizontal prestressing wires, tends to produce tension on the inside face and must be taken care of by vertical prestressing.

Another effect of the " fixed " joint between the wall and the floor is the transfer of prestress from one to the other. If the floor cables are stressed first then, due to the elastic shortening of the floor slab, the lower few feet of the wall are also partially prestressed. This loss of prestress is practically negligible if contraction gaps in the wall are left open until after the floor is prestressed. But, since the floor is prestressed before the wall, contraction gaps cannot be left open in the floor, and therefore, while horizontally prestressing the wall, there is bound to be a loss of prestress from the wall into the floor. The radial shortening due to horizontal stressing of the wall is greater than that due to stressing the floor and, in these tanks, the loss of prestress from the walls into the floor was compensated for by adding extra horizontal cables near the base of the wall.

It should be noted that in a prestressed, or reinforced concrete, tank with a "fixed " joint at the base, cracking is most likely to occur horizontally near the bottom of the wall—in theory, along the junction of the wall and base. But in practice, partly because of the upstand and partly because of the neglected tensile strength of concrete, it is most likely to occur along the lowest horizontal construction joint in the wall where the tensile strength of the concrete is very much reduced, particularly if this joint is within one foot of the floor.

The advantage of a prestressed tank is that the tendency to crack is greatest before the tank is filled. The moment at the base caused by the horizontal prestressing cables is greater than the moment, of opposite sign, due to the liquid loads (under full liquid load there is still 150 lb. per sq. in. residual prestress). This moment from the horizontal prestressing cables tends to produce tension on the outside and compression on the inside face near the base of the wall and the liquid loads only reduce the tension and compression but do not reverse them. Thus, the liquid face is always under compression. The prestressed tank thus undergoes its severest test before the liquid load is ever applied.

Concrete Stresses

(lb./sq. in.)

The following stresses assume that all the usual losses of prestress have taken place :—

	Tank Empty	Tank Full
Hoop compression in wall	630 (near base) 225 (near top)	150 (minimum residual near base) 225 (do. near top)
Vertical compression in wall	425 max. 50 min.	425 max. 290 min.
Compression in base slab	300 max. 30 min.	300 max. 200 min.

The figures given for the residual prestress when the tank is full, in the wall (vertical), and the base slab, depend entirely on the degree of fixity provided at the junction. This is indeterminate and the figures given for residual prestress are based on the estimated degree of restraint used throughout the calculations.

Theoretically, if Young's Modulus for the concrete is 4×10^6 lb. per sq. in. :—

Due to vertical prestress, shortening of wall height

$$= \frac{425}{4 \times 10^6} \times \frac{420}{1} = 0.045 \text{ in.}$$

Due to prestress in floor, radial contraction of base slab

$$= \frac{300}{4 \times 10^6} \times \frac{336}{1} = 0.025 \text{ in.}$$

Due to horizontal prestress, radial contraction

$$= \frac{530}{4 \times 10^6} \times \frac{309}{1} = 0.045 \text{ in.}$$

These figures will tend to increase due to creep and shrinkage under the prestressing load.

Wire Stresses

It may be seen from the above that the strains involved in the concrete are very small and hence the wire stresses will vary very little between the " tank empty " and " tank full " conditions—actually less than 3 per cent. Consequently, the wire stresses which matter are the anchoring stresses and the residual stresses with the tank empty after all losses have taken place. With the tank full, the wire stresses will be up to 3 per cent greater than these residual stresses.

	Anchoring Stress lb. sq./in.	Residual Stress lb. sq./in.
Vertical cables	130,000	114,000
Floor cables	130,000	114,000
Horizontal cables (2 pt. stressing)	130,000 (at sandwich plate)	
	100,000 (mean stress)	87,000 (mean stress)
Horizontal cables (1 pt. stressing)	79,000 (mean stress)	68,000 (mean stress)

General Description of Tanks

The form of construction decided upon was as follows. The tank base was of prestressed concrete 10 in. thick, increased to 2 ft. round the periphery. In plan it was roughly in the form of an octagon on axes 56 ft. long (see Fig. 2). The prestressing cables were arranged to run right through the tank base in two directions at right angles, those in one direction running through the middle of the 10 in. slab, and the remainder at right angles running alternately above and below the cables in the first layer. The cables in the base each consisted of eight wires 0.276 in. diameter, and were spaced at approximately 1 ft. 5 in. centres in each direction, the layout being completely symmetrical (see Figs. 2 and 5).

The tank walls were 9 in. thick, and 34 ft. 7 in. high, with a ring beam 1 ft. 3 in. deep and 1 ft. 6 in. wide at the top to carry the thrust from the domed roof. Prestressing was imparted by means of vertical cables, each of eight wires 0.276 in. diameter passing through the centre of the walls at 1 ft. 3 in. intervals and anchored in the tank base, together with circumferential cables, again with eight wires each, passing round the outside of the tank at vertical spacing varying from 15 in. at the top of the walls to 6 in. at the base.

The domed roof was constructed of R.S.Js., curved in elevation and cased in concrete, carrying precast concrete units, over which a concrete screed was laid (see Figs. 1, 3 and 4).

Planning

In the planning stage, some anxiety was felt over the possibility of leaks through cracks caused by shrinkage contraction of the concrete, both in the walls and the base.

Theoretically the prestressing should close these cracks, although at the same time this would reduce the residual stress in the concrete, but it was felt that any cracking was undesirable in these tanks even if it were subsequently eliminated by stresses. It was finally decided to adopt the following measures. The base was divided into four quadrants, each concreted in as short a time as possible, a period of at least three clear days being allowed to elapse between placing concrete in adjacent quadrants.

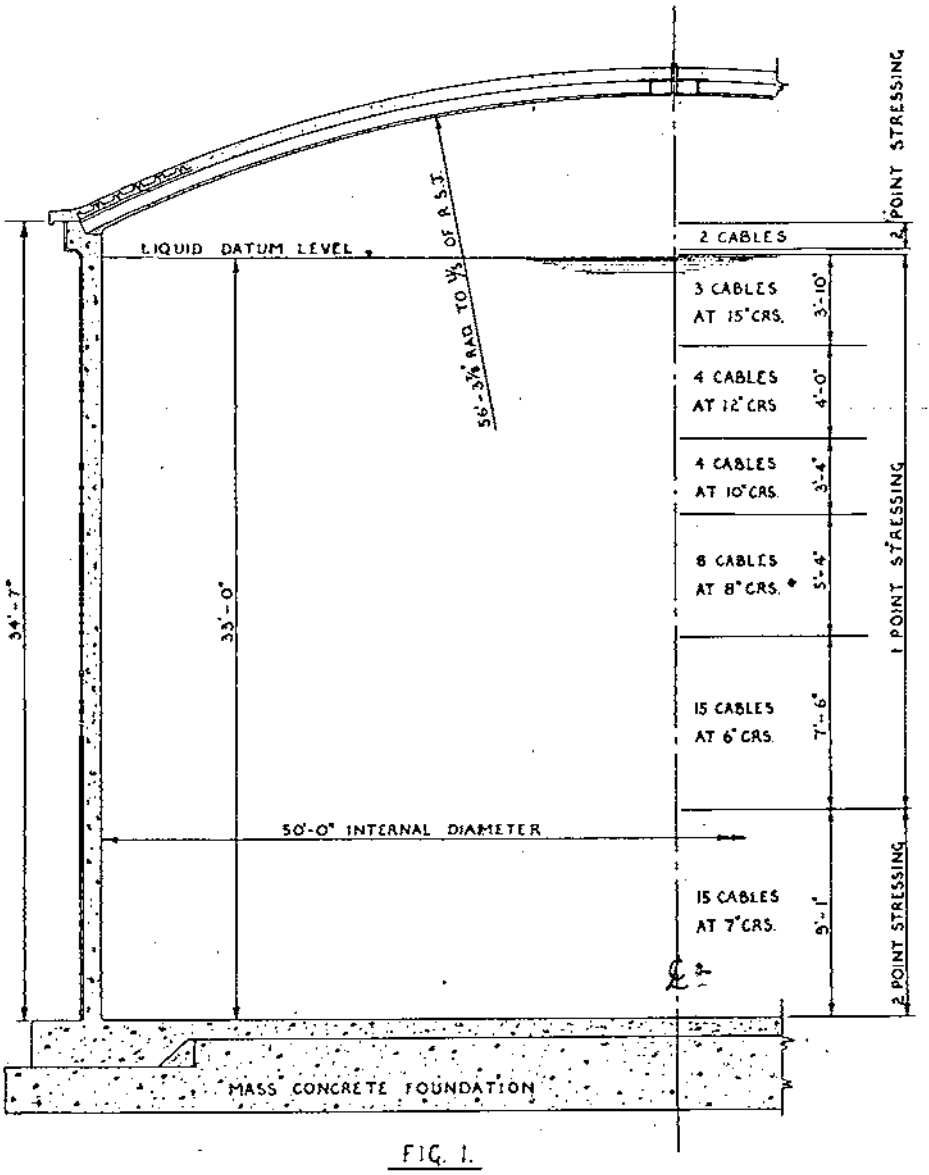


FIG. 1.

