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CONTENTS

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VOL. LX CONTENTS SEPTEMBER, 1946

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Lieut.-Gen. Sir Ronald Charles K.C.B., C.M.G., D.S.O., Chief Royal Engineer, taking the salute.

RE Veterans Parade, Chatham

Portrait of lieut - General Sir William Dobbie
GCMG KCB DSO

EDITORIAL NOTES

1. Chief Royal Engineer.

On 26th June, 1946, Lt.-Gen. Sir Ronald E. Charles, K.C.B., C.M.G., D.S.O., relinquished his appointment of Chief Royal Engineer and was succeeded by Gen. Sir Guy C. Williams, K.C.B., C.M.G., D.S.O.

Lt.-Gen. Sir Ronald Charles became Chief Royal Engineer on 23rd April, 1940, when Gen. Sir Bindon Blood resigned his appointment at the age of 97.

The age limit for this appointment is now fixed at 70, but Lt.-Gen. Sir Ronald Charles was granted a year's extension of office.

H.M. The King created the appointment of Chief Royal Engineer in October, 1936, and appointed Gen. Sir Bindon Blood, G.C.B., G.C.V.O., Col.-Comdt. R.E., to fill the post.

From 1660 to 1802 there had been a " Chief Engineer of the Kingdom " and when the title of Royal Engineers was granted to the Corps in 1787, Maj.-Gen. Sir William Green, who was then Chief Engineer, signed his name as Chief Royal Engineer and continued to do so until he retired in 1802, when the office was abolished and the duties appertaining to it were transferred to the Inspector General of Fortifications and Works.

We reproduce a photograph showing Lt.-Gen. Sir Ronald Charles taking the salute at the R.E. Veterans Parade at Chatham on 16th June, 1946. This was one of his last official functions, and after the parade he spoke to the veterans and the serving troops. On his last day of office he was present at a similar function at Aldershot.

The names of the other officers in the photograph, reading from left to right are :—

Brig. B. T. Godfrey-Faussett, C.B., D.S.O., O.B.E., M.C., Comdt., S.M.E. ; Maj.-Gen. Sir Eustace F. Tickell, K.B.E., C.B., M.C., Engineer-in-Chief; Col. J. H. D. Bennett, O.B.E., Comd. Chatham Wing, S.M.E.; Lieut.-Col. H. G. Woods, R.C.E.

2. Portrait of Lieut.-Gen. Sir William Dobbie, G.C.M.G., K.C.B., D.S.O.

The portrait of Lieut.-Gen. Sir William Dobbie, painted by James Gunn, Esq., has been completed and is now placed in the R.E., H.Q. Mess at the S.M.E., Ripon.

A photograph of this portrait is reproduced in this issue and it will be seen that it is an excellent likeness of this gallant officer and it will be a very valuable addition to the portraits exhibited in the R.E., H.Q. Mess.

The photograph, from which our reproduction is made, measures 11 in. by 9 in. and extra copies can be obtained by officers, if they wish, direct from the photographer, Paul Laib, 3, Thistle Grove, Drayton Gardens, South Kensington, S.W.10, at 10s. 6d. a copy.

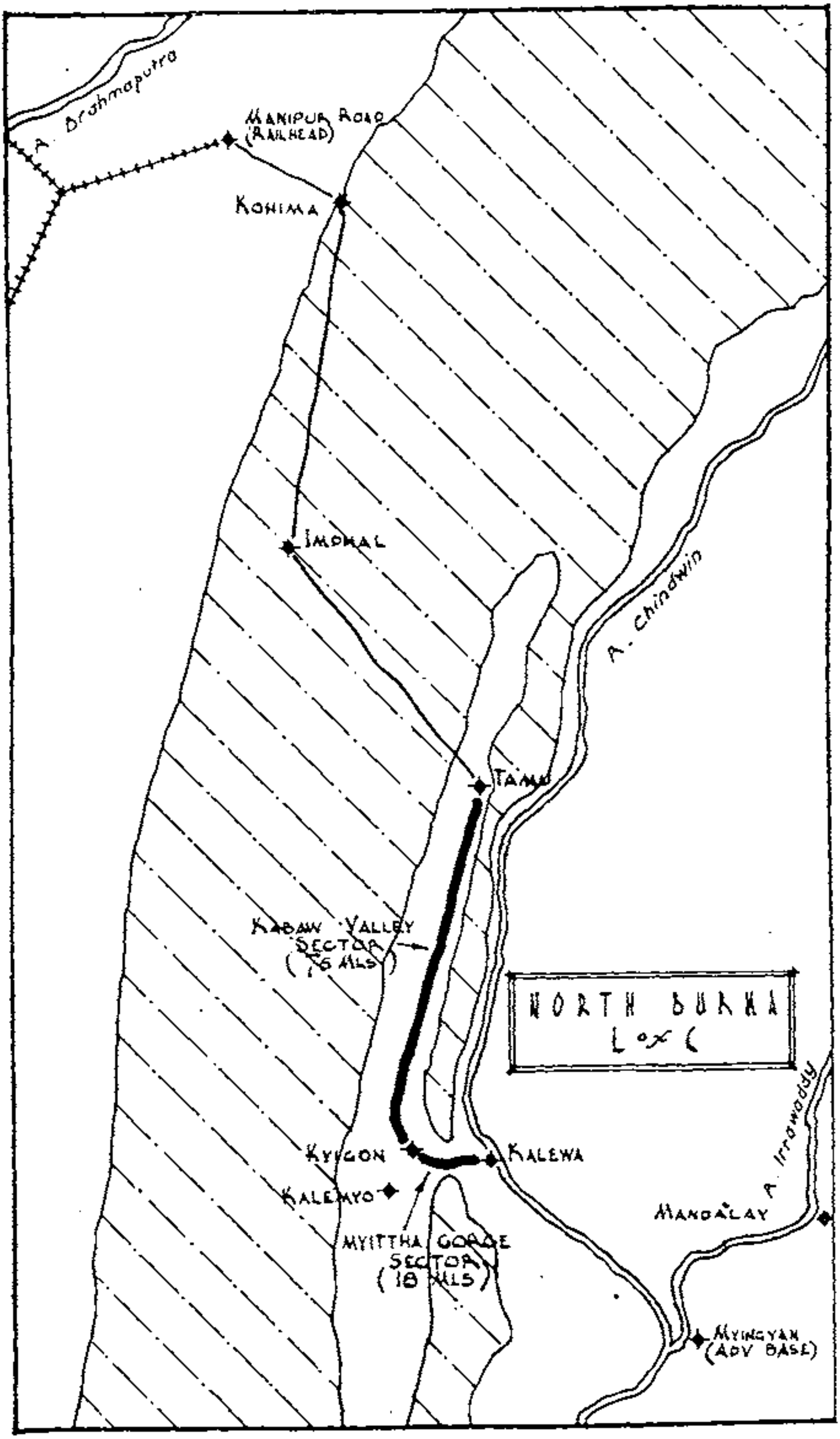

A. Brahmaputra
MANIPUR ROAD
(RAILHEAD)
KOHIMA
IMPHAL
A. Chindwin
TAMU
KABAW VALLEY
SECTOR
(75 MLS)
NORTH BURMA
KYIGON
KALEWA
KALEMYO
MYITTHA GORGE
SECTOR
(18 MLS)
MANDALAY
A. Irrawaddy
MYINGYAN
(ADV BASE)

DIAGRAM I

THE TAMU-KALEWA ROAD

By Brig. P. O. G. Wakeham, O.B.E.