HALF SECTION THROUGH TANK

P

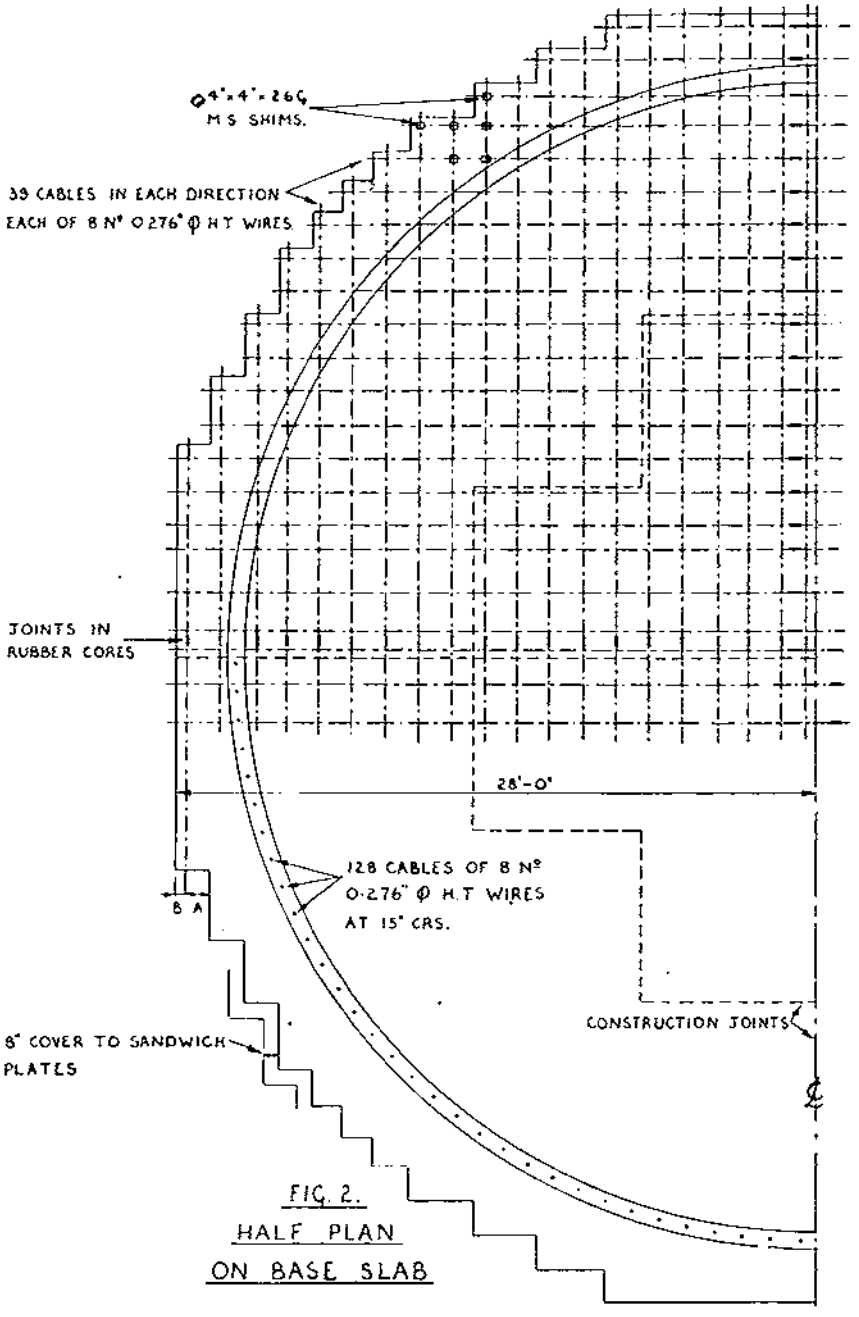


FIG. 2.
HALF PLAN
ON BASE SLAB

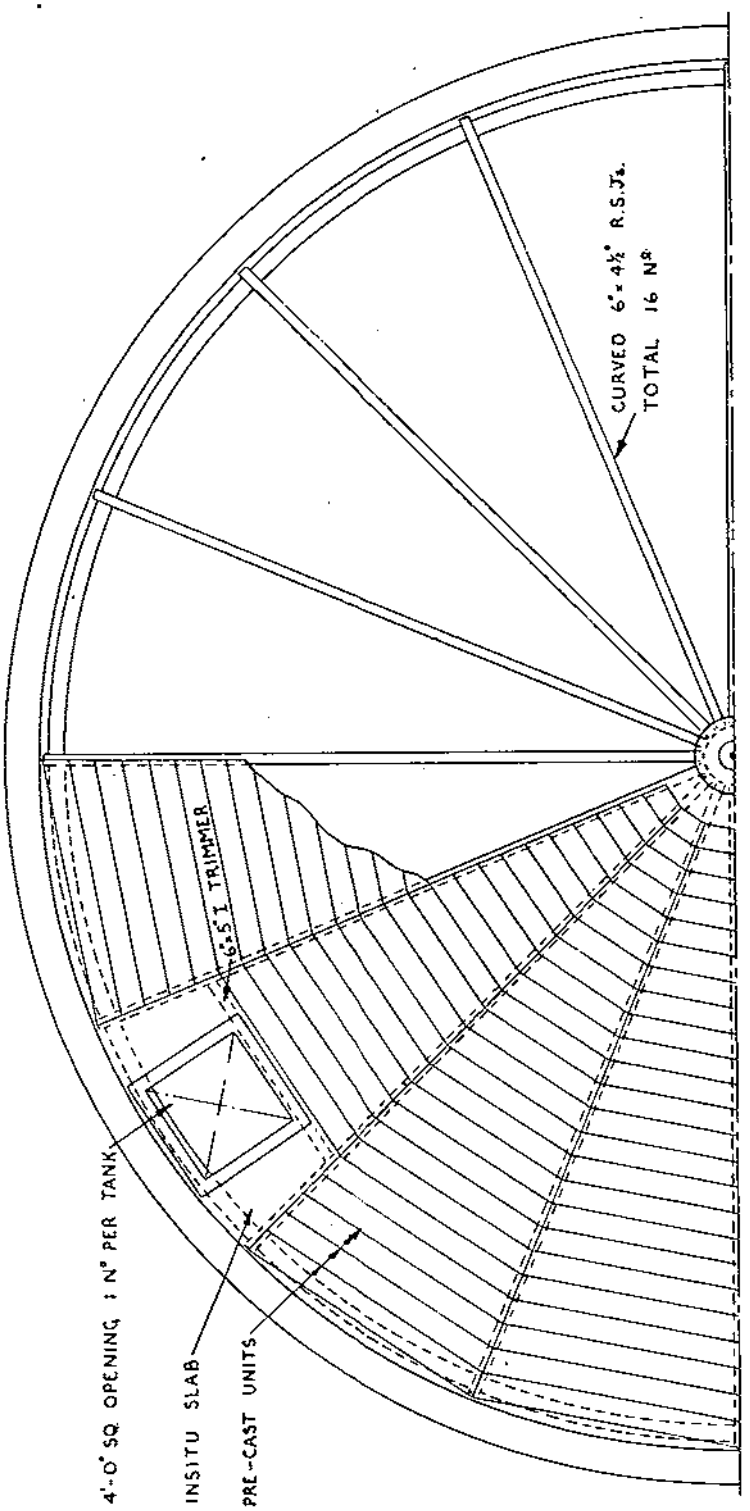


FIG. 3
HALF PLAN ON ROOF

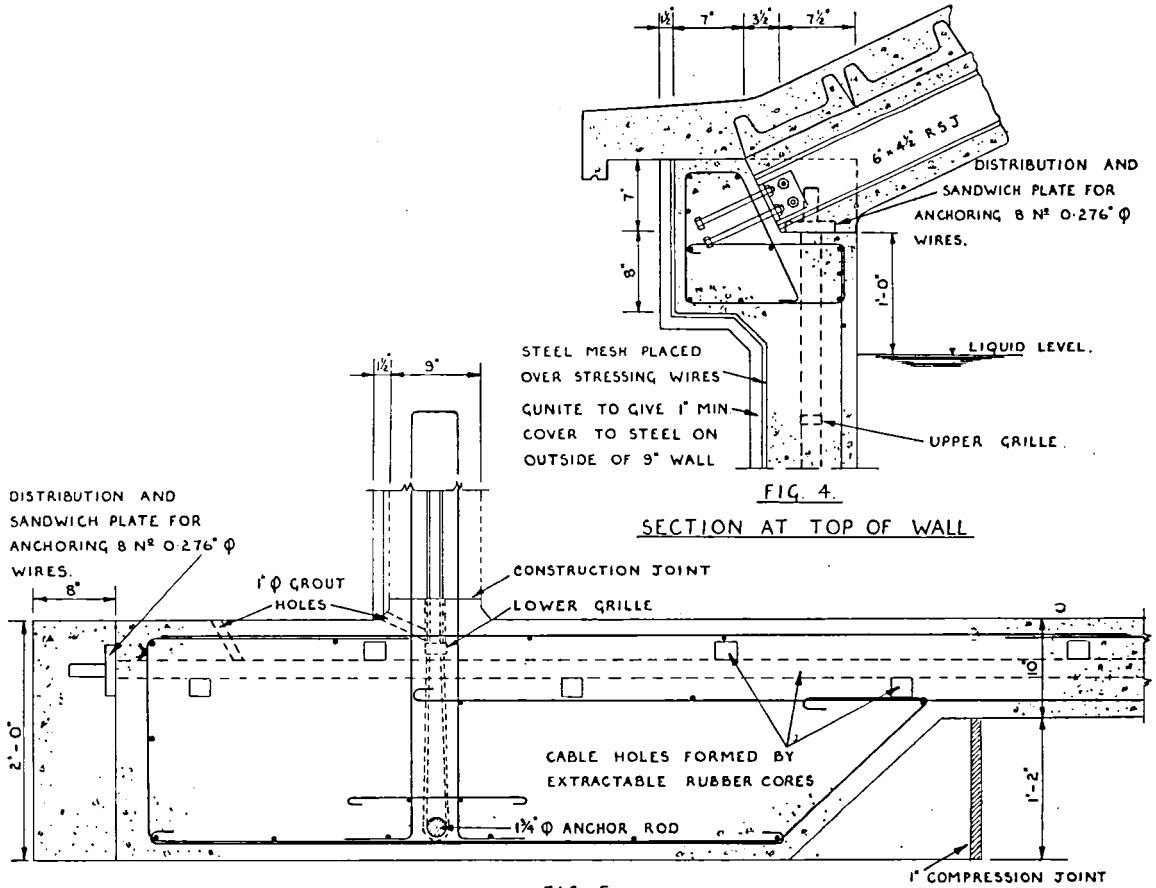


FIG. 4.
SECTION AT TOP OF WALL

FIG. 5.
SECTION AT BASE OF WALL

The walls were concreted in 3 ft. 3 in. lifts, and four gaps 9 in. wide were left at points 90 deg. apart, for the entire height of the wall, and straddling the joints between the quadrants in the base. These gaps were filled later, each lift of the construction gap being filled not less than ten days after the corresponding lift of the main wall.

These gaps introduced many constructional difficulties and, as they subsequently proved to be the only real weaknesses in the tanks, they were eventually omitted, and in the last three tanks each lift was carried out as a continuous process, and proved entirely satisfactory in every respect.

Owing to the dry concrete necessary to meet requirements of strength, considerable thought was given to satisfactory methods of compaction. A 20 ft. square " mock-up " of the base slab was constructed, complete with rubber cores and B.R.C. fabric, and was concreted using various methods of vibration—e.g., immersion vibrators of different types, pan vibrators, and a vibrating screed. It was found that the most efficient compaction was obtained by using an electric immersion vibrator with a short 3 in. diameter head, and finishing off with a vibrating screed. The latter was made up on the site, consisting of a 16-ft. length of 5 × 3 in. R.S.J., with raised " bicycle " type handlebars at each end, and carrying two Sinex vibrators. This imparted a very satisfactory finish to the concrete surface, in addition to compacting the top few inches of the slab.

On the question of compaction of concrete in the walls, it was found that two schools of thought existed, one favouring the use of Sinex vibrators clamped to the shutters, the other favouring immersion vibrators. It was finally decided to use the latter method, partly owing to the large number of Sinex vibrators required and the high initial cost—whereas the number of immersion vibrators required was small by comparison, and available from stock—and partly because it was felt that there was a possibility of shutters slipping after being fixed if external vibrators were mounted on them, and that the lift of the shutters would be reduced. It was realized that the use of immersion vibrators would require very careful supervision of the labour handling the tools to ensure adequate compaction, and this was accepted. As a matter of interest, it was found on completion of the job that in only one small section of the wall, approximately nine inches square, was there any evidence of insufficient compaction of the concrete, and on further investigation, it was found that this section of the work had been carried out by a " scratch " concrete gang working during a holiday period.

Owing to the requirement that the tank walls should be monolithic with the base, the lower ends of the vertical cables had to be anchored in the base slab, and a duct formed round the cable, which

was already in position, whilst the tank base and walls were being concreted. It was decided to form this duct by means of a length of 2 in. O.D. steel scaffold tube, which could be well greased before concreting, and then lifted whilst the concrete was still green. It was necessary that the end of this tube should always be well down into the previous lift, in order to stop grout running down the cable duct and building up at the bottom. The tubes—128 per tank—were, therefore, made 6 ft. long, to allow for 1 ft. in the previous lift, 3 ft. 3 in. in the current lift, and 1 ft. 9 in. protruding from the top ; this latter was more than was actually necessary for gripping and lifting the tubes, but was provided to ensure that the mouth of the tube was well clear of the concreting operation. In practice, keeping these cable ducts clear, so that subsequent grouting could be carried out successfully from the bottom, was a very real problem, necessitating constant attention.

The holes for the cables in the tank base were to be formed by the normal Magnel-Blaton extractable rubber core, in this case of 2 in. square section. This was stiffened by means of a 1 in. diameter M.S. rod passed through the central hole, after being well greased with Shell F.21 grease.

It was necessary that the perimeter of the base should be formed in a series of steps in plan, in order to form a flat surface normal to the C.L. of the cable, against which the sandwich plate could be placed. Some care was necessary over planning these steps, as the dimension A (see Fig. 2) could not be less than eight inches in order that there would be sufficient room for the jack, and the dimension B could not be less than five inches to ensure that the outside leg of the sandwich plate had adequate bearing.

Concrete—Mix and Placing

The mix specified was a nominal 1 : 1½ : 3 by weight and it was originally required that proportioning should be by weight. However, a series of tests carried out by the site laboratory established that the bulking of the sand in use did not vary appreciably from a value of 23 per cent between values of moisture contents ranging from 2 to 10 per cent by weight and it was, therefore, agreed to use volume batching. The stone used was Northumberland Whinstone and the sand was of local origin. The average wet density of the concrete obtained was about 161 pounds per cubic foot.

The water-cement ratio of the concrete was specified as 0.45, due allowance being made for moisture in the aggregates, which were tested every morning before starting work, and again during the day if weather conditions changed appreciably.

A 10/7 Liner Cumflow mixer was used. In this respect, a series of tests had been carried out on both a normal type drum mixer,

and one specially adapted for the purpose, but they were found to be inferior to the open pan type for handling the dry concrete. The calculated quantity of water was weighed out on a spring balance and added directly to the dry aggregates in the pan after they had been thoroughly mixed. For this purpose, a scaffold platform was erected beside the mixer, and from this platform, the cement also was discharged directly from the bag into the pan of the mixer.

The care taken in producing this concrete was amply rewarded by the resulting cube tests. It was specified that the compressive strength of the concrete should be not less than 5,000 lb. per sq. in. after twenty-eight days, and in practice it was found that this strength was almost invariably exceeded after seven days, with a twenty-eight-day strength of between 7,000 and 8,000 lb. per sq. in. These test cubes were hand tamped, and cured on the site in the open, under a single layer of hessian. Using the same materials with a water cement ratio of 0.42, and with cubes made on a vibrating table, but also cured in the open, a cube strength of 10,000 lb. per sq. in. was consistently obtained at eighteen days, with twenty-eight-day results reaching a maximum of 11,700 lb.

It is worthy of note that concrete of this consistency is not easy to handle ; it is very " sticky," being too wet to roll, and too dry to flow, down a chute or out of a hopper or skip. Conversely, it can be piled very high in a barrow !

Preparations of Foundations

The design required foundations capable of bearing 2 tons per sq. ft. The general oversite excavations showed several large patches of bad ground, which were removed and back filled with mass concrete, and it was finally decided to form a mass concrete foundation slab over the whole site. On this slab were formed the circular upstands to fill up underneath the 10-in. tank base slab, inside the toe. Provision was made for the small, but definite, contraction of the tank base on stressing, by floating off the area of the foundation slab under the tank base, and then coating it with bituminous emulsion. In addition, an expansion joint was formed in the upstand with Flexcell boarding, thus leaving the annular prism surrounding the upstand free to give just a little as shown in Fig. 5.

Construction of the Base

(a) *Vertical Cables*

The requirement that the tank walls should be monolithic with the base meant that the 128 vertical wall cables, each of eight wires, had to be in position before any concrete could be placed in the base. The first operation was, therefore, to erect a scaffold some

forty feet high round the perimeter of the tank, its standards carefully spaced to avoid the steps of the base, and also to be clear of the lines of the base cables in both directions, in order that they should not foul the jacks whilst the base was being stressed. This was planned on a large-scale drawing, and the positions of the standards painted on the foundation slab. Cantilever brackets were spurred out from the top of the scaffold to carry a circular timber profile running right round the job, from which were suspended the vertical cables, to pass through the centre of the wall.

The position of each of these vertical cables had also been painted on the foundation slab, as they had to be accurately located to clear the sixteen points of support of the roof girders. This was subsequently simplified by making the sections of the timber profile equal in length to the distance between the roof points, and cutting the housings for the cables at their correct spacing between these points. By this method, it was only necessary to mark out the roof points on the base, and plumb up from these points to fix the profile sections.

(*b*) *Rubber Cores*

It was originally intended to set up the rubber cores in two opposite quadrants of the base at once, and then to withdraw them into the other two quadrants. This, however, proved to be very difficult in practice, owing to the necessity of guiding the towing rope, the core being extracted, through the wall-starter links, spaced at 4½ in. centres, and to the fact that, as it was not possible to extract the rubber core complete with its steel stiffener, the steel rod had to be withdrawn, and then later replaced when the core was in its new position. This scheme was, therefore, abandoned after the first base had been constructed, and in the remaining tanks the whole of the rubber core was set in position before any concrete was placed. As the lengths of rubber core obtainable were not sufficient to stretch right through the base, except at the sides, it was necessary to join two lengths together, which was done by means of a sleeve or "gaine" of 22 gauge metal, 18 in. long, fitting tightly over the junction of the two sections of core, with the steel rod of one core protruding about a foot into the end of the other, to stiffen the joint. The layout was so arranged that these sleeves lay completely within the two opposite quadrants which were to be concreted first, in order that immediately the concrete had hardened the cores could be withdrawn from those quadrants, leaving the sleeves, with the end of the cores from the two remaining quadrants protruding into them, inside the concrete, and thus forming a grout-tight joint (see Fig. 2).

Thin metal shims, 4 in. square, were placed between the rubber cores at every junction. This was to prevent the grout from one

cable duct running into others at the junctions, and causing a blockage. Immediately prior to concreting, the cores were well greased with Shell F.21 grease, in order to facilitate withdrawal.

(*c*) *Grouting Holes*

The grout holes leading to the cable ducts were formed by 1 in. diameter lengths of M.S. rod, with one end cut at 45 deg. Those leading to the floor cables were supported by timber brackets carried on the external shutters, and those feeding the vertical cable ducts were fixed in holes drilled through the external upstand shutter. Where they joined the cable duct, they were housed into a sleeve made up on site from 22 gauge metal. The sleeve was also found to be a satisfactory method of forming the junction between the circular section of the scaffold tube and the rectangular section of the bottom cable grille.

The chamfered end of the rod was pushed hard against the wire, and the hole through which it was passed into the sleeve was sealed with Denso tape. It was, of course, necessary that this sleeve should be grout-tight, and the grille itself was well buttered up with a cement-sand mortar to ensure that no grout should well up through it and thus block the grout-hole. The 1-in. rods were well greased, and withdrawn immediately the initial set had taken place.

(*d*) *Concreting Bays*

It was not thought advisable to try to concrete a base quadrant in one operation, using stop ends to be removed as the work proceeded, and it was finally decided to divide the operation into a two-day task, each operation comprising an external section together with the wall upstand, and an internal section (see Fig. 2).

These two sections were to be concreted with the shortest possible time interval, the construction joint being well roughened, grouted, etc.

Any form of radial stop-end shutter was dismissed as being too wasteful in labour and timber, and all such shutters were made to cross the rubber cores at right angles.

(*e*) *Sequence of Work*

While the external scaffold was being erected, the external base shutter and the majority of the reinforcement to the base, including the starter bars to the wall, were fixed. The vertical cables were then hung in position, the base reinforcement being adjusted slightly where it prevented a cable from hanging in its correct position. It was found better to do this than to hang the cables first, and then to try to fix the reinforcement round them. The rubber cores were then set in position and jointed by means of the metal sleeves, the remainder of the M.S. reinforcement then being fixed. The internal stop-end and the shutters to the wall upstand were then fixed,

together with the topmat of B.R.C. The final tasks were to fix the grout tubes to the horizontal and vertical cables, to place the shims between rubber cores at the junctions, and then, just before concreting, to coat the rubber core with Shell F.21 grease.

Barrow runs were laid on the 9 × 3 in. bearers which carried the upstand shutters, and the concrete was tipped straight from the barrows into the base, consolidated by immersion vibrators, and finished off with the vibrating screed as described previously.

Using three Allam electric immersion vibrators, the maximum satisfactory rate of placing the concrete was 3½ cu. yds. per hour. When concreting was finished, the slab was covered with hessian, which was kept wet, to assist curing, and then as soon as possible after concreting, the stop-end shutters were removed and the face of the green concrete well hacked, scarified, and cleaned off.

The rubber cores forming the cable ducts in the floors were then removed by the night shift, at a minimum period of four hours after concreting had been completed. Various methods of winching were tried for removing these cores, but it was found most expeditious to attach the ends, gripped in a Post Office cable stocking, to a small-wheeled tractor, which then moved away slowly and steadily, withdrawing the rubber core in the process. Little or no damage resulted to the core as a result of this somewhat rough and ready method.

Construction of Walls

Purpose-made timber shutters were used, consisting of 1¼ in. boards mounted on walings of 6 × 3 in. section cut to the necessary radius. The panels were 3 ft. 9 in. deep, 4 ft. 4 in. long, and faced with 24 gauge sheet metal. Forty uses were obtained from these panels, which were then resheeted and used another forty times on other work.

It was quickly found advantageous to bolt these shutters together in pairs. This facilitated setting, gave greater rigidity when erected, and reduced the time of striking and refixing. Clamps were used for fixing the shutters in position and proved most satisfactory.

Prior to concreting a lift of the walls, the surface of the previous lift was thoroughly cleaned and wetted, and covered to a depth of about one inch with a dry 1 : 1½ cement-sand mortar, which was well rammed home. The concrete was then placed in layers of about a foot, and continuously vibrated by means of Allam electric vibrators ; the average rate of placing was approximately 3 cu. yds. per hour, i.e., about 4½ hours per lift.

It was found that to cope successfully with the problem of freeing and lifting the scaffold tube sleeves forming the vertical ducts through the walls, a definite technique was required, and a special gang was formed for this task alone.

As soon as concreting was finished one man moved round the walls scraping away the top 1 in. of the still green concrete. He was followed by another man with a high pressure water jet, who washed the surface of the construction joint. This washed away the fines, leaving an admirably ragged surface in which each piece of stone had its lower part firmly embedded in the parent concrete, and its upper part washed clean and protruding from the surface, ready to receive the mortar preparatory to the placing of the next lift.

While this was going on, the remainder of the gang were moving round the perimeter, twisting the tubes to break the bond, and then lifting each one about six inches to free it completely. This operation had to be carried out between fairly rigid time limits, as all of the 128 tubes had to be treated thus during a period of approximately one hour, after the concrete had gone off sufficiently to maintain the true shape of the duct when the tube was lifted, and before it had set so firmly as to grip the tube tightly, and prevent its easy withdrawal. It was found that weather conditions had a very great effect on these time limits. When all the tubes had been freed thus, they were lifted, scraped clean, greased, and reset for the next lift.

The vertical joints at the contraction gaps were treated in the same way as the horizontal construction joints ; the shutters were removed as soon as possible after placing the lift, and the exposed face of green concrete was scarified and treated with the water jet. The contraction gaps were then filled in lifts, each lift being placed not less than ten days after the corresponding lift of the main wall.

Stressing

All stressing was carried out on the Magnel-Blaton system, using 0.276 in. high tensile steel wire, of 100–110 tons per sq. in. ultimate strength, and 70–80 tons per sq. in. 0.1 per cent proof stress. This was received direct from the manufacturers in coils of 8 ft. diameter, weighing about three hundredweight each, and the stressing cables were made up on site.

(*a*) *Horizontal Cables*

The base cables were straightforward eight-wire cables, with spacing grilles at approximately six-foot centres and varying in length to suit the particular section of the base which they were to occupy. It was found that a cable could easily be pushed into position from one end of its duct, without the necessity of a lead wire or any form of special nose.

Normal Magnel-Blaton jacks were used, and the stressing was perfectly straightforward, with very little slip occurring on the wires as the load was released.

The extension of the wires on stressing varied from $1\frac{7}{16}$ in. on the shortest cables, 25 ft. long, to $3\frac{7}{16}$ in. on the largest cables, which were 59 ft. long.

(*b*) *Vertical Cables*

These were made up from four long wires, each with a 180-deg. bend at its mid point, where passing round the $1\frac{3}{4}$ in. anchor bar.

The end of each wire was then passed successively through the lower grille, the tube used to form the cable duct, and the upper grille (Figs. 4 and 5), forming in effect an eight-wire cable. Since the lower end of the cable was concreted into the base to a depth of 1 ft. 5 in. to form an anchorage, it was necessary that the cable duct should start from this level, which was, in fact, below the top of the base slab. As the vertical core former could not be pushed down hard against the lower grille, owing to the change from square to circular section, a junction sleeve was made up on site from 22 gauge metal, and, as shown earlier, the 1 in. diameter rod used for forming the grout hole leading to the base of the cable was passed through this sleeve.

The normal type jacks were used, in a vertical position, and no difficulty was experienced in stressing these cables. The extension of the wires was about $2\frac{1}{8}$ in., in a cable approximately 36 ft. long.

(*c*) *Circumferential Cables*

Four wire cables were first made up, their length being sufficient either to pass right round the outside of the tank walls, or half-way round, depending on whether they were to be used for single-point or two-point stressing.

The finished cable was to consist of eight wires, so the four-wire cables were therefore made up in such a fashion that when combined they formed a flat eight-wire cable.

Cable 1 was first placed in position and stressed, then cable 2 placed over it and stressed in its turn. Small clips of 18 gauge strip spaced at approximately ten feet centres were used for binding the cable.

For supporting the cables in position on the tank walls prior to stressing, hangers were made up from 20 gauge strip. These were hung from rawlbolts set into the top of the wall, and were notched at the correct pitch to carry the cables. Cable 1 was placed in the notch, and cable 2 was then later hung from its top pair of wires, which were placed in the notch above cable 1.

Single point stressing was used for the majority of the cables, and consisted, in effect, of pulling the two ends of the same cable apart. The extension obtained on a cable 160 ft. long was about $5\frac{7}{8}$ in., dependent on the friction between the cable and the surface of the tank wall. It was found that if members of the stressing gang moved along the cable, whilst the tension was being applied, tapping it with club hammers, the extension was noticeably increased, and this procedure was, in fact, adopted as a routine drill. A small pneumatic

vibrator clamped on to the wires was tried out in an effort to overcome this problem of frictional resistance, but was not successful owing to its lightness.

Two-point stressing was used on the ring beam, and near the base of the walls, where it was necessary to ensure a more even distribution of the prestressing force. In this method, two jacks were used, both working at diametrically opposed points of the tank, on the same cable which only passed half-way round the perimeter of the tank.

In order to achieve the most satisfactory conditions of tensioning, the aim was to obtain similar extensions at each jack, and this necessitated careful work on the part of the stressing gangs to ensure that the load was taken up equally on the two jacks. Since the jacks were diametrically opposite each other, field telephones were provided for intercommunication between the two gangs, and were found to be most effective.

The technique of tapping the wires during stressing was also employed, but was less necessary, owing to the shorter length of cable being tensioned. The average extension obtained on a pair of cables, together 160 ft. long was about $7\frac{3}{4}$ in.

Stressing points on successive cables were staggered in plan, to assist in obtaining an even distribution of stress round the perimeter of the tank and in order to avoid too sudden a loading. All of the type 1 four-wire cables were fixed and stressed before the type 2 cables were fixed, with the exception of the ring beam, on which both cables were stressed first of all to take up the thrust of the roof joists.

A special jack carrying two strongbacks was used. One strongback was fixed to the jack frame, and the other, mounted on the ram of a hydraulic cylinder, moved away from the former as the load was applied by means of a normal hydraulic pump. The jack was hung by chain blocks from scaffold cross trees fixed close to the tank wall, so that it could be easily raised or lowered.

(d) Quantities

The quantities of steel used in each tank were as follows :—

Mild steel reinforcement

10.1 tons (excluding tank roof)

High tensile steel wire

Base cables	3.05 tons
Vertical wall cables	3.65 tons
Horizontal wall cables	6.55 tons
Total H.T. Steel per tank ...	13.25 tons

Grouting

In order to provide permanent protection for the stressing cables, the vertical and horizontal cable ducts were grouted up as soon as possible after stressing.

The grout used was made up from equal parts of cement and sand, with sufficient water to give a w/c ratio of 0.45. It was mixed in a Colcrete grouting pan, which gave a very smooth and consistent colloidal grout.

The grout for the floor cables was led in through the sloping hole at one end of the cable duct, using the corresponding hole at the other end as an air escape. The apertures round the sandwich plates were first buttered up with mortar to prevent an excessive loss of grout.

The cable ducts in the lower of the three layers in the base were grouted first, then the central layer, and finally the top layer. This was to ensure that, if one of the shims separating the ducts had become misplaced, there would be less likelihood of a grout leakage from one duct to another causing a permanent blockage.

It was found that the Colcrete mixer itself delivered the grout under sufficient pressure to force it through each floor duct in one continuous operation.

The grouting of the vertical wall cables was carried out from the sloping grout hole formed at the base of the cable. In this case, it was found necessary to lift the Colcrete mixer up on to the scaffold, with a longer delivery hose leading down to the base of the wall. In order to ensure that the grout did not run out again when the delivery nozzle was withdrawn from the grouting hole, the following device was adopted :—

An 18-in. length of rubber hose was wired securely at one end on to a 12-in. length of 1-in. water barrel. The other end of the water barrel was then thrust into the sloping grout hole and packed in position with mortar. About two dozen of these were fixed in position before grouting was commenced. The nozzle on the delivery hose of the Colcrete mixer was inserted into the free end of the rubber hose, and fixed with a Jubilee clip, and the delivery valve was opened until grout appeared out of the top of the cable duct. The delivery valve was then closed, and the rubber hose bent double and wired in that position. This effectively cut off the flow of the grout, and the nozzle of the mixer could then be withdrawn and passed on to the next cable duct. After about an hour, the grout had hardened sufficiently for the lengths of barrel and hose to be withdrawn, and the grout remaining in these was easily dislodged by rodding and tapping.

The grouting was an arduous and dirty task, and it was necessary to equip the grouting gang completely with oilskin suits, sou'westers,

boots and goggles. There is no doubt, however, that they considered themselves amply rewarded when, on one occasion, the delivery hose burst, and the general foreman was covered from head to foot in a rich creamy grout.

Final protection to the sandwich plates anchoring the floor and vertical wall cables was effected by encasing them in concrete. A coping was cast on the top of the tank wall, to cover the vertical sandwich plates, and a casing 8 in. thick was cast round the tank base to cover the horizontal plates. (Figs. 4 and 5.)

Gunite

The horizontal prestressing wires and sandwich plates were protected by coating the whole of the outside surface of the tank with a 1½ in. layer of Gunite. This was applied whilst the tank was full of water, in order to ensure that no cracking of the coat occurred on subsequent filling.

4 × 4 in. × 10 gauge B.R.C. fabric was placed all round the outside of the tank wall, and fixed with tie wires to the horizontal prestressing cables. The Gunite, which consisted of 1 : 3 mortar of cement and sharp sand, was then applied in two coats.

Filling and Testing

After all stressing had been completed, the tanks were filled and tested. The initial filling was carried out in stages in order to distribute gradually the strains in the concrete and prestressing wires. Water was pumped in to a height of 12 ft., at a rate of 1 ft. per hour, and the tank was allowed to stand for six hours. The level was then raised a further 12 ft., at the same rate of filling, and allowed to stand for another six hours, after which filling was completed to the final working level of 33 ft.

Throughout the eight tanks, no serious leaks occurred, but it was found that on the first five tanks, each of which had been constructed with the vertical contraction gaps in the walls, damp patches occurred up the joints between these gaps and the wall proper. The damp patches varied in degree from some which were only visible under dry weather conditions to some in which a small seepage of moisture was actually noticeable on the outside of the wall.

A few similar damp patches also occurred on some of the horizontal construction joints between lifts on the first two tanks.

In all cases where there was any evidence of dampness or moisture on the outside face of the wall, the tank was drained, and a patch put over the corresponding area of inside face. This was done by hacking the area to a depth of about one inch, to leave a thoroughly clean and well-roughened surface, and then applying a three-coat rendering of Sika, and it was found on retesting to be effective in every case.

The last three tanks, in which each lift had been constructed as a full circle with no gaps, required no remedial work whatever—i.e., the 9 in. concrete walls were completely impervious to water under a head of 33 ft.

Roof Construction

The Ministry specified that the roof should be a dome with a minimum thickness of 5 in., designed for a superimposed load of 30 lb./sq. ft.

The roofs could have been constructed in the orthodox manner with timber shuttering. This would have delayed the roof construction by several weeks as scaffolding and shuttering to the roof of each tank could not have been commenced until after the tanks had been tested. Furthermore, a considerable amount of timber would have been required owing to the limited time allowed for erection and the waste which is inevitable in circular cutting of timbers to shutter such curved surfaces.

As a precast concrete manufacturing yard was available, it was decided to form the roof with light precast concrete channel units supported on sixteen 6 × 4½ in. R.S.Js. curved to the shape of the dome and meeting at a central crown ring like the ribs of an umbrella. In this way it was possible to eliminate complicated and expensive shuttering and to cast and mature the roof units during the construction of the walls.

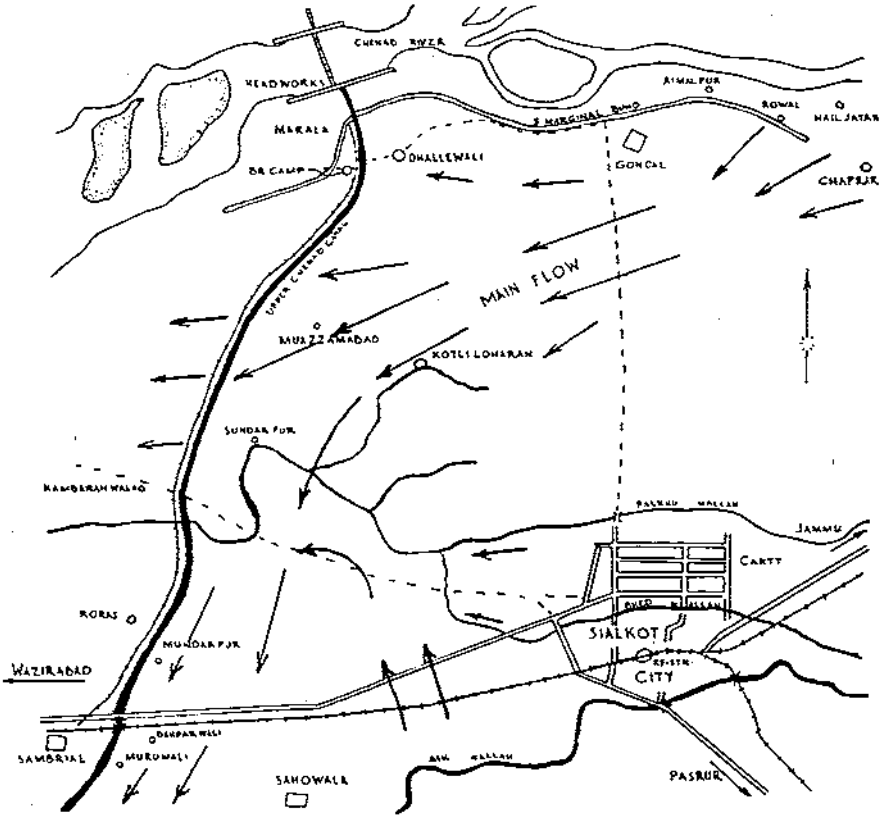
Whilst erecting the steel roof joists, the crown ring was carried on a central scaffold tower ; the joists were not fitted into position until the vertical stressing of the tank wall and the circumferential stressing of the cables on the ring beam had been completed, and not until all circumferential stressing had been completed was the central scaffold tower removed, and the thrust from the roof joists transferred to the walls.