Introductory

THE maintenance of Fourteenth Army during the Burma Campaign, 1944–45, over one single land route from Calcutta to the advanced base at Myingyan (the longest supply route in any theatre) was one of the finest achievements in South East Asia; not the least remarkable feature of which was the construction of a road from Tamu to the transit centre at Kalewa, on the Chindwin, through 94 miles of largely untouched territory, using a novel method of construction to overcome the limitations of time, resources and transport.

For some years past this area has been the scene of various abortive attempts at road construction; before the war the Burma P.W.D. built a 9 ft. metalled road from Kalewa to Kalemyo and in 1929 surveyed a track from there north to Tamu; but work was not proceeded with and refugees in 1942, perforce followed the bullock tracks which connect villages in the valley areas. Further attempts followed and in spring 1944, General Reserve Engineer Force (Gref) had cleared and levelled some ten miles of a new alignment; but on the advance of the Japs towards Imphal this also was abandoned and it was not until after the Monsoon Campaign in 1944 that a start could be made in earnest.

In October and November, 1944, the Japanese 33rd Div. was pursued from Tamu down the Kabaw Valley to Kalemyo; by mid October the single fair-weather track south was a morass and our forward division (11th East African) was on air supply. As the monsoon rain ceased another fair-weather road was cut forward through the jungle, at some 4 miles per day, to carry the supporting division and this rapidly became the sole road L. of C. for Fourteenth Army, carrying up to 3,000 vehicles per day. Meanwhile there was an immediate requirement for a double way, all-weather, heavy service road to deal with the maintenance commitments for 1945. In October, 1944, the advanced H.Q. of 145 D.C.E. Works (Indian) was established near Tamu to put this work in hand.

Planning

The area between Tamu and Kalewa falls into two distinct topographical sections—the northern from Tamu to Kyigon (76 miles), near Kalemyo, comprises the Kabaw Valley sector; from Kyigon to Kalewa runs the Myittha Gorge and the "Gorge Road." The Kabaw Valley is covered largely by heavy teak forest with a close knit jungle undergrowth and few clearings, what paddy fields there are being mostly overgrown. To the south there is a heavy growth of tall bamboo. The gorge by contrast is a narrow valley seldom wider than 400 yds. and up to a 1,000 ft. deep. At the Kyigon (west) end it is cut through soft sandstone which grows progressively harder towards the east—hence the vegetation grows sparser and the gorge narrower and more rocky until the Myittha-Chindwin confluence at which Kalewa stands. The climate in the area is typically monsoon. March to mid May is dry and hot; mid May to mid October rainy (especially June to September when up to 100 ins. of rain falls) and the remainder of the year dry and comparatively cool.

The specification called for a class 70 two-way route which should be capable of an average of 350 tons per day in the monsoon period and be ready before its onset, estimated for the 15th May. With existing limitations of manpower and machinery any orthodox pavement type of road was clearly out of the question; and soil stabilization as normally understood (involving the skilled admixture of selected material to the formation, followed by a surfacing of tarmacadam) seemed equally impracticable. Accordingly it was decided by C.E. Fourteenth Army to employ a method—hitherto untried in road construction practice—which may be termed, "Compaction and waterproofing." This method, which had previously met with considerable success in Airfield strip and taxitrack construction, consists in consolidating a graded formation at its most suitable moisture content and then preserving this condition by a waterproof and airtight seal of Prefabricated Bituminous Surfacing (P.B.S.)—a bitumen impregnated hessian fabric. It is the initial employment of this method on so large and important a project which gives the Tamu-Kalewa road its unique interest.

The initial engineer appreciation was made off the one inch map while the territory was in Jap hands. Ground reconnaissance, under 107 C.R.E. Works (Ind.), extended over October and November of 1944. Owing to lack of information about flood heights it was attempted to keep the road 10 ft. above the plain level—on this basis river crossings were selected and adjusted on the ground. These were then joined by the shortest route consistent with a ruling gradient of 1 in 15 and a minimum radius of 90 ft. to the carriageway centreline and a 10 ft. trace was cut by pioneers. Finally a longitudinal section was taken along this trace, minor adjustments were made to avoid excessive cut and fill, and the cross drainage calculated. Though a soil survey along the route was very desirable in view of the projected method of construction this could not be made in the reconnaissance stages.

The bridging and culverting requirements were then computed. In all 145 bridges were needed (approximately 1.6 per mile) which were designed variously in Stock Span, Hamilton and Bailey equipment, to class 70 one-way specification throughout. Piers and abutments were, for the most part, to be of mass concrete, going down to 6 ft. below stream bed level or until a firm foundation could be reached. The span design was in no case spectacular, the longest being the 140 ft. triple-triple Bailey at Tamu. The bridge of greatest overall length was the 240 ft., 3-span Bailey, at Htinzin. Aggregate figures for the three types of equipment were as follows:—

Bailey	2,790 ft.
Hamilton	3,600 ft.
Stock Span	2,131 ft.

In addition numerous culverts were sited (on the average 5 per mile) for construction with corrugated iron rounds in six ins. of mass concrete.

On the basis of these requirements the construction plan was made and resources allocated to the job (see Table I). Work was under control of 3 C.'sR.E. (north, middle and south sections) but proceeded from a single face—units being transferred from one to the next as the face moved southwards. There was, however, a shortage of transport and machinery which persisted until April, 1945, in dislocating the balance of resources. Work commenced on the road in December, 1944.

For the purposes of this article the project may be considered in three separate categories; the Kabaw Valley sector (soil/P.B.S. construction); the Myittha Gorge sector on which (for reasons which will be described later) P.B.S. could not be used; and the bridging-culverting programme. Since the employment of P.B.S. on a large road is of such unusual engineer

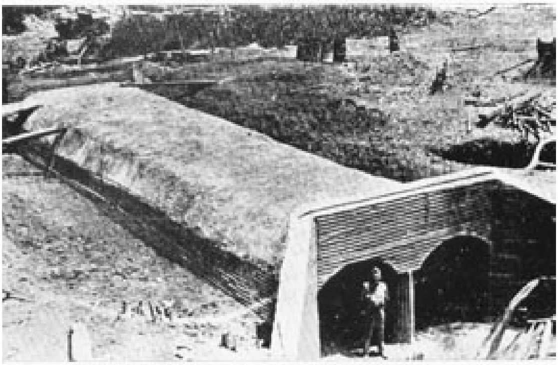
Preliminary earthwork.

Laying P.B.S.

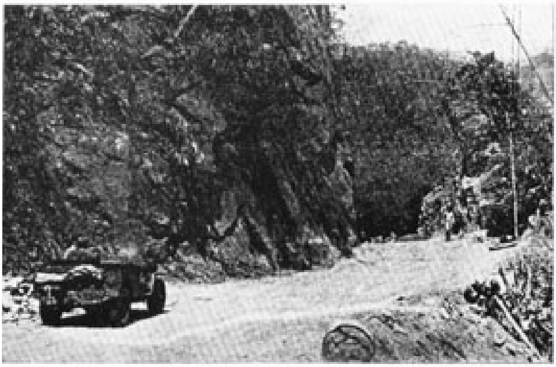
Transverse P.B.S. on bunds.

The Tamu-Kalewa road

Finished Road.



Concrete box culvert.



The Gorge Road.

The Tamu-Kalewa road 2

interest the bulk of this article will be devoted to the Kabaw Valley sector. Bridge and culvert construction proceeded on orthodox lines in accordance with the programme outlined above; and though it formed a very large and important part of the work it will not be mentioned again. The peculiar problems encountered in the Gorge sector will be briefly described at the end.

Kabaw Valley Sector

At this stage a brief account of the principles involved in soil construction methods might not be out of place. The bearing capacity of any cohesive soil depends upon two entirely separate factors; the inherent stability (physical grading) of the soil, which comprises all varieties and mixtures from sands to fat clay; and the moisture content, which can modify any such soil from dust through firm soil to mud. Normal soil stabilization implies control of the former factor (grading) by the admixture of a carefully graded complementary fill to the formation, thus ensuring a sufficient bearing capacity over a reasonable range of moisture conditions. The alternative method accepts the soil (within reason) as it stands and aims at controlling the moisture content at its most advantageous figure (i.e., that quantity of water which results in the soil compacting to its maximum density when consolidated—known as its Optimum Moisture Content). This may be done, within a limited class of soils, by the careful addition of water-repellent chemicals. The novel method of external sealing projected for the Kabaw Valley road gave promise of stabilizing a far wider range. There are, however, two conditions essential to the success of any moisture-control method; a formation soil potentially stable (hence the requirement for an initial soil survey—large scale importation of fill destroys the whole object of the system); and freedom from rainfall in the construction period so that the appropriate moisture content can be achieved. In the Kabaw Valley from December to May both these conditions were fulfilled.

The process of construction may be considered in three basic stages. Firstly, preparation of the subgrade or formation; which in this case involves not only the usual earthwork and grading but also the removal of all vegetable soil (which is highly unstable) and all stumps, roots, and rocks (which inhibit compaction around them). This is very important. It is undoubtedly desirable therefore to build such a road on a bunded formation and a 2 ft. bund was initially specified. When shortage of resources made this impossible a 6 in. minimum cut was accepted with consequent loss of strength to the road.

The second stage, that of compaction at O.M.C., requires still more careful control. In the absence of a soil survey the " squeeze " test may be employed to determine the correct condition. A handful of soil is taken and squeezed between the fingers; if it flows between the fingers it is too moist; if it fails to bind, too dry. If it binds without flowing it should be tossed 12 in. to 15 in. and allowed to bounce on the palm of the hand. With soil at O.M.C. it should break at second bounce. If the soil is too damp it must be allowed to dry out before rolling. If it is too dry the moisture must be increased; on this project lack of equipment precluded the use of mixing plant and pressure distributors (spraying alone affects surface layers only and is worse than useless); it was found, however, that moisture increased with depth of cut and excavation was continued till soil slightly above O.M.C. was exposed. This achieved, the formation is consolidated by thorough rolling.

Thirdly the compacted soil must be sealed in that condition. A waterproof, airtight seal is required over the wearing surface and berms, and must be sunk, as a cut-off, 18 in. into the bottom of the side drains. (See Diagram II.)

Thus a dumpling of compacted soil and air is formed which will resist not only water from above but also a rise of the watertable from below consequent on flooding. Any failure in the seal will obviously make a considerable length of road useless.

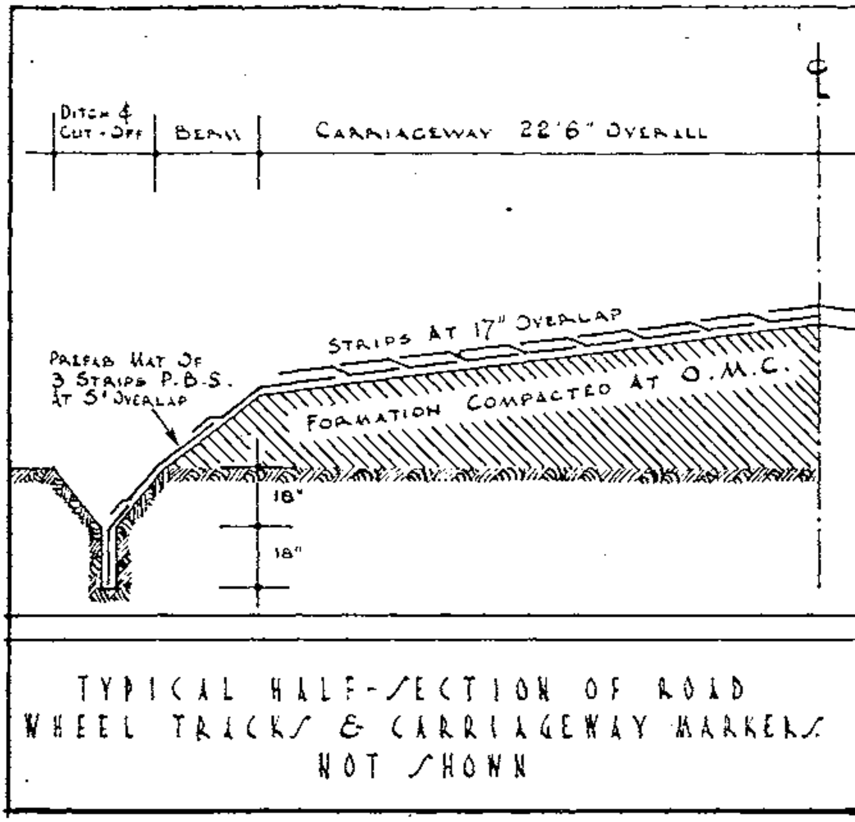


Diagram II

The actual sequence of construction that was adopted to conform with the above principles is summarized at Appendix II and calls for no special comments; certain points, however, are in connexion with the employment of plant and the laying of the P.B.S. seal which are worthy of record.

Mechanical equipment plant was used at all stages in the foundation work. Four or five D.8 Dozers would be engaged in clearing the 100 ft. trace assisted by explosives on all trees greater than 12 in. diameter. Trees and undergrowth were dozed to one side and a further four dozers followed to strip the vegetable soil from the surface accompanied by pioneers removing roots and shattered stumps, etc. Earthwork (cut and fill) was done by both scrapers and dozers; although the specification called for the placing of fill in 6 in. layers it was found that the plant generally placed 18 in. layers and this had to be accepted. Compaction was carried out by sheepsfoot rollers; tractors and scrapers do not produce satisfactory compaction for this type of construction, and, as it was, only the top 6 in. of an 18 in. layer could be adequately consolidated. Owing to an initial shortage of tractors these rollers were towed behind scrapers thereby slowing down the earth moving operations. It is recommended that one roller (plus prime mover) be employed for every scraper used—carelessness in compaction is paid for many times over in maintenance requirement. Cambering and drain cutting was done by auto-patrols; main drainage by dozers and scrapers (Killefer ploughs were not satisfactory) and final compaction by 10 ton smooth rollers. Elephants gave very useful service throughout in handling timber where mechanical plant could not be employed.

The P.B.S. used was of Indian manufacture (P.B.S. 5) supplied in 35 yds. rolls of 32 in. width. It was overlapped to double thickness (17 in. overlap for safety) on the carriage-way; single thickness on the berms and cut-offs (See Diagram II). Laying was done by hand throughout; following some 2 days behind the earthwork and rolling parties to allow for hardening after compaction.

The 22 ft. 6 in. carriage-way required a mat of 17 strips of P.B.S. (at 17 in. overlap) each mat covering 100 ft. length. A two days' task was set at a time, half the width being laid each day. The day before laying P.B.S. was dumped along the track, 17 strips per 100 ft., and the carriage-way edges set out, from the centre line pegs, in telephone wire.