In conclusion we would like to express our appreciation of the help, assistance and guidance, both during the construction of these tanks and during the preparation of the paper, which we received from the undermentioned :—

Sir Charles J. Mole, M.V.O., O.B.E., F.R.I.B.A., Director General of the Ministry of Works ; E. H. Bate, Esq., M.B.E., M.C., A.M.I.C.E., Chief Site Control Engineer of the Ministry of Works, and the following members of Messrs. Stressed Concrete Design Limited ; J. Singleton Green, Esq., M.Sc., A.M.I.C.E., A.M.I.Mech.E., M.I.Struct.E.; J. W. Ager, Esq., B.E., A.M.I.C.E., Assoc.M.A.S.C.E. ; R. F. T. Kingsbury, Esq.

PUNJAB FLOOD—SEPTEMBER, 1950

By Captain J. S. R. Shave, M.C., R.E.



SIALKOT DISTT: SEPT 1950

Introduction

THE following is an account of the activities of the Pakistan S.M.E. during the floods in Sialkot district during late September, 1950. Viewed in retrospect the events of those days have lost much of the aura of fear and disaster under which they took place, this account, therefore, must enlist the aid of the imagination in order that the tense atmosphere of the time may be assimilated.

During August and early September, extensive flooding occurred in the district and its subsidence apparently lulled the inhabitants into the belief that flooding was over for the year 1950. The three-

day downpour which started on the 17th September and the subsequent disastrous flood, therefore, came as a surprise, and found the villagers quite unprepared for such an emergency.

Situation in Sialkot

The downpour continued steadily and soon all outlying parts of the cantonment experienced ever increasing floods. Palkhu nallah to the north and Aik nallah to the south continued to encroach rapidly. Bhed nallah, normally a tiny stream dividing the cantonment from the city, became a rushing torrent, in places several hundred yards wide. The major damage to cantonment property was not the result of flood, however, but was due to the unceasing downpour which soon penetrated all buildings in need of repair and caused them to collapse. On all sides people began hurriedly to move out of flooded or collapsing accommodation into whatever buildings were available—recreation rooms, churches, the hotel—every dry roof was soon sheltering refugees.

News of the situation in outlying districts was very hard to come by, the few refugees who braved the flood to reach the cantonment described a watery scene of desolation in which the few survivors were clinging to trees and the roofs of buildings which were in danger of collapse.

Events of the 19th September

The first definite news of conditions in the district was brought in by Major A. W. T. Lucas, M.B.E., R.E. (S.I. Bridging), who had set forth to attempt to reach the Upper Chenab Canal (U.C.C.) at the point where it is crossed by the Sialkot–Wazirabad road near Sambrial. At this time an all arms watermanship course (RAW/1) was due to move to Marala for training at the bridging camp there and it was thought that the only route left to them lay from the Sambrial road bridge, north along the canal bank. Major Lucas reached the bridge in a DUKW, but did not ferry the course personnel to it because he saw the flood waters were already overtopping the canal bank which normally stood 8 ft. above the level of the surrounding country. At 1700 hrs. Major Lucas reported to C.I.F.E. (Lieut.-Colonel T. R. Dalton, R.E.) at Sialkot with the information that villages near the main road were submerged and collapsing and survivors were in a sorry plight.

Lieut.-Colonel H. L. Lloyd, O.B.E., M.C., R.E. (O.C. S.M.E.), and Lieut.-Colonel Dalton visited Sialkot Station H.Q. to exchange information and were told that the Chenab River had overflowed and breached a large bund set along its south bank. Accurate information was not to be had and there was no news of the true situation at Marala camp, or of the headworks of the U.C.C. at Marala.

These reports convinced O.C., S.M.E. that unless quick action was taken the extensive damage to property would be overshadowed by a large death roll due to drowning, starvation, and exposure. He decided to call an " O " group at the S.M.E. at 2000 hrs. to issue orders for action at dawn on the 20th.

Plan for 20th September

The aim of operations on the first day was twofold, firstly to undertake all relief work and reconnaissance possible, using the equipment in Sialkot, and secondly to try to reach Marala to clarify the situation and to use equipment from there to carry out more extensive relief work. Floating equipment available consisted of :—

1 DUKW.
1 Folding boat with 22 h.p. outboard motor.
2 Assault boats Mk. III with 9.8 h.p. outboard motors.
1 Assault boat Mk. II with 9.8 h.p. outboard motor.

Personnel available for work included F.E. Wing staff not engaged on instructional duty and the " All Arms " watermanship course just assembled.

Having received their orders at the " O " group, Captain Hussain (Q.M., S.M.E.) and Subahdar Mir Hussain (Wing Subahdar F.E. Wing) spent the night with F.E. Platoon preparing and loading stores and equipment for the operation.

Events of 20th September

At 0500 hrs. a convoy consisting of the DUKW, 6-ton and 3-ton lorries moved off from S.M.E. On the Wazirabad road the convoy was strengthened by a group from the Punjab Regiment, under command of Captain Abdul Matin, and a wireless truck. Rain continued to fall steadily and despite the time of year the atmosphere was bitterly cold, all felt strongly for the thousands of villagers who had spent yet another dreary wet night shivering with cold and fear in the trees and on housetops.

Very soon the DUKW leading the convoy was splashing through water which was moving northwards from Aik nallah to Palkhu nallah, several trees which had collapsed across the road were hacked and sawn through. Finally a dry spot was reached some three miles from the U.C.C. and from this spot, across a vast expanse of water, could be seen the line of trees which marked the position of the canal.

A base was established here to which inhabitants from the surrounding villages could be brought, the base was staffed by the party from the Punjab Regiment. The folding boat (Lieut.-Colonel Dalton) and two Mk. III Assault boats (Subahdars Mir Hussain and Lal Khan) were launched and began to make a reconnaissance to

north and south to locate groups of stranded villagers. Having reported on conditions to the south the folding boat joined the assault boats to the north, moving from hamlet to hamlet in which villagers could be seen waving for help. These villagers were gradually brought in to the base, where they were fed. The DUKW (Lieut.-Colonel Lloyd) moved off along the submerged road, with the intention of leaving it once deep water was encountered, to evacuate villages to the south.

The countryside in this area is very flat and falls gently from north to south, the larger villages are sited round small knolls, while the small ones are on level ground. A broad swiftly-moving expanse of water some 3 miles wide and up to 6 feet deep covered the whole area. The bulk of the water came from the direction of the Chenab River and had been joined by the flow from the Aik and Palkhu nallahs. The water was navigable, but everywhere there was the danger of submerged obstacles which would rip the bottom out of the flimsy boats. During the night 19th/20th the water had fallen slightly and great breaches in the canal bund were now visible. The current in the vicinity of these breaches was very fierce and quite unnavigable, any boat caught in it would have been swept into the canal to be dashed against one of the bridges.

The DUKW made a very slow start on rescue, since it stuck for two hours where it tried to leave the road. O.C., S.M.E. left it there and, after wading back to the base he sent down a 6-ton lorry which pulled the DUKW back on to the road. After a second attempt this amphibian reached deep water and moved off south-west towards Dahparwali and Muruwali. O.C., S.M.E. did not go with it, he joined C.I.F.E's. boat and set off on a reconnaissance to the north. The DUKW reached Dahparwali, where some 200 villagers were waiting to be taken off, this task was left to the assault boats, which by now had moved into this area. The DUKW moved on to Muruwali, which lay close to the canal near a wide breach in the bund, the water here was swift and covered a number of low lying houses on which the craft grounded several times. The central mound of the village was a mass of half-fallen houses, amongst which several hundred people were huddled with bundles of belongings and a few cows and buffaloes. As the DUKW neared shore a concerted rush was made for it by the frantic people. Twelve trips were made to the canal bund from which the people could go on foot to Sambrial to find food.

The condition of Muruwali was typical of that of thousands of villages in the Punjab at the time, many people had lost all their possessions, their homes washed away and their cattle drowned, they had absolutely nothing to help them make a fresh start. Fortunately the loss of life everywhere was found to be much less than

expected. To the relief of all, the rain stopped at midday and the glowering clouds began to break up, the flood also was noticed to be falling appreciably and it was realized that unless the DUKW moved quickly it would not be able to reach the main road again. All women and children were taken off from Muruwali, and several loads of men before the DUKW had to turn away and make northwards. Even so it was too late, the water had fallen a foot during the day and this ungainly craft stuck fast on the railway line which lay to the south of the road. After frantic efforts the DUKW was refloated and was then filled up with people from Dahparwali before turning east to make towards the base. Finally it had to be abandoned in shallow water a mile from the base, it was recovered later after the fields had dried out.

During the afternoon the folding boat with its powerful outboard motor was taken 5 miles north of the main road to the area east of Kambaranwala. *En route* two men were picked up from a raft, improvised from a table top and empty drums, they almost refused to stay aboard when they found that their raft was to be abandoned. The folding boat rescued about one hundred people from this area, ferrying most of them to the canal bank. It was decided that no attempt to reach Marala was feasible whilst so much work remained to be done near the main road. One difficult operation successfully accomplished was the rescuing of a group from the roof of an old Hindu temple in the middle of a grove of trees which gave little room for navigation. The folding boat dropped swiftly down the flood on its return journey to arrive back at the base by 1700 hrs., it then helped to evacuate passengers from the DUKW. All personnel had reached the base at 1830 hrs. and as darkness fell it was decided to cease operations for the day and make another early start on the 21st.

Refugees had been taken to Sialkot in S.M.E. transport during the afternoon and the Deputy Commissioner had also organized a train which was now waiting to take more refugees. O.C., S.M.E. travelled back in the train with the D.C., making plans for the next day's work. A guard was left with the equipment with instructions to move it towards the canal as the flood receded, in order that it would remain afloat until we returned next day.

The journey back to Sialkot was accomplished slowly owing to the existence of several breaches in the road, originating as drainage channels hacked across the road by thoughtless local inhabitants, these breaches were now rivers 10 ft. wide and 2 ft. deep. Lieut.-Colonel Kenworthy, R.E., and Major Lucas were encountered *en route* and informed us of the diversions round these breaches, they had come out with road repair parties.

O.C., S.M.E. issued orders at the S.M.E. upon arrival at 2130 hrs.,

all then dispersed to prepare for the next day and to snatch a little sleep before the early start. More than one officer had then to search for his family before he could settle down for the night, since during the day many more buildings had collapsed and roofs previously sound had leaked badly, causing further evacuation.

With the exception of the loss of the DUKW the operations of the 20th had been extremely successful in that valuable experience had been gained and several hundred people had been assisted to safety.

Plan for 21st September

To establish a base at the Sambrial crossing over the U.C.C. and from it to carry on rescue work in the area and to commence the distribution of food. Representatives of the D.C. were to be taken to Sambrial and Kambaranwala to organize the distribution of the food which we should transport to those places from the base at Sambrial. An attempt would be made to get up to Marala, taking a wireless set which would provide a link with Sialkot. Definite information was required of the extent of damage to the canal, headworks, marginal bunds, and railway, news of the R.P.E. contingent at Marala camp was also desired. Information was required of conditions in the whole area north of Kotli Loharan and to north and east of Gondal. If possible, centres for distribution of food were to be established at Gondal and other centres to the north.

To carry out operations on the 21st there was no more equipment than that used on the 20th, but some fresh personnel were available as crews, they were an "All Arms" fieldworks course (JAF/9) which was at the S.M.E. at the time. C.I.F.E. was to command operations from Sambrial and Marala, the same officers and J.C.Os. would go out, but O.C., S.M.E. would remain behind to organize maintenance from Sialkot.

Events of 21st September

The convoy again left S.M.E. at 0500 hrs. and moved to an R.V. at which a vehicle carrying two wireless sets was due to be met; it was not there, so C.I.F.E. pressed on whilst a search was made for the sets. Having arrived at the equipment left on the 20th he gave instructions for it all to be moved towards the canal. He then set off in a 3-ton lorry down the road, with two guides wading ahead to locate the verges for the truck driver. The lorry contained the D.C's. representative and food for Sambrial.

The flood had again fallen considerably during the night and this truck was able to get through to Sambrial. Having dropped off the D.C's. representative with his sacks of atta, the truck returned to the canal bridge and a reconnaissance was made to determine how the floating equipment could be put into the canal. By the time the

equipment had arrived, a plan was ready and the boats were warped through a breach in the bund downstream of the crossing.

The D.C's. representative for Kambaranwala with his sacks of food was placed in the folding boat, and with C.I.F.E. operating the motor it set off up the canal to drop the food and party and return to Sambrial.

Subahdar Mir Hussain set out in his boat to make a reconnaissance to Bhopalwala, a large village 5 miles to the south which had been in the path of the main flow and from which there was no news.

A camp was set up at the Sambrial crossing and a good wireless link with Sialkot established. This base was run by Lieutenant Farooki, R.P.E., and Jemadar Shabir Hussain, who did much useful work, kept food prepared for boat crews, acted as a clearing house for information, and maintained a record of food distributed.

The canal is about 350 ft. wide and at the time contained about 10 ft. of thick brown water. Beneath the arches of the numerous brick bridges there was just sufficient clearance for our boats to pass. A folding boat powered by a 22 h.p. Johnson outboard could make fair headway, but an assault boat with its 9.8 h.p. motor only made slight progress upstream.

By 1100 hrs. C.I.F.E. had returned from Kambaranwala, which lies 6 miles up the canal on the west bank. Half an hour later the boat was again heading north, this time it carried a full complement, the five members of this crew made up in enthusiasm what they lacked in skill. The boat also carried lifebelts, kit, tools, spares, fuel and food, and a wireless set with two operators.

At midday on this day the centre of gravity of S.M.E. operations moved northwards up the canal. Marala became the advanced base from 1800 hrs. and a system of boat ferries later linked it with the Sambrial crossing.

The first trip up the canal was not devoid of incident, in fact it proved to be quite exhilarating. The water was sufficiently dangerous to temper our spirits, but we felt excited to be on the way to Marala at last. Above Kambaranwala the canal bunds were breached almost continuously for over 1,000 yards, water was pouring in through breaches in the east bund and out again through the west bund. Where these racing cross currents were encountered there were great whirlpools, and one could feel the bottom of the boat grating over trees which had been washed out of the bund into the canal. The water rose appreciably at each of the spots where the main flow down the canal was retarded by the cross current, above each breach was a small area of comparatively slack water.