On the first day eight strips were unrolled and laid in the sun, wearing side downwards, over the full width of the road, for fluxing. When the sun had eased the kinks and softened the fabric, solvent (normally 50 : 50 petrol/diesel oil) was sprayed on from cans at 2 to 3 gals. per roll and spread evenly by hessian mops on bamboos. When the sheets were considered fluxed (time varying with temperature) the first sheet was aligned along the carriage-way edge and successive sheets were positioned by 15 in. measuring sticks and lapped like the tiles on a roof (see Diagram II). Each sheet was tensioned longitudinally to ensure that it lay without rucking. On the following day the other 9 sheets were laid; the last being placed as a ridge tile down the centre line of the carriage-way. Subsequently 4 more strips were laid as wheel tracks (centres 2½ ft. and 7½ ft. from centreline either side) and the whole given an anti-skid dressing of petrol/kerosene and coarse sand. (This was later proved superfluous and was discontinued.) Corners of radius greater than 200 ft. were easily dealt with by laying the strips along the curved alignment; for sharper curves they were cut into 10 to 15 yd. lengths and lapped as for Sommerfield track.

Berms and cut-offs were sealed with prefabricated mats of 3 strips of P.B.S. at 5 in. overlap laid longitudinally. These were lapped under the outer strip of the carriage-way mat and sunk into thin 18 in. cut-off trenches dug at the bottom of the side-drains (see Diagram II). On the high bunds (over 4 ft.), however, it was necessary to lay the strips transversely owing to looseness of the surface. Sealing the whole of high bunds was well worth while since it allowed the dry angle of repose to be used in construction and prevented scouring under heavy rainfall. Since berms were sealed with single thickness, carriage-way markers were erected to ensure that they were used for parking only and not for overtaking. The most effective type of marker consisted of sandbags wrapped in P.B.S. and placed at 100 ft. intervals on either side of the carriage-way proper.

The progress of the work and its performance when completed, fully justified the risk taken in deciding to build with P.B.S. A length of bund laid by Gref in 1944 was adopted as an experimental stretch to finalize construction methods, to train Officers, N.C.Os and operators in soil selection and compaction, and to familiarize the Pioneer Companies with the handling of P.B.S. which being new to them, had initially aroused a certain degree of scepticism. This stretch was opened to traffic for 10 days in January during which time an average of 1,300 vehicles per day passed over it. The results were sufficiently encouraging for construction to proceed on the road as a whole. All types of soil from low compressibility clay to sand were encountered and utilized successfully. The only section requiring special treatment was a 5 ft. deep bog, at mile 3, of black, organic, spongy soil with very low capacity. This was cleared by hand and levelled—a single layer of P.B.S. was laid followed by 4 to 5 ft. of selected fill compacted in 6 in. layers. Over all the normal P.B.S. seal was placed and fluxed to the damp proof course below. This formed a totally enclosed soil mattress and has given no trouble since.

The Kabaw Valley road was opened as far as Kyigon (where the road enters the Myittha Gorge) by mid April. Though this was too late for the road to be completed through to Kalewa by 15th May there is no doubt that had the estimated resources been made available the target date would have been achieved. The road immediately came under heavy traffic, the average for May was 1,000 vehicles per day with peaks of 2,700.

Failures occurred at various points along the road as a result of faulty construction (mostly due to haste). For example vegetable soil had been left in the formation along certain stretches of road where a 6 in. cut had been adopted instead of the original 2 ft. bund. This was inevitable, as in virgin forest humus extends down to a depth of 18 in., and as a result trouble was encountered sometimes within a fortnight of laying. This was remedied by rolling back P.B.S. (replacing it if damaged), excavating all humus, roots and rocks, back-filling with 4 in. hand rammed layers of selected fill at O.M.C., cambering and relaying P.B.S. Carelessness with the moisture content on compaction also necessitates lifting P.B.S., and either permitting the formation to dry out or, if it is too dry, thoroughly mixing in water with harrows or mix-in-place machinery before re-consolidating. Up to ½ in. maximum of surface dust is acceptable provided that soil below is at O.M.C. Faulty sealing was due chiefly to manufacturing faults in the P.B.S. and could usually be spotted and remedied before serious damage was done. Insufficient cross drainage, however, can be far more serious; in one place 100 yds. of bund was washed out for this reason and necessitated complete realignment for that section; and in other places culverting was insufficient.

Eleven Pioneer companies and one Road Construction company have been employed on maintenance continually since the road was opened. As a result of their efforts the road has taken, during the monsoon, nearly twice the target figure of 350 tons per day up to the time of writing.

The Gorge Road

Work was not started upon the Myittha Gorge section of the road in earnest, until mid April; a fact which was most unfortunate for a number of reasons. L. of C. requirements demanded continual use of the existing P.W.D. road, by now reduced by ourselves and the Japs to a dustbound switchback pitted with 18 in. potholes and bereft of even the most rudimentary drainage. But under the circumstances no alternative alignment was feasible for the all-weather road, which had accordingly to be constructed from scratch on an alignment which the L. of C. traffic continued to employ. Moreover the rains were imminent and monsoon rain conditions make soil/P.B.S. construction virtually impossible. Moisture content cannot be controlled, rain and mud inhibit sealing of P.B.S., and mechanical equipment moving over soil above its plastic limit does far more harm than good.

For both reasons it was decided that the specification for this section would be stone rather than P.B.S. Soling and metalling can be placed and rolled under monsoon rain and will permit the passage of traffic during construction. The quarrying and importation of 75,000 tons of stone for this 18 mile stretch (as against 14,000 tons of surfacing for the 76 miles of Kabaw Valley road) was a commitment which was inevitably accepted. By the end of April it was clear that the target date of completion would have to be postponed by 2½ months and soling of the Gorge Road was not in fact completed until 1st August, while even then a very heavy maintenance commitment remained.

Nevertheless the road was a success in that it continued to transmit the required tonnage of stores (daily average of 600 tons for June). This was achieved by opening the road to construction and traffic in alternative 12 hr. periods, 05.00–17.00 hrs. for construction, the remainder for L. of C. use. Otherwise no problems of special engineer interest have arisen out of the Gorge road sector; its working remains a tribute to routine maintenance methods under extremely difficult circumstances.

CONCLUSIONS

The Tamu—Kalewa road project provides an ideal study of the advantages and limitations of soil/P.B.S. construction. The chief lessons may be summarized as follows :—

Advantages.—(*a*) Soil/P.B.S. construction requires, in surfacing material, approximately 1/20 of the tonnage needed for Telford macadam pavement.

(*b*) Speed of construction with equivalent resources is 2 to 3 times as great as for stone specifications.

(*c*) Soil/P.B.S. construction permits use of a much wider range of soils than can be stabilized by any admixture.

Disadvantages.—(*a*) Soil/P.B.S. construction cannot be employed under rainy conditions.

(*b*) Carelessness at any stage incurs almost immediate trouble and a heavy maintenance commitment.

Finally it must be stressed that (as with any operation) the key to success lies in thorough training of personnel involved in the principles underlying the system.

APPENDIX I

Allotment of Resources.