Above one breach the boat was steered into the bank to refill the petrol tank before the next bad spot was encountered. As it came into the side one of the untrained crew stuck a boathook into the bank

and tried to arrest our progress instead of waiting until we had lost way. The boathook snapped off and he was thrown back into the boat where he struck the sharp edges of spare wireless batteries and jerricans, he sustained a nasty bruise in his back and was in considerable pain for the rest of the voyage.

The stretch of bank at which we had pulled in was now an island, and C.I.F.E. climbed up to the road level on top of it while we were refilling the tank. Suddenly he spied a wild boar which had been marooned on this piece of dry land, and called us up to have a look at it. Just as our faces drew level with the top of the bund the animal charged. The sight of those wicked tusks backed by fifteen stone of fighting pig was too much for our morale and we " advanced to the rear " with all speed. Apart from bruises which resulted from diving off the bund on to the gunwale of the boat, the only casualty was the breastline man, who was brushed aside by the pig and fell into the water, he received a slight gash in his thigh.

After this episode we were glad to start up and cast off again, the water grew calmer as we passed higher up because the breaches were fewer and smaller. Soon it was noticed that the level of the water was falling appreciably and we concluded that the main inlet to the canal at Marala was closed, all the water in the canal at the moment had come in through the breaches.

Throughout the work on the flood waters all concerned saw snakes swimming along in the current, they had been flooded out of their holes and were searching for dry land. In the enclosed waters of the canal snakes were to be seen every few yards, most of them were the small vipers and krites common in this area. At first the crew struck at them with oars until we realized that backsplash could easily carry a tiny, vicious enraged krite into the boat, a hurried order was given to let swimming snakes swim !

A careful record of all breaches in the bund was made as we progressed northwards, after we had recorded twenty-eight breaches large and small, we noticed that the current had ceased to flow against us, we had passed into the back water from the last breach and it would now be only a matter of time before our boat grounded. Soon we were forced to take soundings to find a channel deep enough to operate the motor. After feeling our way for some hundreds of yards we landed to set up the radio for the report we were to give at 1500 hrs. We were now about 4 miles from Marala, and as there were some locals on the bank here, C.I.F.E. borrowed a bicycle and set off along the canal road towards the camp. From the camp a 15-cwt. truck was sent down to pick us up and after trying vainly to contact Sialkot we moved off to reach Marala at 1800 hrs. The boat was left under guard and marked the limit of navigable water for a return journey.

The Situation at Marala

Our arrival at Marala was received with great enthusiasm by the considerable force of R.P.E. which had been marooned up there. The camp contained the staff and students on a number of courses. Subahdar Lal Shah in charge of the camp had not remained idle during the emergency, on the 19th and 20th he had organized a number of assault boats and Class 2 rafts to evacuate Dhallewali and several small villages to the east of the canal. The inhabitants of those villages were now living on the bunds and were in urgent need of food. Courses which could not be usefully employed on rescue work had been ordered to continue training. For this work and subsequent relief work Subahdar Lal Shah, Jemadar Abdul Ghani and all ranks at Marala deserve high commendation.

After a meal Lieut.-Colonel Dalton issued orders for the preparation of equipment for the following day and then interviewed the executive engineer (XEN) of the Marala division of the U.C.C. in order to obtain the information required at Sialkot. The gist of the information supplied by the engineer (Mr. Ahmad Tarique), was as follows :—The headworks were intact and also the south marginal bund up to Rowal where breaches existed. The worst flooding was not being caused by the Chenab itself but by one of its tributaries, the Jammu Tavi, which joins the Chenab about 8 miles above Marala where there was no bund to retain the water. Although the bund had given way in the area of Rowal this had little effect on the flooding to the north of Sialkot, it merely saved the rest of the bund. The situation report which we tried to pass over the wireless that evening gave the picture in a nutshell, it included details of the 600 people who had been rescued in the area in addition to the following :—

"SITREP to 1800 hrs from XEN and RPE camp. All tps and eqpt unharmed. Headworks untouched. Villages evac by RPE as follows (6 villages). 14 days rations in camp for RPE only. Main bund sound east from headworks to area Rowal 7739. Breach starts 762398. Four big gaps in bund in this area. Chenab running in own channel and back to medium flood 150,000 cusecs—falling. Villagers from Gondal area living on bund. Kotli Loharan cut off but self supporting at present. Village Chaprar 7938 said to be surrounded by deep water and best relieved from Sialkot. Damage being done by Jammu Tavi pouring past bund beyond Rowal. 23 FC (Frontier Constabulary) per evac from Gondal to headworks. Food required for 1000 Marala. Good DZ est SME camp 636387. Food 66 required Gondal and 300 Aimalpur. DZ along bund. May canal authy be info by DC early what arrangements essential so that collection and distn from ZEN house may be org."

Plan for the 22nd

Although the wireless operators had tried continuously to get through to Sialkot since our arrival, they could not pass our sitrep owing to the constant passage of routine messages from the numerous outstations nearer control. Accordingly one task for the 22nd was to make ground contact with Sialkot to make a report and to arrange details for ferrying food up the canal. It was known that aircraft were out dropping supplies, so we arranged the marking of a dropping zone (D.Z.) on the 21st and we hoped that arrangements could be made to drop food direct to the R.P.E. camp for distribution. One folding boat was detailed to establish contact with Sialkot, another was detailed to commence the food ferrying up the canal from Sambrial.

Reconnaissance and relief to the north and west of Kotli Loharan was to be undertaken by several cutters, assault boats, and Class 2 rafts from a base to be established at the point on the canal to which boats from Sambrial could reach. Villages to the east of Kambaranwala were also to be relieved.

The canal authority's railway was intact for some 5 miles down the west side of the canal, and the XEN kindly offered to place a train at our disposal for the move of the floating equipment from the camp to the area of operations. This offer was accepted with alacrity and much use was made of the railway during the next few days.

Since the flood was falling we realized that the canal would soon empty, but temporarily we were able to use it as a waterway for 9 miles north of Sambrial, there we could transfer to a 15-cwt. truck waiting at the H.Q. on the bank or send heavy goods up on the train which ran once a day from this spot.

Events of 22nd September

An early start was marred by some irritating delays, one of which was caused by the driver of a 15-cwt. truck who suddenly swerved off the canal road for no apparent reason. His truck was saved from a 10-ft. drop into the canal by the soft bank which arrested its progress and held it at a perilous angle. The N.C.Os'. course, who were passing by in the train a few minutes later, salvaged the truck by expert placing of tackles.

Along the canal the folding boat left on the 21st was found to be half a mile lower down than before, the water had again fallen during the night. Two folding boats were soon ready to move off from this spot and taking some sick men aboard they got under way for Sambrial. The train reached this spot and equipment was carried across a nearby bridge to the east bank, where Lieut.-Colonel Dalton set up his H.Q. for rescue work.

Three cutters manned by recruits left for Kambaranwala to distribute food from the D.C's. representative there to the villages cut off in the area. Two rafts left for the villages to the east of the canal opposite Kambaranwala to evacuate the inhabitants to the canal bank. Four assault boats were sent to the east and north-east on reconnaissance for stranded villagers who might still be existing in what was clearly the main path of the flood.

After the departure of this flotilla of small craft C.I.F.E. set off in a 15-cwt. to gain further detail of the situation in the areas along the south marginal bund. He took with him enough men to drop off pairs near the main villages of Gondal and Aimalpur, to visit them and report on conditions there after contacting the local police and village Lambardars. The truck reached the first breach in the neighbourhood of Rowal and further reconnaissance parties set off on foot from this point. The villagers of Rowal were instructed in the mysteries of marking out a D.Z. because their area was in urgent need of food supplies.

A general condition affecting all flooded areas was the complete lack of clean drinking water. All areas depended on surface wells for their water supply, these had been filled with flood water and most of the well head gear had collapsed. This condition did not add to the general depression however, all seemed quite content to drink the brown flood water. Arrangements were made to send up water purification chemicals with the food supplies from Sialkot but we saw none used. There was no outbreak of disease after the flood so one may conclude that the populace as a whole were very healthy.

On the return journey from Rowal area C.I.F.E. arranged for a D.Z. to be marked out on the bund near Aimalpur and another near Gondal, despite the clear marking of all D.Zs. and their equally clear reporting, no food was ever dropped. A Bristol freighter aircraft did make some runs over the D.Z. at the R.P.E. camp one evening but nothing was dropped. We hoped that the reason we received no supplies from the air was that they were all being dropped in areas which were receiving no other assistance.

In some areas one received the impression that the people expected everything to be done for them and were willing to do very little to help themselves. At Gondal the biggest village of the area, in which there were many solid houses still standing, the inhabitants congregated on the bund and expected to be fed. The main reason for their want of food was that the mill which ground the corn was out of action. Inquiry revealed that small spares only were required, but no one was willing to face the journey to Sialkot to fetch them. The mill owner was sent off under police escort to Sialkot to fetch the necessary spares, and the Lambardar was instructed to bale out the mill and have it working by the following day.

The area north of the bund contained several small villages which had disappeared completely. Used to periodic small floods the villagers had moved to the bund with their cattle and belongings, so there had been little loss of life. Some of these people were remarkably active and began to rebuild the mud walls of their homes as fast as the waters receded.

The passage of the folding boats down the canal was swift and uneventful, it was still not possible to see the trees in the canal at Kambaranwala, but the water was calmer than previously. Only two folding boats were available because the best of the folding boat equipment had been sent off to Lahore earlier in the month to be used in gaps created by the first floods of the season.

Sambrial was reached by 1100 hrs. and a truck waiting at the H.Q. there was used to complete the journey to Sialkot. At the S.M.E. the office of Major W. J. Mason, R.E. (S.O. II (G)) resembled a battle H.Q., a wireless set on the local formation net was working in a corner and the latest flood news was available. Always hard worked, the additional burden thrown on this office by the flood can be gauged by the fact that a file started for flood messages and correspondence quickly grew to a hundred pages.

A report was made to the O.C., S.M.E., who at once took it along to a conference at Sialkot H.Q. where we hoped some air dropping could be arranged. It was also hoped that the information brought from Marala would assist the irrigation authorities to plan for the rapid reconstruction of the canal system, the appalling damage to which threatened the total loss of the next harvest. All were relieved to hear the details of the situation along the Chenab and arrangements were quickly made with the D.C. for further food supply. A representative of the D.C. was also found and taken to Gondal to organize food distribution in the bund area. This representative was taken back to Sambrial bridge, the two boats, loaded with sacks of atta and corn, then set off at 1500 hrs. for the return to Marala. Opposite Roras two assault boats commanded by Lieutenant Farooqi and Subahdar Lal Khan were passed, which had been delivering sacks of food to the Kambaranwala distribution centre.

On the return journey to Marala the photographs of the canal shown here were taken, the water had fallen still more during the day and the level in the canal was now a foot below the level in the surrounding country. Trees previously buried under water were visible and the damage to the canal and outlying villages was beginning to stand out naked and hideous. In many places the bloated carcases of cows, sheep and buffaloes were being left stranded high and dry at the mercy of the blazing sun, portending a feast which the kites and vultures would remember for the rest of their days.

After rowing for the last half-mile we found C.I.F.E. at the bank

H.Q. receiving reports from the returning boats and rafts. The story was the same from all sides, villages reduced to heaps of mud and many hundreds of small holders rendered destitute. Not only were these people without food and clothing, but many had no longer a plough or a bullock to draw it for the autumn sowing. The day of hot sunshine had put warmth and heart into the villagers and they were willing to start again provided that a little help could be given. Several parties brought in samples of the only food left over a wide agricultural area, this was grain which according to custom had been buried under floors and courtyards for storage. The prolonged wet conditions had caused this grain to sprout and grow together into a solid mass. The grain was being dug out, dried, and ground in primitive stone mortars to make flour, but many people had not even this poor fare.

When all boats had returned, orders were issued for certain equipment to remain at this spot under guard until early next day when some food distribution could take place in the area. The remainder of the equipment was carried back to the waiting train which set off slowly for the camp. The representative of the D.C. was sent off to Gondal in a 15-cwt., which also carried several sacks of grain and salt. The order was given for an "O" group to assemble in camp, after a meal, at 2100 hrs.

Plan for 23rd September

Distribution of food was to commence in the area east of the bank H.Q. and a relief was also to be extended to the area north of the bund. There the village of Hail Jatan, some 2 miles north-east of Rowal, had not yet been contacted and was believed to be in a bad way. An attempt was also to be made to reach Chaprar from the Rowal area.

Events of 23rd September

The train carrying boat and raft parties set off early for the bank H.Q., from which food distribution and further reconnaissance proceeded smoothly throughout the day. A 15-cwt. carrying a Mk. III assault boat with crew and sacks of food, another with the recce. party for Chaprar set off along the main bund at 0700 hrs. Both trucks reached the limit of the road at the Rowal breach by 0800 hrs. The Chaprar party set off on foot and the remainder set off for Hail Jatan. The boat was first carried some 400 yards across mud to a point at which the water was still deep enough to launch it. After half a mile of smooth paddling the water again gave out and leaving the boat the party set off through the 6-ft. high grass, carrying the sacks between them. Fortunately a villager from Hail Jatan was encountered at this juncture on his way to Rowal to contact the outside world, he acted as a guide and set off at a pace which the

laden sappers found hard to maintain. After another half-mile a large open expanse of water appeared and beyond it could be seen the few remaining houses of the village. The guide followed a foot-path through the water which proved to be only waist deep, but since the earth beneath was very soft the party had great difficulty in making progress. Had we not divided the loads into small bundles before leaving camp we could not have overcome this obstacle. At Hail Jatan lots of refugees from the northern area had gathered and they warmly appreciated the efforts to relieve them. After handing over the food to the Lambardar and retrieving the sacks from him (why is the army always short of containers?) we set off to wade along our return journey. We were rather apprehensive about snakes, but saw none, although leeches were plentiful.

We reached the truck at 1130 hrs. and then launched the boat on the large pool which had formed at the first breach in the bund. A stone tied to a lashing indicated a depth of 30 ft., this was common to most large breaches where the scour had left very deep pools. So deep were many of these pools that the new bunds were later reconstructed round them in loops instead of along the original straight alignment.

The Hail Jatan party moved back to camp leaving the other 15-cwt. to await the return of the Chaprar party. As parties returned to camp that day their reports indicated a general improvement of conditions all round. The Chaprar recce. party returned during late afternoon, and reported that it was possible to wade to Chaprar and that some food was required in that area. They met a similar party of infantry who had come out from Sialkot after wading up to their necks in places.

Plan for the 24th September

The Pioneer course and the N.C.O. course were due to return to Sialkot, and since the situation had now eased it was decided that the pioneers would move off to Sambrial on the 24th. The N.C.O. course would await orders from the R.P.E. Centre before moving off. Lieut.-Colonel Dalton decided to return to duty at the S.M.E. at the same time as the Pioneers, leaving an officer to close the S.M.E. camp. The recruit parties were to carry on with such training as they could in a foot of water in the canal. The N.C.O. course would occupy themselves by salvaging three cutters which were now high and dry on the canal bottom 3 miles from camp. Relief would be extended to the Chaprar area with the last few sacks of food held in the relief stock.

Events of 24th September

The train set out at 0700 hrs. carrying the Pioneer course down to the point from which it would have to start walking down the broken

canal bank to Sambrial. C.I.F.E. moved in a 15-cwt. truck as far as the bank H.Q. and was fortunately able to use a powered folding boat for the rest of the journey. This was the last trip made by boat in the rapidly emptying canal.

The N.C.O. course faced with confidence the arduous task of salvaging the cutters. These large boats lay 12 ft. below the level of the surrounding countryside and had to be taken out and placed aboard the train in order to be returned to the camp stores, where they arrived safely late in the evening and were off loaded by recruits.

During the day the camp was visited by Major Hussain, C.I.W. of R.P.E. Centre, who had cycled along the Gondal track on a route reconnaissance, and returned via the canal bank to complete his circuit. At this time a journey along the canal bank was a most exhausting affair, every breach presented either a deep water obstacle or a wide muddy detour, around which a bicycle had to be carried. A man deserving of mention at this juncture is Sapper Khuda Bux, a driver who had acted as a messenger since his DUKW had been stranded on the first day of operations. On the 24th he accomplished the feat of making the journey between Sambrial and Marala twice each way. On his second trip he arrived at the camp in Marala at 0300 hrs. on the morning of the 25th, his message from R.P.E. Centre ordered the N.C.O. course to remain at Marala until further notice, and demanded an immediate "Ack." Khuda Bux declined the offer of a relief and set of at once on his journey to Sambrial. In all he covered 52 miles of track that day, much of it extremely rough going.

Late in the afternoon, Asst. Comdt. Mohd. Arshad Khan, of the Frontier Police Force, arrived at the camp. He wished to reach some police outposts which had been cut off for a long period. Arshad carried a letter from Sialkot H.Q. asking that every assistance should be given to him to reach the villages of Gangwal, Popin and Jog, which all lie on islands in the Chenab some 5 miles above the headworks at Marala. His request was rather a tall order, but as we knew that the people in those villages would be in pretty sore straights, we determined to do our best to get to them. The only craft available were assault boats, because the folding boats had all sprung bad leaks. After some hard thinking it was decided that a Mk. III assault boat with an outboard would probably do the trip and had the advantage that it could be carried above the headworks to a suitable site for launching into the raging Chenab.

Plan for the 25th September

Orders were given for C.I.F. staff to sort out a good Mk. III assault boat from store and for the senior operator to overhaul the most serviceable 9.8 h.p. outboard motor. A crew of four recruits

and a naik, all good swimmers, were selected, and a local waterman was asked to go as a guide. The party was equipped with life jackets and ordered to carry water and rations. Two sacks of grain were obtained from the representative of the D.C. at Gondal. The party was ordered to take the boat up to the headworks by truck and be ready for launching at 0700 hrs. It was decided that after the conclusion of this trip there would be no more relief work undertaken, the commander of the S.M.E. camp could then return to Sialkot.

A Trip up the Chenab River, 25th September

At 0700 hrs. the canvas assault boat was launched some 400 yards upstream of the headworks. The river here was a slowly-moving expanse of water, a mile wide, which thundered ponderously down over the barrage past the headworks. A course was set north-west through the islands in order to reach the main channel, the waterman did what he could to select the best route, but even so we were continually scraping over sand banks newly formed in the flood.

By 0830 hrs. we were steering an easterly course up the main channel of the river. Still in flood, this main channel varied between 300 and 500 yards in width and in many places the water was a cauldron of turbulence and whirlpools which we avoided as best we could. On the inside of bends in the river the current was so fast that with the motor and six paddlers working hard we could make no headway. On these occasions the nose of the boat was put oblique to the current and we would move swiftly across the river to the area of shallow, calmer water on the outside of the bend, there we would soon be in trouble again on the sand banks.

A tributory called the Munawar Taw joins the Chenab from the north some 3 miles above Marala. The mouth of this river was found to have moved 300 yards and we were unable to get past the cross-current here and turned in to land. The boat was dragged through 500 yards of shifting quicksands, up the side of the Munawar Taw to a spot at which we could cross it to land on the wide sand bank which now separated us from the Chenab.

Arshad and the waterman had both travelled these waters on happier occasions and said that the mouth of the Munawar Taw was a favourite spot for fishermen. Here the great mahseer lie feeding where the warm water of the Manawar Taw joins the cold snow water of the Chenab, and fish of up to 90 lb. weight have been taken out of this deep.

Carrying the boat across the great sand bank between the east side of the Manawar Taw and the north bank of the Chenab we passed a half-picked skeleton. Looking forward some 2 miles to the north-east we could see the village of Gangwal, our destination,

Water flowing into the canal through a breach on the east side above Kambaranwala.

Water pouring out to inundate the countryside to the west of the canal.

Voyage to Marala. The Upper Chenab Canal—22nd September 1950.

Typical railway conditions, Sialkot District—29th September, 1950.

Punjab Flood, September 1950 1,2,3

Typical railway conditions, Sialkot District—29th September, 1950.

Typical road conditions, Sialkot District—29th September, 1950.

Punjab Flood, September 1950 4,5,6

across the far side of the river. We reached the village at 1130 hrs. to the intense excitement of the Frontier Police and inhabitants. Their island was now quite free of water, but during the worst of the flood they had spent thirty-six hours in the trees. We gave them the food and petrol for their battery charging set so that they could re-establish wireless communication with Sialkot, and after Arshad had received reports from nearby Popin and Jog, we set off back at 1215 hrs.

With the engine just ticking over we raced down the Chenab in fine style arriving at our starting out point at 1255 hrs. having covered, in an effortless forty minutes, the same distance we had earlier traversed in 4½ hours of labour.

Returning to Sialkot that afternoon under a hot sun the eyes and nose were greeted by the picture of the desolation created by this great catastrophe. At every breach in the canal dead cattle had been left by the retreating flood waters. As yet untouched by the vultures still busily picking the carrion lying in the open fields, these carcasses befouled the air for hundreds of feet around. Many people were on the move to visit relations from whom no word had been received since before the flood. The main road was in a sad state of repair and the railways were washed out in numerous places. Representatives of the D.C., Sialkot, could be seen distributing cooked food in the camps of refugees at the roadside. Arrival at the S.M.E. at 1700 hrs. concluded the last of our active operations on the flood waters.

After the flood it was apparent that a tremendous effort would be needed to get some water down the canal system to irrigate the winter crops. The army was called out to assist the irrigation department in the repair of bunds. Reconnaissance of the damage and estimates of work required were made by students from the S.M.E., and a large amount of work was quickly completed by plant from the R.P.E. Centre and from Army Engineers. Enough work was completed by the middle of November to enable the canal to be half filled, and the crops were saved.

Conclusion

This account has dealt with a portion only of the vast area of the Punjab which was devastated by the September floods. By reason of the proximity of the Sialkot District to the sources of the flooding (in the mountains of Jammu and Kashmir) conditions in the area described were as bad as those in any other district. Time has dimmed the outline of many memories of those days, but one which will never fade is of the behaviour of all ranks during the emergency. That courage and enthusiasm were never found wanting in the face of unknown dangers is evidence of the high morale of the corps of R.P.E. and of all arms who assisted them in flood relief.

ARE YOU PLANT MINDED?

By "THE DUFFER"

ONE of life's minor but genuine pleasures is to become conversant with some activity which has its own jargon. After the first ski-ing holiday the disappointingly short time spent abroad is slightly made up for by being able to talk about christianias, telemarks and stem-turns. There may even be some who get keen pleasure out of talking casually about tractors, 19R.Bs., Tournapulls and other such fascinating machines. The writer sympathizes with this tendency and has often indulged in it himself, but feels that it is wrong to make Plant a separate subject, a closed shop, a technique known only to the few. Plant, it is felt, is so important that it should be part of the engineer's professional equipment to know about using it—and by engineer is meant Second-Lieutenant Holdfast.

From any who read these words the writer is sure he will receive telepathic messages, some almost indignant, which he has often heard spoken and seen written—"I quite agree, Plant is most important," "Plant must be given the highest priority in training," "We must save manpower and use more machines," "Everyone should know how to use Plant." They are all in the same encouraging vein. They may come from the highest as well as the lower. Splendid. What difficulty can there be? All are agreed that Plant is most important.

But there is a good deal of lip-service in these sentiments. They do not always bear fruit in action. As a Corps we are not Plant minded, and the writer feels that this defect merits suggestions for improvement.

Tell a British sapper officer to do a job in the field; what will he ask you? "How many men will I have?" It may be an exaggeration to say that a similar order given to an American engineer officer will produce "What machines do I get?" but it is on the way to being the truth. Perhaps "When do I start?" would be more accurately the American attitude, but there is no doubt that they are more Plant minded—and quite naturally so, they are lucky enough to come from the home of plant as applied in a big way.

How many R.E. officers are alive to the fact that a Caterpillar D8, properly used, is the equivalent of about a thousand men? This sounds absurd; but it is not a bad approximation to put three men against each brake horsepower—that makes 339—and if there are three shifts a day you get about a thousand.

When someone rings up and says casually "I say old boy, I wonder whether you can let me have a bulldozer for a couple of

days?" he has obviously not been thinking on these lines. The responsibility for mis-employing several hundred men weighs much more heavily than any idle time spent by a machine.

It is no use to try and minimize the enormous potentiality of these machines by saying, "Oh well, they only have limited uses; you can't get them to type your letters or anything like that." This has been heard from an eminent sapper officer. Certainly they will not type, or shoot, or even be very effective on the parade ground. That is all the more reason for using them properly. Let the civil engineering contractor's attitude point the way. Idle machine time is abhorred. Sometimes the contractor is using plant on hire and idle time is paid for; but even when using his own plant he does not allow it to stand about doing nothing. He probably plans his contract so that his own plant is fully employed and any peak requirements met by hiring.

In military engineering the virtue in keeping plant at work is not at once obvious; why not husband the resources when they are not directly needed? What use deliberately to look for work? An oft-quoted fact will at once correct this insidious idea, and that is "In the field there are never enough sappers for the tasks that confront them" or words to that effect. Whole projects are shelved or cut down for lack of sappers to carry them out. Formation commanders are driven to accept meagre fighting assistance because so many sappers are filling potholes on the roads and airfields. More plant of all kinds would, if properly applied, cure the ill—but masses of plant, misused or neglected, would be a hindrance to the campaign.

How can we as a Corps make ourselves masters of the plant we have, and even worthy to receive more? The shortcoming will be examined under the headings of the Senior Officer, the Junior Officer, and the Other Rank, and a few suggestions will be offered.

The Senior Officer.—By this is meant generally any officer who has the power to order plant to work or to move it about. He needs a knowledge of its capabilities and failings, and of how much care and attention it needs. He must actually prefer using plant to using men and keep this constantly in mind. He must be able to resist anyone who comes begging the loan of a "Bulldozer, old boy"—except on those rare occasions when the prospective borrower actually has a job suited to plant and which will fit in with the general scheme of things. If he is a more senior officer who deals in plant by the acre rather than numerically then his capacity to hinder or help a campaign is considerable. Let him occasionally reflect that a hundred size II tractors are equivalent to about 72,000 men when they are on shift work.

One of the most effective ways to keep the engineer commander fully plant-conscious is to have in his office a chart or board showing

what his plant is up to. This can be a duplicate of what is kept in the office of the staff officer directly controlling the plant. There are many ways of arranging it according to the size of the command, the amount of plant and the number of different locations where it may work. Some of the main headings, if they can possibly be accurately known at the engineer commanders' H.Q. are :—

Type of machine (e.g., " Size II angledozer with P.C.U.").

Working at site.....

Available for work.

Workshops repair.

Operator's name—may sometimes be useful.

A tag can be hung on a nail, or a chalk sign be made, under the appropriate column. Plant labelled " Working at Site " can be seen on the ground and the officer in charge given a word if it is idle or misemployed. Plant " Available for Work " but not working should be kept to the minimum. It may be thought to be in reserve for an emergency, but generally it can reinforce working sites if there is nothing new directly required—it can still be pulled out for an urgent call.

" Workshops repair " can also be watched. Of the two main types of earthmoving plant, tractors are likely to need repair more often than excavators. No reliable guide can be given as to what to expect, because the factors of age of machine, toughness of job and availability of spares all cause great variations in workshops times. One thing the engineer commander must do, is to drive hard to reduce time spent in awaiting spares. For genuine repair work, however, the commander must not be surprised at figures as high as 30 per cent for tractors—that is, percentage of total time which is spent in workshops.

Finally, the engineer commander must ensure that proper maintenance is carried out, otherwise plant will quickly drift into the workshops. This paper is not the place in which to go into the system of maintenance—suffice to say that there is one, it is a good one, and if properly applied it will enormously reduce plant casualties.

There are some random reflections on the senior officer's aspect. He must know how to employ plant and realize its importance ; he should preferably have some immediate means of seeing graphically what it is doing ; and he must be what the operator would probably call " hot on maintenance."

The Junior Officer.—Although it has been said above that lip-service is paid to plant, this is an exaggeration where the training of the junior officer is concerned. It must be admitted that plant is now being put into the Y.O's. training where it was almost absent a few months ago. He is to have three weeks of it in future. This is quite different in aim from the smattering of plant knowledge put out on short courses to the Corps as a whole. In the short

courses an officer is given an idea of plant application and the deployment of several pieces of plant on a job. In the Y.O. course the emphasis is on practical operating and maintenance of one machine at a time. We no longer want the officer who has to bow to what his operator says because he knows nothing himself. Whether the problem is " Can I expect the man to move that piece of earth ?" or " Is it any good the operator trying to cure that breakdown ? " the young officer must know the answer. The fine independent spirit of the typical plant operator is all very well, but he must not be the master. The junior officer must be worked round to a state of mind in which when confronted with a job he agitates for the right plant if it is not provided. Of course, this does not mean falling his sappers out for a smoke while he sends wireless messages for a bulldozer ; it means asking for one in the reconnaissance stage, and pushing hard to get it. He will be more alive to the need for plant if he can operate it himself and has a feeling for earth-moving and the mechanical application of power generally. He should be itching to get at the job—not primarily with his own hands or those of his men, but with some powerful machine.

The Other Rank.—There is no need to examine the problem of making the operator plant minded—the problem is how to make him soldierly, but that is another subject which need not concern us here. Nor does the toiling infanteer need much encouragement to lean on his shovel and let a back-acter dig his trench. The shortcomings it is felt are these :—

Firstly, a lack of warrant officers and senior other ranks who can run a construction job using plant—earthmoving, roadmaking, quarrying, piledriving. Our courses produce Clerks of Works for building, mechanical and electrical work ; but where are the men who can take charge of teams containing dozers, scrapers, navvies, crushing and screening plant, spreaders and finishers, and many other useful tools ?

Secondly, there is a gap in the trades of the Corps where we should have operators familiar with plant other than the purely earthmoving variety.

The writer can only suggest that a realistic and ruthless sapper officer or committee, wielding enough power, should bring in the necessary courses and trades—if need be, by elbowing out some of the trades which are not needed for battle. The loving care and skill expended on sanitary and decorative work should be transferred to the rougher elements.

What we all need is literally a wider vision—not to focus on the elaborate fireplace, the smoothly flushing lavatory and the illuminated scroll ; but on the hillside scarred by tractor-scraper teams, on the noisy, bustling quarry, and on the smooth majestic progress of the graders, rollers and paving machines !