Units	Dec. 1944	Feb. 1945	Apr. 1945	Jun. 1945
Artisan Works Coys.	1	3	5	4
Mech. Eqpt. Pls...	2	3	4	2
Rd. Constr. Coys.	–	2	2	2
General Transport Coys. (incl. Tippers)	3	3	5	4
Indian Pioneer Coys.	13	25	31	30
Fd. Coys.	3	3	–	–
Rd. Roller Pls.	–	1	1	1
Elephant Coys.	½	½	½	½
Engr. Bn.	1	2	1	1
Quarrying Coy.	–	½	1	1
Forestry Coy.	½	½	½	1½
Tunnelling Coy.	–	–	–	1
Indian State Labour Units	–	–	–	4

Appendix II

Sequence of Construction

1. Clearing 100 ft. traces by explosive (12 in. trees) and dozing.
2. Removal of vegetable soil (Dozers), root stumps, and rocks (pioneers). Culverting was carried out simultaneously with this phase.
3. Cut and fill to bring formation to required level. 10 ft. service track graded.
4. Consolidation with sheepsfoot rollers.
5. Grading, cambering and super elevation by auto-patrols.
6. Side drain cutting by auto-patrols with blades at 45°.
7. Rolling with 10 ton smooth rollers.
8. Laying P.B.S. carriage-way.
9. Laying berm protection.
10. Digging cut-off trench (18 in.) and installing cut off.
11. Construction of main drainage.
12. Installing P.B.S. wheel tracks, anti-skid surface and carriage-way markers.

Appendix III

Quantity and Time figures. P.B.S.

(*a*) Quantity of P.B.S. required per mile of road. (22 ft. 6 in. carriage-way plus berms, cut-offs and average amount of bunds)—150 tons (13 rolls per ton).

(*b*) Solvent per mile at 3 gals. per roll (50/50 petrol/diesel or petrol/kerosene)—2,700 gals. petrol. 2,700 gals. diesel or kerosene.

(*c*) Laying. An average party of 20 men will lay per man 4½ rolls/day on level carriage-way and 2½ rolls/day bund, berm and cut-off. Allocation—16 layers, 2 measurers, 1 solvent man, 1 mop man, Tools—4 half-drums for mixing, 6 No. 2 gal. spray cans, 6 mops.

Note

It is felt that this method of construction opens up such a vast new and important field in military engineering that it is to be hoped all officers interested will aid in further research and study of the object. C.E., ALFSEA will be glad to answer any further enquiries.

AN OUTLINE OF ENGINEER WORK IN THE ITALIAN CAMPAIGN

BY MAJOR-GEN. N. A. COXWELL-ROGERS, C.B., C.B.E., D.S.O.

NOTE :—The title " Headquarters, Allied Armies in Italy " (H.Q.A.A.I.) has been used throughout this narrative to denote the headquarters which for part of the time was designated H.Q. 15th Army Group.

I.

IN this article the episodes which are described in some detail to illustrate the conditions and problems with which the Engineers were faced in Italy, are those in which British, Dominion and Indian Engineers were concerned. No attempt has been made to give an account of the great exploits of the American Engineer units of the Allied Armies in Italy.

2. OBJECTS OF THE CAMPAIGN

One object of the invasion of Italy was to establish an allied strategic Air Force in the Foggia area and provide for it a secure base from which it could attack those parts of Europe which were inaccessible to aircraft based in England.

The other object was the destruction of the German Armies in Italy.

3. THE PLAN

Eighth Army was to cross the Straits of Messina and advance up the Calabrian Peninsular. Fifth Army, composed of the 6th U.S. Corps and the 10th British Corps assembled in North Africa, was to land on the beaches just South of Salerno with the object of capturing Naples and establishing the future main base of the armies in Italy. A British Airborne Division then in North Africa, followed later by H.Q. 5 Corps and 78 Division, were to go by sea to Taranto in order to secure that port and drive the few Germans in the area northwards with a view to capturing the heel ports of Brindisi and Bari. The final decision to launch this force against the heel was not made until it was known that the Italians had surrendered and that there would be no opposition to the landing at Taranto.

4. THE ENGINEER PROBLEMS

Anybody who knows Italy or studies a map of Italy will appreciate how great were the engineering problems that would be encountered due to the physical configuration of the country.

There are comparatively few good tarmac roads leading northwards through Italy. On the East coast there is virtually only one road. This crosses innumerable watercourses which are liable in winter to big spates. West of the Central Apennines there are two main roads leading North from Naples to Rome, thence there are four roads, converging into three roads before Florence is reached. Many parts of these roads are tortuous with steep gradients and untarred stretches. They all cross many mountain streams, watercourses and occasional ravines. Good lateral roads are few and all go over high mountain passes. The main rivers West of the Apennines between Naples and Florence are the Volturno (350 ft.), the Garigliano (350 ft.), the Tiber (600 ft.), and the Arno (450 ft.), all perennial rivers with high banks. There are a countless number of smaller rivers from 80 ft. to 250 ft. in width.

Our assault bridging equipment was limited to Mk. 2 and Mk. 3 Assault boats, Kapok and such rafts as could be made out of standard Folding Boat equipment. Superstructures for Class 5 and Class 2 rafts were only just coming into production in England and it was not until late in the campaign that we were to receive any Class 9 Close Support rafts or Class 50/60 Heavy rafts.

The standard of training in bridging of the majority of Engineer units on the order of battle gave some cause for anxiety. Those who had fought in the North African campaign had training and experience in dry Bailey bridging but had little or no experience in Bailey Pontoon bridging. With the exception of the Engineers of the Canadian Corps, nearly all the other Engineer units came from the Middle East, where they had no opportunity for training in bridging because little Bailey equipment had at that time reached the Middle East. We had, therefore to make great efforts to provide training facilities in the limited time before the invasion of Italy and also to provide at an early date training facilities in Italy.

5. Landings in Italy and the Capture of Naples

The landings in Italy were successfully accomplished according to plan. Eighth Army crossed the Straits of Messina unopposed, making contact with a retreating enemy some miles inland. On the 9th September the Airborne Division landed unopposed at Taranto, followed later by H.Q. 5 Corps and 78 Div. On the same day Fifth Army landed on the beaches south of Salerno, achieving tactical surprise. Eighth Army advanced rapidly up Calabria, the chief delay being caused by demolitions. During this advance 24 Bailey bridges were built and 12 fair weather airfields constructed in the space of fifteen days. By 15th September contact had been made between Eighth and Fifth Armies and by the Airborne Division with the right flank of Eighth Army. Work was started on opening the lateral road Bari-Potenza-Salerno, a task which involved the construction of a considerable number of Bailey bridges.

At Salerno, after a critical period a few days subsequent to the landing, the build up of Fifth Army continued rapidly. Engineer work consisted of the construction and maintenance of the exits from the beaches, the repair of roads, a certain amount of bridging, the repair of Montecorvino airfield and the construction of a number of temporary fair weather landing grounds. On the 22nd September, Fifth Army advanced on Naples, meeting extensive demolitions on all roads. The advance continued until it was halted by the enemy at the River Volturno. The dock area in Naples and a part of the town of Naples had been destroyed by allied air attacks and enemy demolitions. A large number of delay action mines remained in the area. L. of C. Engineer units moved quickly into Naples and started the big task of clearance and repair of the docks, repair of the town water supply system and the search for and removal of demolition charges and delay action mines.

6. The Crossing of the Volturno by Fifth Army

The Volturno river was the first perennial river of any size which had yet been encountered. It was some 350 ft. wide, with high banks and, as we were soon to know, subject to heavy spates. After considerable preparation, engineer reconnaissance and mine clearance, an attack was launched by Fifth Army on 12th October, 6 U.S. Corps being on the right and 10th British Corps, consisting of 46 and 56 Divisions, on the left. Shortage of pontoon and folding boat equipment, due to difficulties of supply from the Salerno beaches, made it necessary to adopt a cautious bridging plan. The only assault equipment at that time available consisted of assault boats and decked folding boat rafts. 10th Corps quickly designed and made in their Field Park

Workshops an admirable superstructure for fitting on two folding boats to provide a Class 5 shore-landing raft. This 10th Corps pattern Class 5 raft eventually proved rather more satisfactory than the Class 5 equipment sent out later from England.