THE TRAGEDY OF POLLY PHASE

A Case of Techinical Indigestion

By Brigadier A. MacG. Stewart

EDDY Current and his bride Millie Ampere had just been star-connected in harmonic matrimony by the Resonant Tungsten Sparks. They had been warned that although there were potential diversity factors between them they were tripping out into the earth in parallel and must from now on act synchronously, treating with iron-clad back-to-back resistance any prospective surge to form electro-platonic friendships which might step down the peak of the fluorescent spectrum of their happy future.

After the ceremony they left the Resonant Registrar under an arc of copper-lapped split conductors, which waved with a high frequency in the inductive flux, like vibrating reeds, so that the reflection from the copper looked like dielectric polar curves in the æther.

Seated in a six-cylinder turbo-alternator, with five polychromatic laminated Pelton wheels, the happy couple, fused now into one single phase, were about to drive off to the hydro electric-station. But before the switch-board attendant could press the dash-pot of the flush type face-plate starter, relays of anodes and cathodes, harnessed to a grid of insulator strings, imparted kinetic energy to the transmission and with subtractive-polarity dragged the rated burden to the Terminal. The way was full of windings, but they took a short circuit across neutral fields, and throwing their whole power-factor into the yoke, they overcame all reactance. At creeping speed, using their economizers to the full, with vacuum in their ducts, and their glands super-heated, they boosted the alternator round the last vector just in time for the bride and bridegroom to step up into the artificial honeymoonlight express.

Millie and Eddy were impelled by a reverse power relay into their compartment, under a battery of mercury arc rectifiers radiated by a summation of photographers. Escaped from the photographers our hero and heroine fell back into their steradian seatings. Their resistance broken, they sat, a damped and cab-tyred pair of worn out inter-connected neutrals, while their friends cascaded ultra-violet and infra-red rose petals on them.

The train set off at high acceleration, drawn by a quadrature booster. They were alone, and filaments came into Millie's eyes.

To rectify this leakage of condenser water Eddie began to stroke the pancake coils of her crowning glory, but this went beyond the permittivity of insulation, for she feared he would disturb the permanent sandwich windings.

Eddie sagged back and illuminated a corona.

Millie lowered her eye-bushes to conceal the reflection of triumph in her eye-bolts. By the exercise of her positive maximum demand she had got her man. She had had to fight for him against that re-volting type Polly Phase, who at one time had him in her compensating coils. Polly was of opposite polarity to herself, but the ratiometer had shown Eddie to be neutral for an inverse time element. Polly had taken him pub-crawling round the bus-bars. Millie's favourite tipple was distilled water, though she had gone so far at the wedding as to take a glass of rheostat and lemon. Luckily Polly suffered from solenoids which made her wheeze through her ports and speak with a torque, so that Eddie became adiabetically reactive to her, and shunted his affections to herself. Now she was safely fingering her shield ring of cadmium copper ; Eddie was hers.

Her dreams were interrupted by a mobile Ticket Trivector. "Just like his ruddy impedance" she thought. He said that as the co-efficient of utilization of the feeder line was low, and the thermal value of pulverized shale lower still, no matter how high the sliding scale tariff might be drawn by convection there would inevitably be heat losses, and so the train was being withdrawn, and the permanent way sold to contact breakers.

This triple pole case against nationalization reduced Millie to a series of outbursts of hysteresis. This induced British Railways as a special case, never to be quoted as a precedent, to attach a reaction-turbine in tandem with the quadrature-booster. As a result the double-headed train entered the Substation with such rolling momentum that it took some smart regenerative-braking on the part of the Station Superintendent to avert what might have been a cross-blast-breaker arrival, but the Horn gap arrestors just stopped their stock rolling in time.

Eddie and Millie isothermally thanked the diffusors of their excessive speed, left the train, and as far as I know they are still living happily yoked together in parallel, the balance of their characteristics holding them together with a discriminative over-current of personal magnetism.

But what of poor Polly? Her very core was displaced by the loss of her man, and the balance of her heart was so disturbed that its regular beat became an irregular series of tappings. She could bear it no longer, and with a cry of, "Ohman, Watt an Erg is he" she swallowed a cell full of electrolyte and closed down for ever.

MEMOIR—COLONEL G. A. P. MAXWELL

From :—

BRIGADIER-GENERAL SIR H. OSBORNE MANCE, K.B.E., C.B., C.M.G., D.S.O.

To :—
The Editor,
R.E. Journal,
Chatham, Kent.

Hill Top,
Frith Hill,
Godalming, Surrey.
14th October, 1953.

DEAR SIR,

I should like to add a footnote, based on personal knowledge, to Brigadier-General Sir Godfrey Rhodes' tribute to Colonel G. A. P. Maxwell, published in the September, 1953, issue of the *R.E. Journal*.

Maxwell was one of the three officers and thirty O.Rs. who served for three years in Nigeria from 1908 to 1911 on the construction of the Baro-Kano Railway, being responsible for the track-laying and advance maintenance. His organization was such that he easily kept within the time-table prescribed for each season, and he achieved the unusual result of effecting considerable savings on the scanty funds allotted for his job. He learnt Hausa and, assisted by a few Sappers, directed some 1,500 to 2,000 natives of different tribes with insight and sympathy, with the result that he could count on them to respond enthusiastically to any appeal for a special effort. With this team Maxwell was able to beat the world record for telescopic track-laying, having laid 6⅓ miles of main line in one day and 800 yards of sidings (to allow successive construction trains to reach railhead), the total track laid out being 7 miles.

At the outbreak of the first World War Maxwell, then under orders for Nigeria, called at the War Office for instructions. He arrived at the same time as an urgent telegram from France requesting the immediate replacement of a D.A.D.R.T. who had gone sick. Maxwell, although rather junior, was appointed and fully justified his selection. After the war he was responsible for organizing the international railway missions sent by the Supreme Economic Council to numerous countries in Europe and for keeping track of the expenditure of the British credits for the re-establishment of communications. He contributed greatly to the smooth and economic running of the Communications Section of the Supreme Economic Council.

Maxwell had a very clear mind, with great organizing ability, a grasp of detail but a keen sense of proportion. He was devoted to the job in hand, without thought of personal advantage and was the most loyal of colleagues. It is easy to understand his subsequent brilliant service in the Africa he loved and in the second World War.

Yours truly,

H. O. MANCE.

MEMOIRS

MAJOR-GENERAL SIR THEODORE FRASER, K.C.B., C.S.I., C.M.G.

The following Memoir is reprinted by permission from *The Times* of 23rd May, 1953.

MAJOR-GENERAL SIR THEODORE FRASER, who died on 22nd May, 1953, at the age of 87, was a Royal Engineer officer who served for most of his career with the Indian Army. His inclination was for staff work, and he held a succession of staff appointments both before and during the 1914–18 war, when he saw service in France and in Mesopotamia.

The son of the Rev. Donald Fraser, D.D., of Inverness and Marylebone, he was born on 15th June, 1865, his mother being the fourth daughter of Major-General Alexander Gordon, R.E. From University College School he went to Clare College, Cambridge, obtaining his commission direct into the Royal Engineers in February, 1886.

Indian service soon brought him experience of frontier warfare. He was in the Chin-Lushai expedition of 1889–90 and the Hazara expedition, 1891. He got his captaincy in August, 1896, and during the Tirah campaign of 1897–8 he was adjutant, R.E., 2nd Division.

He had some experience of the South African War as a special service officer, from February to December, 1900, being employed in Cape Colony, the Orange Free State, and the Western Transvaal, where he was at the action of Frederickstad in October.

In 1901 he passed into the Staff College, but after graduation it was some time before he secured staff employment. He was promoted Major in his corps in September, 1904, and appointed D.A.A.G. Bombay Brigade in February, 1905, passing to the Headquarters of the Army in November, 1907, to become a D.A.Q.M.G. there. He left Simla in February, 1909, and at the beginning of 1910 was selected to be an instructor at the Indian Staff College. Here he remained three years, being promoted Lieut.-Colonel in December, 1912. After leaving Quetta he came home and passed through a course at the Naval War College.

Eager for active service on the outbreak of the war, he had first to be content with the post of Embarkation Commandant. It was not until March, 1915, that he was appointed A.A. & Q.M.G. on

the staff of the Lahore Division, then in France. In this capacity, and later as A.Q.M.G., he was with the division at "Second Ypres," and the battles of Aubers Ridge and Festubert, and accompanied it to Mesopotamia at the end of the year.

In May, 1916, Colonel Fraser was appointed G.S.O.I on the staff of the newly formed 15th (Indian) Division, which remained on the Euphrates front, until, in October, he was transferred to the III Corps as Brigadier-General General Staff. With the Corps he saw the Battle of Kut and the advance to and occupation of Baghdad, and then the operations on the Adhaim in April, 1917. He had received a brevet in March, and reached the substantive rank of Colonel in December, by which time the operations in the Jabal Hamrin area had been concluded. From February to April, 1918, he acted as Chief of the General Staff to General Marshall, the Commander-in-Chief.

For his services in the 1914–18 war he was awarded a C.B., C.S.I. and C.M.G. and the Serbian order of the White Eagle and was Mentioned in Despatches seven times.

He succeeded to the command of the 15th Division in September, 1918, and in the following March took over the 18th Division, being promoted Major-General in June. He was engaged in the Kurdistan operations of 1919–20, and relinquished command in October, 1921. For these services he was created a K.C.B. and Mentioned in Despatches twice. From March to November, 1922, he commanded the forces in Iraq, but was not again employed until May, 1924, when he was appointed to the Malaya Command. Three years later he retired from the Army on an Indian pension.

He married Constance Ruth, the youngest daughter of Mr. Nathaniel Stevenson, in 1903. She died in 1918 ; he leaves two sons and a daughter.

Major-General Sir Theodaore Frazier KCB CSI CMG

Brid-Gen Sir Charles L Magnaic Kt CMG CBE

BRIGADIER-GENERAL SIR CHARLES L. MAGNIAC, Kt., C.M.G., C.B.E.

CHARLES LANE MAGNIAC was the eldest son of the late Major-General Francis Lane Magniac of the Madras Staff Corps. He was born at Wardha, C.P., India, on 14th December, 1873, his father being judge of the Small Cause Court at Nagpore.

Educated at the United Service College, Westward Ho, and the Royal Military Academy, Woolwich, he was gazetted to the Royal Engineers in 1894, and on completion of his course at the S.M.E. was ordered to India in September, 1896, where he joined the Military Works at Attock, then in the Punjab.

In March, 1897, he was lent to the Government of the United Provinces for famine work at Allahabad and on completion he received the thanks of the Government of the United Provinces for this work. He was then posted to the North-Western Railway as Assistant Engineer and was ordered to Khushalgarh for railway work in connexion with the Tirah campaign, for which he received the thanks of the Government of India.

He was transferred to the Eastern Bengal Railway in 1898, as Assistant Engineer in connexion with the Ganges river crossings, and in 1901/2 he went through a Traffic course with the N.W. Railway and served as Traffic Officer in charge of the Delhi-Durbar Light Railway in 1902. On release he served in various capacities in the Traffic Department of the Eastern Bengal Railway and acted as Deputy Traffic Superintendent in 1907.

In 1908 he was offered and accepted the appointment of Deputy Agent, Madras and Southern Mahratta Railway Company under Mr. (later Sir Arthur) Anderson. In 1914 on Sir Arthur's appointment to the Railway Board, Magniac was appointed acting Agent, but on the outbreak of the war with Germany he was ordered to France and sailed with the Meerut Division in September, 1914.

At Marseilles he was ordered to join the Transportation Branch and served under Lieut.-Colonel (later Major-General Sir Henry) Freeland, R.E., at Boulogne, Abbeville, etc. As personal assistant to Freeland he selected and organized various regulating stations and depots for the B.E.F., other than the R.O.D., and drew up rules for all B.E.F. train movements including troops, reinforcements, ammunition, ambulance, leave, posts etc.

On the arrival of Sir Eric Geddes, Freeland was seconded to assist him and Magniac became A.D.R.T. in his place. Later he joined Sir Eric Geddes' administration as D.D.R.T. under Brigadier-General Freeland, who was then D.R.T.

On the appointment of General Freeland to Mesopotamia, Magniac became D.D.R.T. and personal assistant to Brigadier-General V. Murray, and continued as such until his return to India in March, 1919.

He was awarded a C.M.G. in 1916, a Brevet Lieut.-Colonelcy in 1917, C.B.E. in 1919, Legion d'honneur, officier, in 1918, and was five times Mentioned in Despatches.

On his return to India he rejoined the Madras & Southern Mahratta Railway Company as Agent, but was almost immediately ordered to Army Headquarters, Simla, to take up the appointment of Director of Railways under the Q.M.G., Sir Edward Altham, and later General Richardson, during the Afghan War. At the end of the Afghan War he received a Mention in Despatches and returned once more to Madras in 1919, as Agent of the Madras and Southern Mahratta Railway Company. He was elected Chairman of the Indian Railway Conference Association for the year 1921, and received a knighthood in June, 1923.

He retired from the Army in 1922, and left India in 1925, to become Secretary of the Madras and Southern Mahratta Railway Company.

In 1934, he was appointed Chairman and Managing Director of this Company in London. He had also joined the West of India Portuguese Railway Board in 1930 as a Director.

In 1944, when the Madras and Southern Mahratta Railway Company was taken over by the Government of India and became a State Railway, Magniac was appointed one of the Liquidators.

Sir Charles Magniac did not bear with fools gladly and he had no patience for laziness or incompetence, but, both at work and play, he himself set an example to all about him. He was uncompromising indeed, but his was a fearless rectitude. A good and loyal friend, he did not forget his friends, and they will remember him and miss him.

One recalls him at the bridge-table with his chin on his right thumb, intensely purposeful, for he was as thorough at play as at work and asked no less of those he played with. On the golf course too, or the tennis court he was a stout partner, and "played the game" as he did in all matters. An expert and indefatigable gardener, he did wonders in the arid tropical conditions of India, and took sheer delight in the results that he achieved. He took great pleasure too in hospitality, and there are few of his friends but will remember his kindly badinage and shrewd humour, presiding as he did with all dignity at his own most hospitable board.

A memorable personality is no more with us, and the world is the poorer. We are all composite characters, but men of extremes who are well balanced are God's grace in their day and generation.

In 1900, he married Letitia Anne, third daughter of T. H. W. Knolles Esq., of Oatlands and Killeigh, Co. Cork, who survives him.

C.C.

BOOK REVIEWS

ATOMIC WEAPONS IN LAND COMBAT

By COLONEL G. C. REINHARDT and LIEUT.-COLONEL W. R. KINTNER

(Published by The Military Service Publishing Company, Harrisburg, Pennsylvania, U.S.A., Price $3.95.)

It is a signal event in the field of military literature that the United States Army have passed for general publication a book on atomic tactics in land warfare. The two co-authors, moreover, are serving officers whose appointments during the recent experimental years have given them the opportunity for a clear view of the facts on which to base their conjectures. It adds greatly to the value of the book as a work of reference that they have set out and interpreted these facts clearly, though the reader must not expect any new or startling revelations. The important point is that by now the admitted facts narrow the field of tactical conjecture sufficiently for it to be explored intelligently, *coram populo*, in a not very long book. Will the last word on atomic tactics ever be written? Here, at any rate, is the first.