The crossing of the Volturno river emphasized the importance of rafting as it proved impossible to get a bridge across on the front of 10th Corps for a considerable time after the infantry assault. The first bridge on the 10th Corps front consisted of a Bailey bridge constructed across the timber piers of a temporary bridge which had been built by the Germans. A Bailey pontoon bridge was built at Capua (see Plate 1). Owing to the amount of earthwork necessary on the approaches it took 48 hrs. to complete. The Americans on the right used treadway bridge equipment and also built a heavy pontoon bridge. Work was started by American engineers as soon as the tactical situation allowed on high level, two-way, timber bridges, one at Capua (see Plate 2) and another about 4 miles upstream. These were completed by 7th November, fortunately before the first spate occurred. This spate came down the river and wrecked all the floating bridges in Fifth Army sector. Some damage was also done to the high level bridge at Capua. Useful lessons were learnt as regards the danger of debris and the best method of securing floating bridges. A number of additional high level Bailey and timber bridges were constructed over the Volturno during the winter.

7. The Advance of Eighth Army

In the meantime Eighth Army had been advancing up the East coast. North of Barletta they began to encounter demolitions on a big scale. Every road and rail bridge was found destroyed and even the railway tracks and sleepers had all been cut. Opposition by the Germans increased and heavy rain added to the difficulties. The rivers Fortore, Biforno and Trigno were crossed and bridged against determined opposition. Over the Trigno a 340 ft. Bailey bridge supported on steel cube piers was constructed in 36 hours in replacement of low level bridges built during the assault phase. By early November, Eighth Army with 5th Corps on the right and 13th Corps on their left had reached the River Sangro. Trouble was being experienced due to the condition of the coast road beyond Termoli. On this road three divisions had to be maintained. It was a bad waterbound road, barely two-way in width and through villages only one way. There was no stone within fifteen miles, except for gravel from the rivers.

8. The Sangro Battle

The Sangro Valley is commanded on the south side by the Paglietta Ridge, about 500 ft. high and at a distance varying from 500 to 2,000 yds. from the river. On the North side of the river there is an escarpment 1,500 yds. from the river and about 50 ft. high. The ground then rises gradually up to the Colli Ridge, from which the Germans had perfect observation over the Sangro Valley with the exception of some dead ground at the foot of the escarpment. A road runs parallel to the river on both the North and South sides. The Southern road is from 700 to 1,000 yds. from the river and the Northern road is about 2,000 yds. from the river. The width of the river at the main road bridge, two miles from the river mouth, is 1,000 ft. Above this bridge it becomes narrower, until at the Paglietta Bridge, 2½ miles upstream it is only about 400 ft. wide. There are normally a number of small water channels in the river bed which in dry weather are fordable by both men and vehicles. After heavy rain the river is liable to rise very quickly.

5th Corps, consisting of 78 Division, 8 Indian Division and an Armoured Brigade, was ordered to attack across the Sangro on the axis of the coast road.

The first objective was the capture of the high ground immediately overlooking the river, followed by the capture of the small port of Ortona and an advance to the Pescara river. The main attack was to be preceded by a preliminary operation by a Brigade of 78 Div. to secure the start line on the escarpment.

The tasks of the Divisional Engineers prior to and during the assault phase of the operations were the bridging of a mill race which crossed the approaches to the river, work on the approaches to the fords, construction of one F.B.E. bridge, and the bridging of some gaps in the main road between the river and the escarpment. Corps Troops R.E. were made responsible for the building of low level bridges as soon as the situation permitted and also for the construction of a high level Bailey bridge at the site of the demolished Paglietta bridge. To 8th Army Troops, R.E. was given the task of building a 1,200 ft. high level Bailey bridge where the coast road crossed the river.

The preliminary operation was successfully accomplished on the night 19th/20th November. The next day heavy rain fell; the river rose quickly putting all fords out of action and only one folding boat ferry was kept in operation.

On the night 21st/22nd November, work was started on low level Bailey bridges. By next morning one crossing for wheel vehicles, consisting of one 30 ft. Bailey and one 140 ft. Bailey, had been completed and at another site a 100 ft. Bailey was built to provide a tank crossing. On the following night a third bridge (140 ft. Bailey) was built. Then came the first serious spate. Nothing could be seen of the bridges except the tops of the girders in the middle of a sheet of water, 1,000 ft. wide. Next day the water level dropped quickly and it was discovered that the only damage was to the approaches to the bridges.

By 26th November, three low level bridge crossings were in action. The main attack was launched that night. A fierce battle ensued and it was not until the 30th November that the enemy was driven off the high ground and denied close observation of the river.

During this time, two of the low level bridges across the river were knocked out by direct hits and replaced by new bridges. Divisional Engineers built a 50 ft. and a 100 ft. Bailey bridge on the road leading North from the river right under the nose of the enemy.

On the 27th November preliminary work started on the high level Paglietta Bridge. In order to save time it was decided to build temporary piers of steel cubes on the river bed and to replace them as soon as possible by Bailey Panel piers on the foundations of the old piers. On the 4th December this bridge, 350 ft. long supported on three twenty foot steel crib piers, was opened to traffic. Two hrs. after the bridge was opened, the river had risen six ft. and was alleged to be flowing at a rate of ten knots. By midnight one pier had collapsed and every other bridge had become impassable (see Plate 3). The 8th Indian Division, the 78th Division and the 1st Canadian Divison, who were relieving them, were thus cut off from the road communication with the South bank of the river. On the afternoon of the next day, the 5th December, the river level had fallen sufficiently for the work of repair to Paglietta bridge to be started. At the same time the construction of another 350 ft. bridge, partly folding boat equipment and partly Bailey equipment, was begun. By the 7th December both these bridges were in operation and an anxious period came to an end.

The building of the 1,200 ft. Bailey bridge (see Plate 4), at the site of the demolished bridge on the coast road began on the 7th December. The bridge was the longest Bailey which had at that time been constructed and was completed by the 17th December after ten days' work. It was a triumph of good organization. All the equipment, plant and stores, had to be brought along a narrow winding road which at the same time had to carry the maintenance traffic of three divisions.

9. Winter, 1943/44

After the capture of Ortona, operations on the front of 8th Army came to a standstill. Conditions of snow, rain and mud prevailed. By the end of December 323 Bailey bridges had been built amounting to a length of six miles of bridge.

During the winter engineer resources were fully stretched. The main tasks were construction of Jeep tracks, repair and continual maintenance of roads that were fast disintegrating, snow clearance, replacement of Bailey bridges by permanent or semi-permanent structures, hard standings and the provision of accommodation and amenities for the troops.

Italian Engineer companies were formed. They provided labour for road-work and a number of skilled tradesmen for work in Field Park Coy. workshops. Civilian labour both skilled and unskilled was organized and put to work.

10. The Garigliano and Anzio Battles

In December, plans were made for an offensive operation by Fifth Army. The plan was as follows :—

(*a*) An attack by 2 U.S. Corps (right) across the River Rapido, and by 10th British Corps on the left across the Garigliano.

(*b*) An amphibious landing on the beaches at Anzio by the American 6th Corps which included one British Division and at a later date two British Divisions.

The Garigliano river varies in width from 250 to 400 ft., with banks from 15 to 20 ft. high. The valley is narrow with steep hills on either side until it nears the sea, where it opens out into a marshy plain, part of which had been flooded by the Germans. Throughout its length it is dominated by hills rising to mountains on the German side. The only metalled approach was along Route 7, though a single line rail track further inland provided another possible hard approach. The whole front was heavily mined.

Engineer patrolling and mine clearance were continuous every night for some time before the attack. Engineer Officers swam across the river to obtain valuable information. The attack of 10th Corps went in on the night of 17th/18th January, and met with initial success. By next morning R.E. had Class 2 and Class 5 rafts in operation at four sites and by 10.00 hrs. a Class 40 raft also in operation. All these crossings were still under observed small arms and mortar fire. The rafting equipment had been carried on jeeps and trailers for this operation on account of the difficult approaches. In one case the equipment for a Class 5 raft had to be man-handled a distance of 2,000 yds. By 02.00 hrs. on the 19th the first Folding Boat bridge was completed but shortly afterwards was put out of action by a lorry being blown up by an undetected mine under one of the approach ramps. Owing to enemy fire, work on the first Bailey Pontoon bridge did not start until the evening of the 19th. It was eventually completed by the afternoon of the 20th, work having been carried out during daylight under a smoke-screen. Gradually the bridgehead deepened but the situation stabilized with the Germans still in possession of ground giving them direct observation throughout the whole length of the river. Additional pontoon and folding boat bridges were constructed. All these bridges remained under enemy observation until the Cassino battle in May. Their maintenance was a difficult problem and employed continually a comparatively large number of Engineer units.

The situation was materially helped by the use of smoke to conceal all crossings during daylight.

In the meantime the landing at Anzio had achieved tactical surprise but the Germans, who held all the commanding high ground, managed to seal off the bridgehead. During the critical period, a few days after the landing, all the Divisional Engineers had to be employed in an infantry role. The port of Anzio was opened by an American Shore Regiment, hards being built to take L.S.T's. and other landing craft. Until the breakout of the bridgehead in May the perimeter was only some eight miles deep. Engineer work was, as usual, primarily devoted to the repair and maintenance of roads, the construction of emergency landing grounds and the development of the port and beaches to facilitate supply. Here again, a continuous smoke-screen over Anzio beaches was most effective.

11. The Spring Offensive and the Battle of Cassino

The intention was to destroy the right wing of the German 10th Army and to pursue the remnants of the 10th Army and 14th Army to the Rimini—Pisa line. The first objectives were the capture of the airfield at Viterbo and the port of Civitevecchia.

Eighth Army was moved from the East coast and concentrated West of the central Apennine ridge, leaving one Corps on the East directly under command of H.Q. A.A.I. Under command of Eighth Army were the Polish Corps, 13th Corps and the Canadian Corps. They had to capture the Cassino feature, cross the Rapido river and advance with their left flank on the river Liri, eventually passing to the East of Rome, Fifth Army, on the left, consisting of the French Corps and the 2nd American Corps were to attack on the front between the Liri valley and the sea, their only good maintenance road being Route 7 running along the coast. The French Corps was directed across a roadless and waterless tract of mountainous country with the object of cutting the line of retreat of the Germans opposing Eighth Army. At a date to be decided later the Corps at Anzio, also under command of Fifth Army, was to attack and get astride the line of retreat of the German forces on the main front.

Immediately in front of Eighth Army was the Rapido river. Beyond, astride the line of advance, was the Tiber and its tributaries and a large number of smaller rivers and mountain torrents. Route 6 through Cassino had been completely obliterated by the intense air bombardment and by shell fire.

The immediate tasks of the Eighth Army Engineers were the opening of Route 6 and the railway running parallel to it as a road through Cassino, the bridging of the Rapido river between Cassino and its junction with the Liri river and the construction of M.T. tracks up the valley.

The Rapido river is only about 80 ft. wide, but is deep and fast flowing. There are two episodes of particular engineer interest in the crossing of this river. A mobile Bailey bridge was used by the Engineers of 8th Indian Division successfully for the first time in Italy. The bridge was built on a Sherman tank and pushed forward by another Sherman tank to the river bank. The original design had been prepared by the Canadian Engineers and developed by 8th Indian Engineers. Although in the fog and confusion on the first morning of battle the site which had previously been reconnoitred could not be found, yet it was successfully launched at another site when our Infantry had only just reached the far bank of the river.

On the 4th Division front no bridges were got across during the first night and maintenance of the Division continued throughout the next day by ferry. It was essential to get a bridge across on the second night and, although the river was still under direct observed small arms fire and heavy mortar fire, two Companies of 4th Division Engineers were ordered to construct a 100 ft. Class 40 Bailey bridge that night. Working in relays under heavy fire, they completed the bridge by 05.30 hrs. the next morning, having lost 15 killed and 57 wounded including 3 Officers.

The organization for the opening of Route 6 to Cassino and also for opening the railway as a road is of interest. An Engineer Task Force known as the Cassino Task Force was formed by the Chief Engineer. This consisted of the following :—

South African Corps Troops.
Three South African Road Construction Companies.
A Quarry Company.
Two Mechanical Equipment Platoons.
Five G.T. Platoons.
A Detachment of a Light Transporter Platoon.
Three Pioneer Companies.
120 Tippers.

37 Bulldozers were allotted for the operation with a further 18 in reserve. The whole force was under command of the C.R.E. South African Corps Troops and formed up in an assembly area on D+1 day. An elaborate system of communication was organized and careful plans, based on air photographs, prepared.

On the 17th May it was possible to start work on the railway, although it was still under shell fire, and, in some places under mortar fire.

By midday on the 19th the railway for a distance of four miles had been turned into a two-way Class 70 road. Three Class 70 bridges had been built, 23 culverts put in, and 50 ft. of demolished embankment repaired. The whole road was surfaced by blading the ballast with motor graders.

On the morning of the 18th May it was possible to start work on Route 6 through Cassino. Here 2 bridges, each of 80 ft. span were built, some 50 craters filled and the whole road for a distance of two and a half miles cleared for two-way traffic by 1400 hrs. on the 19th. This operation is a good example of the effect of using mechanical equipment in a large concentration. Work continued day and night.

12. The Pursuit to Florence

From the Engineer point of view, the pursuit was one of continuous bridging and road construction. The chief problem was to maintain the supply of bridging. During the period from May to July more than 350 Bailey bridges were constructed, an equivalent overall length of 8 miles.

On the West coast, the American Fifth Army opened the devastated Port of Civitevecchia with great speed, making the supply of bridging and engineering materials to them an easier problem than to the Eighth Army. By the end of July the general line Ancona-Florence-Leghorn had been reached and the river Arno crossed and bridged.

The withdrawal of the French Corps, an American Corps and various ancillary units for a landing in the South of France slowed down the pursuit and made changes of plan necessary. The decision was now made to move Eighth Army back to the East coast and to launch the main attack against the Gothic Line on that flank. The move of Eighth Army involved the opening of the two lateral roads leading from Foligno across to the East coast. Orders were issued on 4th August for work to start. In ten days 40 bridges were constructed on these roads and by the 25th August, Eighth Army was concentrated ready to start its advance towards the Gothic Line.

Initial surprise was achieved and the Gothic Line was penetrated by the

3rd September. This advance was against the grain of the country and involved bridging on an unprecedented scale. It was during this battle that armoured Engineers were first employed in this theatre. The "Ark," which was the main equipment of the first Armoured Engineer unit to be formed in Italy, proved its worth and, although insufficient of them were available, they undoubtedly helped towards the success of the operations.