In the opening chapter we are invited to reflect on the trick of fate whereby the first atom bombs were not ready in time for Iwo Jima or Okinawa. Had these strongholds been the first atomic targets would they have provided sufficient of an object lesson to bring about an earlier Japanese surrender? They would in any event have given the world a different—perhaps healthier—" slant " on the new " super but not absolute " weapon of war, and many of the answers now being sought would have been provided. But the authors do not dwell on history as it might have been; they pass quickly on to the practical business of applying an average one-mile radius of devastation to armies deployed in varying fashion. Attackers are shown to be at least twice as vulnerable as defenders, but of what account is this if the attackers possess three times as many missiles? The stock pile is a potent factor. And there are all the stages from stock pile to target: logistical movement, holding at readiness, expert handling, supreme accuracy of aim by whatever means is employed. Even larger problems lie in providing the commander with true information on which to base a momentous and often rapid decision, and afterwards in ensuring prompt exploitation. It is easy to see how a case for super efficiency in wielding the super weapon is built up. In our armed forces we must all become better at everything. And the defence? Mobility, the authors say. There is much else, but the key-note is " move or die."

One of many interesting themes developed in this book strikes at the long established concept of fire and movement, under which a commander, having decided when and where to send his infantry and armour in amongst the enemy, only secondarily organizes his puny conventional fire power to make the movement possible. An atomic blast is gargantuan fire power, and throws this familiar concept out of balance, for the aim is to destroy the enemy forces, and *within a certain radius* atomic missiles are quite unrivalled for this purpose—far superior to infantry and armour.

Any excessive concentration of the enemy is thus a worth-while atomic target, even at short notice as in counter-attack, and the movement of infantry and armour in to exploit the burst becomes subsidiary. Subsidiary, but very important. Prompt mopping up in the outer rings of semi-devastation may treble the bag. However, to reach this area the

exploiting troops may have to break through a surviving crust of front line defence, and to achieve this they will need conventional fire support. Accordingly in minor tactics it is still "fire and MOVEMENT," but in major tactics it may be "FIRE and movement." So runs the theme.

This is a sincere and thoughtful book, and fully merits being allowed to set the ball rolling. But the ball may be played back at the authors good and hard, and they seem to invite this on the subject of dispersion especially. The very word sets them spluttering, with "cure-all" "Will-o-the-wisp," "shibboleth." "Will five small scattered gasoline tank farms be safe where one large one would not be?" they cry out loud. In its context this is not quite (though very nearly) as odd as it sounds, for the two colonels have worked out to their own satisfaction that true dispersion means making do with one small tank farm, and not shipping the other four into the theatre of war. We should be sorry to see an ally adopt this policy, especially the United States, for it has always been consoling to reflect that their armies, as we have seen them alongside us, would be able to keep going with four-fifths of their administrative backing knocked out—an eventuality that may not be uncommon in atomic warfare.

T.I.Ll.

ATTACK IN THE WEST

By MAJOR W. G. F. JACKSON, M.C., B.A., R.E.

(Published by Messrs. Eyre & Spottiswoode. Price 21s.)

The military student, confused by overmuch reading of great books on twentieth century warfare, can turn with relief to *Attack in the West*. Major Jackson, who is a Sapper, has harked back to first principles by seeking inspiration from Napoleon on the problem of the defence of the West. The result is most impressive.

Although Clausewitz says that, in war, the simplest thing is difficult, Napoleon at least made it *look* simple to defeat Austrian armies considerably larger and better equipped than his own. From his experience in the campaign of 1794, he knew the Apennines like the back of his hand and, at 27 years of age, he was in the first vigorous flush of his genius for war. The new significance which he at once gave to morale, speed and surprise, brought him an immediate succession of brilliant victories. A new military era was dawning.

Major Jackson's fascinating story with its wealth of up-to-the-minute diagrams makes the reader feel that he is being refreshed with the real stuff of war. *Mutatis mutandis*, there is much indeed which modern commanders can learn from Napoleon's Italian Campaign, e.g., the higher tactics of the battle on interior lines, the quick modification of plans without the creation of disorder, and the sure control, under one hand, of many formations. The book may even prompt effort to make modern Corps and Divisions more flexible. Their present unwieldiness is terrifying.

The author's warm impatience has made him a little rough on Italian and French names, which sometimes differ in text and diagram or defy tradition. Bologne for Bologna, Leghorne for Leghorn and Bromida for Bormida seem strange and Arcole may be good Italian but most of us remember the bridge of Arcola. Guyeux/Guyeau and Pigeon/Pigion are two other small slips. But these are only minor blemishes.

Peterborough has warmly praised the book in the *Daily Telegraph* and it will be rated one of the outstanding military books of 1953.

B.T.W.

TO BENGHAZI

By GAVIN LONG

(Published by *The Advertiser* Printing Office, Adelaide. Price 25s.)

The official history of Australia in World War II is being tackled in five series—one each for the Army (seven volumes), the Navy (two volumes), the Air (four volumes,) Civil (four volumes) and Medical (four volumes). Gavin Long, a distinguished Australian journalist, was specially selected in 1943 to be the general editor of the whole history except the medical part, which has an editor of its own. Eleven other writers, approved of both by the Government and by the Opposition, are to write the fifteen volumes, which the general and medical editors do not write themselves. Chester Wilmot, to mention one of them, is to produce the book on Tobruk and El Alamein.

In the preface of "To Benghazi," Mr. Long says that censorship by the Government is to be limited to the technical secrets which must still be preserved. He describes the history as official in the sense that it has been financed by the Government, that the writers have been given access to official papers and that they have been conscious of the special responsibilities which rest upon the authors of a national history.

Mr. Long seems, in this first Army volume, to have given full weight to these special responsibilities, since he makes no forthright criticism of the general conduct of military affairs by the Dominion and British governments. This is perhaps a pity, because the two governments between them rather failed to provide for the difficult situation which, in the event of a second World War seemed certain to develop in the Far East and the Western Pacific. Singapore in particular, with its insecure hinterland and its situation on a narrow sea was assuredly not a naval base on which Australia could place any firm reliance. Yet rely on it, she did. So much so that the Australian people felt no qualms about dispatching once again an A.I.F. to the Middle East, there to emulate the prowess of its predecessor in World War I.

How vital a part the A.I.F. played in the heartening early successes of the desert war in North Africa is described with the factual excellence and the clear sketches of really good military history. Particularly pleasing is the account of the capture of Giarabub.

On the failure to overrun the whole of Italian North Africa before the Germans could intervene, the author is content once more to provide the evidence and to let the reader judge the matter for himself. This again seems rather a pity, since in a history of war, it is surely good to emphasize, that when military resources are scanty, it is wiser to finish off one campaign completely, before embarking on another, lest both come to grief as they did in Cyrenaica and Greece.

But with six further volumes still to come on the far more difficult campaigns which fate had in store for Australia, there is much to recommend the sober and accurate style in which Mr. Long has started the history.

Readers of this first volume will look forward eagerly to its successors in full confidence that they will receive from them illumination on many matters which are at present rather obscure.

B.T.W.

TECHNICAL NOTES

INDUSTRIAL USES OF ATOMIC ENERGY

(The Engineering Journal of Canada)

The issues of *The Engineering Journal* (Canada) for June, July and August, 1953, contain four interesting papers dealing with different aspects of the application of atomic energy to industrial use. The development of a new source of power is an exciting idea which has given rise to much speculation and some thought, but paradoxically it is in the field of delicate measurement and examination that substantial progress has already been achieved.

Radioactive isotopes, the by-products of nuclear reaction, emit two kinds of radiation, beta rays and gamma rays. The former have been adapted to the measurement and automatic control of the thickness of sheet material made by rolling, extruding or pressing. Gamma rays compete successfully with X-rays in industrial radiography, notably in the inspection of welding, and are also being used to measure wall thickness in pipes and tanks. New techniques are constantly being produced, an example being the use of nuclear radiations for determining soil moisture and density (see *R.E. Journal* for June, 1953).

Commercial adaptation and development of atomic energy for power production are hampered by the demands of militaty security : nevertheless, its feasibility has been demonstrated on a laboratory scale, and it is predicted that some electric generating stations using atomic energy will be in service by 1975. That this is desirable is shown by the estimate that, in the North American continent, power requirements will be quadrupled within twenty-five years, by which time the Canadian demand alone is expected to exceed all exploitable hydro-power resources by some 7 million kilowatts.

The present conception of method is that the nuclear reactor will replace the boiler and furnace in the generation of steam for conversion to electrical power by conventional equipment.

All nuclear reactors, existing and projected, consume nuclear fuel : most require a material such as heavy water, called a " moderator," which is not consumed but which may be costly : all produce both heat and new elements, the most important of which, at present, is plutonium. The amount of heat liberated per pound of fuel consumed may be 10,000 times as great as that of coal. The early types of reactor are very large, and waste the heat generated : smaller reactors using enriched fuel, i.e., fuel to which fissile material is added artificially, are expensive both to build and to operate : in a third type, called a " breeder," one kind of fuel is consumed, but another is produced to replace it. The practical aspect of the " breeder " type is that the plutonium produced can remain in the fuel and assist the nuclear reaction to an increasing extent as the original fissile material is consumed, thus vastly increasing the amount of energy that can be extracted from the natural fuel.

The economic aspect can be assessed only by intelligent guesswork. The conclusions reached are, broadly, that capital outlay is likely to be high in comparison with hydro-electric or modern steam plants, even though present costs are inflated by the stringency of restrictions and the experimental nature of existing construction, and that operating costs will be excessive if the uranium is entirely consumed, but should be relatively low with breeder-type reactors or where a profitable market exists for plutonium or for radioactive by-products.

THE MILITARY ENGINEER

(*Journal of the Society of American Military Engineers*)

May–June, 1953

"Military Use of De-salting by Ion Exchange," by Fred F. Kravath, Commander, Civil Engineer Corps, United States Navy.

The author puts forward the claims of ionic exchange, using selective resinous membranes, as one of the most fascinating and promising methods of producing potable water from salt water. While granular exchangers were used in 1906, it was only recently that industry found the secret of manufacturing in relatively large sheets, resinous membranes with the property of selective permeability—the ability to be permeable to ions of one charge and impermeable to ions of the opposite charge. A series of such cation permeable and anion permeable membranes are arranged alternatively in an electrolyte of salt water between two electrodes. On passage of a current, the positively charged ions move in one direction through one membrane and the negatively charged ions in the other direction through the other membrane, until alternate compartments of heavily concentrated salt solution and of plain water are obtained. Large units, not yet developed, may be expected to work at a ratio of some 20 kW.-hours per 1,000 gallons of fresh water produced compared with a ratio of about 110 kW.-hours per 1,000 gallons of fresh water at present produced by the best type of vapour compression mechanical distillation equipment now available after more than thirty years research and development. From present indications ion-exchange de-salting units (less electrical generators) of comparable capacity to the latest distillation units should be only about ten per cent of the cubage and weight of the mechanical units and much simpler in operation, maintenance, and manufacture.

It is unfortunate that the author does not carry his comparison further and deal with the relative efficiencies of both methods when used to deal with radio-actively contaminated waters—the real military water purification problem of the present day.

July–August, 1953

"Nuclear Energy as a Source of Power," by John W. Landis.

The author is a Reactor Engineer in the Division of Reaction Development of the Atomic Energy Commission. His previous experience included four years in the Ordnance Service, followed by service as a consultant to the Navy Department.

In an interesting, easy to read, and well illustrated article, the author deals comprehensively with the basic theory of nuclear energy and fusion and fission reactions. He examines conventional and nuclear fuel reserves, the economics of the nuclear power plant, reactor design and its problems; and concludes that nuclear power plants to-day are not only technically and economically feasible, but are within a decade of becoming commercially competitive with conventional power plants. Reviewing the remarkable progress made since the discovery of the neutron only twenty-one years ago ; the chain reaction only twelve years ago ; the first nuclear reactor only ten years ago ; he strikes a note of confidence in the possibilities of the future which does not exclude even the, as yet remote, fusion reactor as a successor to the fission reactor.

It is interesting to note that the author's estimate of the energy available in the world's fissionable nuclear fuel reserves is about twenty-three times that of the energy in the fossil-fuel reserves, and that these latter he estimates will last only about one hundred years. One pound of uranium if

completely burned will produce about 10 million kWh. of heat, a coal equivalent of about 1,300 tons, and a fuel cost in terms of cents per kWh. of .0039 compared with .35 for coal. The savings effected by the low cost of the nuclear fuel give promise of more than offsetting the increased capital cost of a nuclear power plant over that of a conventional power plant. On a conservative basis this permits approximately $40 million more to be spent on the nuclear end of 500,000 kW. power plant than on a conventional boiler and coal-handling equipment, and still remain economically competitive.

CIVIL ENGINEERING

June, 1953

One of the most interesting features of this month's publication is the cover, on which a sheet pile coffer is illustrated, which was designed by two students from the S.M.E. while on Long Civil Engineering Courses. The cofferdam is unusual in that the sheet piles are supported by three mass concrete arch ribs over a span of 100 ft. It will also be noted that the ribs are separated by the light transportation steel trestling.

An interesting article by Dr. Chettoe shows some of the bridges built by the Germans to replace those destroyed during the war. They are all major bridges and most of them are over the Rhine. It will be noted that the designs are not by any means stereotyped. Prestressed concrete has been used in some cases and the continuous span plate girder gives particularly pleasing lines.

A description of the hangars for B.O.A.C. at London Airport discusses the choice of layout and dimensions of the structures, whose entrance spans of 300 ft. are the largest in the world.

In the review of contractors' plant there is a description of the capacity of the new Blaw Knox 10 cu. yd. scraper, but the item which might interest sappers most is the wire rope clamping system which uses metal ferrules to join the rope, thereby avoiding tedious splicing. It is quick, requires little skill and produces a joint stronger than the rope itself.

July, 1953

An article on the main access tunnel to the centre of London Airport where the airport terminal buildings will be constructed gives details of the design and sequence of construction of the tunnel. The tunnel is of reinforced concrete and is being built in open trench. It will provide four traffic lanes for motor vehicles and two subways for pedestrian and cyclist traffic.

An interesting article begins in this edition giving information about the sea defences on the Kent Coast. The dimensions of the protecting banks and sea walls provide an interesting source of discussion on the much-argued engineering points of how to prevent scour due to tidal and wave action. It is interesting to note that most sea wall failures are not due to erosion on the seaward side but to decay of the rear face, with consequent failure of the wall. The number of different boards, commissions of sewers and other parties interested in coastal erosion make this essential public service very difficult to organize.

The new plant reviewed in this edition shows the Cheshire trench-digger. This is a small bucket trencher driven by 6 h.p. motor which digs a ditch 6 in. wide and up to 30 in. deep. It only weighs 5 cwt. Wider ditches can be cut by taking several cuts. For laying underground cables or digging foundations for buildings it would appear to be an admirable tool.

HISTORY OF THE CORPS OF ROYAL ENGINEERS

Volumes of this History, covering the period 1066 to 1938, are on sale from the Institution of Royal Engineers, Chatham, at the following rates :—

Individual volumes—price 10s. each to members of the Institution or 35s. to non-members.

Volumes I to VII ordered together—price £2 10s. to members, or £10 to non-members.

Volumes IV to VII ordered together—price £1 10s. to members, or £6 to non-members.

Volume III is temporarily out of print, but is being reprinted and should be available again early in 1954.

Further Volumes VIII and IX, covering the period 1938 to 1948, are being written. No date can be given for publication.