In the meantime Fifth Army were advancing through the Northern Apennines and meeting extensive demolitions. Not only had the bridges been destroyed but long stretches of mountain road had been completely obliterated. Timber cribbing was used extensively, in particular on the repair of route 67 (see Plate 7). Bridging was not made easier by the restricted amount of room available for assembling and launching. In some cases piers up to 60 ft. in height had to be constructed.

By the end of December, after sixteen months fighting, the number of Bailey bridges built had reached a total of One thousand nine hundred and twenty. One thousand and ninety four Bailey bridges had been dismantled and the greater proportion replaced by permanent bridges.

The Engineer battle that Winter was harder than in the previous one. The greater part of the front lay in the Northern Apennines where roads are few and where snow or rain was almost incessant until February. Conditions on the low lying river Senio sector were no better. Torrential rain fell at the beginning of November. At H.Q. A.A.I., in the woods near Sienna, 7 in. of rain came down in less than 24 hrs. The river Arno overflowed its banks, reaching a level just higher than the previous record exactly one hundred years ago. The water was lapping the transoms of the Bailey bridges which were about 15 ft. above normal river level. On that day all roads leading Northwards from the Arno were cut and all roads between Florence and Rome were cut.

13th Corps, then under command Fifth Army, were holding a sector in the mountains where road and track conditions were at their worst. Mules carrying supplies in the forward area frequently sank up to their bellies in the mud. The condition of the few roads became such that only six-wheel drive lorries could get along them, and even in a Jeep chains on the wheels were generally necessary and low reduction gear had almost continuously to be engaged. There was considerable doubt whether stone could be quarried, crushed, transported and put on the roads fast enough to defeat the combined efforts of traffic and weather to obliterate them. In the end, British and American engineers backed by American six-wheel drive tippers managed to win.

Although all engineer units were fully employed, it was essential to get both American and British engineer units out for training in floating bridging and rafting in preparation for operations in the Po Valley in the spring.

New equipment, such as the close support raft and the Class 50/60 raft, had arrived but no units had yet any opportunity to train with this equipment.

13. Preparations for the Spring Offensive

Operations in the Po Valley and beyond were going to present considerable engineering problems. We were faced by the River Po, with an average width of 1,000 ft., liable to be in flood in April which was about the date we expected to reach the Po. Beyond, there were a succession of formidable rivers, varying in width from 350 ft. to 1,500 ft. There was also considerable danger of floods which could be engineered by the enemy from the Po and the Adige.

By this time we were well supplied with Floating Bridge equipment.

We had also now received a number of Class 10 close support rafts, storm boats and Class 50/60 rafts. One of the problems was to design and provide the most rapid means of constructing high level bridges over these wide rivers. We knew the difficulties of trying to maintain floating bridges and their vulnerability. Individual spans of the bridges over the Po varied in length between 230 ft. and 280 ft. Therefore, even if, as we hoped, we could build Bailey piers on the foundations of the old piers yet the gaps between piers would be too wide for standard Bailey equipment. The possibility of constructing pile piers was considered, but from all the evidence available it appeared that this was not a practical proposition on the lower reaches of the river where Eighth Army would cross. Various designs for reinforced Bailey bridges, and also a design for a suspension bridge, were prepared at H.Q., A.A.I. Eventually, the South African Engineers developed a design for a continuous reinforced Bailey bridge which was accepted as the best solution to the problem.

For the construction of a Bailey Pontoon bridge and the high level Bailey bridge over the Po on the main Army axis, the C.E. Eighth Army formed the Po Task Force. It was under command of the Commander 22nd A.G.R.E., and composed of Eighth Army Troops R.E., the South African Corps Troops and other units. This force was given a period of intensive training before operations began. Load trials of the high level special continuous Bailey bridge and a rehearsal of constructing and launching it were carried out.

At the S.M.E. a series of special courses were run to train raft commanders and stormboat crews. A cadre of Officers and N.C.Os. from nearly every Field unit, which was going to take part in the forthcoming operations, attended these courses. Remembering the history of the operations on the river Piave in the last war, a number of Italian partisans, who were skilled watermen, were collected, formed into a unit and given training in British rafting equipment at the S.M.E.

The American Fifth Army established a temporary training centre on the Arno near Pisa where a number of Engineer regiments were given training in rafting and floating bridging.

During the winter the Armoured Engineer Brigade was formed and trained. The composition of this Brigade was as follows :—

One R.A.C. Regiment (51 R. Tanks, consisting of 1 Squadron of Flails and 2 Squadrons of Crocodiles).

Two Armoured Engineer Regiments, each consisting of 3 Squadrons, equipped with A.Vs. R.E., Arks and tank dozers.

One Armoured Engineer Park Squadron.

The "Ark" had been produced in Italy and consisted of a turretless Churchill tank to which were attached fore and aft two American treadway tracks. Experience during the Gothic line battle had shown that in the preparation of an "Ark" crossing the assistance of tank dozers and an A.V.R.E. was usually wanted. It was this experience that influenced the final organization of the Armoured Engineer Regiments. One Squadron of the Second Armoured Engineer Regiment was specially trained in the handling of mobile bridges.

During the early months of 1945, the Canadian Corps, one Bridge Company, one H.Q.A.G.R.E., and two complete G.H.Q. Troops R.E., as well as other ancillary units were withdrawn from the theatre to North West Europe. This serious loss was in part made good by forming a new G.H.Q. Troops from three independent Field Companies (two from the Balkans) and an Artisan Works Company converted into a Field Park Company.

14. The Object and Plan of the Operation

The object was to destroy the German Armies South of the Po, and pursue and destroy the remnants in Northern Italy.

The outline plan was as follows :—

Eighth Army was to attack first, northwards across the rivers Senio and Santerno and break through the Argenta Gap along Route 16, thence to swing between the Reno and Po and cut the German line of retreat from the Bologna–Imola pocket. It was not anticipated that Eighth Army could make rapid progress across the series of river obstacles which were astride the line of their advance. The main punch was, therefore, to be the attack of Fifth Army out of the mountains West of Bologna. This was timed to be launched several days after the Eighth Army attack, with the expectation that the German reserves would be so far committed opposite Eighth Army, that Fifth Army with a left hook would be able to complete the encirclement of the enemy South of the Po. In addition to this enveloping movement both Fifth and Eighth Armies were to cross the Po and press northwards towards Verona and North East Italy respectively.

15. Eighth Army Engineer Plan

Divisional Engineers and Armoured Engineer Units under command of divisions were responsible for the preparation of all the assault crossings over the various rivers and canals. The work included rafting, low level Bailey bridges, " Ark " crossings, Folding boat bridges, and mobile Bailey bridges.

Corps Engineers had as their primary task the opening of the main Corps axis, including high level bridges. They were employed well forward in the divisional areas so that they could take over at the earliest moment the bigger bridging projects, thus leaving Divisional Engineers free to support the leading infantry and armoured units. For the first phase of these operations 5th Corps Troops R.E. were reinforced by one G.H.Q. Troops R.E. consisting of a Field Park Company and three Field Companies.

22nd A.G.R.E., composed of two G.H.Q. Troops R.E., and a Road Construction Company, under command of the Chief Engineer, Eighth Army, were put in support of 5th Corps. Prior to the beginning of operations they took over all road and bridge maintenance well forward into the Corps area. Their particular tasks were the development of Route 16 forward of Ravenna as a Class 70 road, including high level bridges, and the building of a pontoon bridge and high level Bailey bridge over the river Po on the main Army axis at Pontelagescuro.

16th A.G.R.E., under command of the Chief Engineer Eighth Army, was to support the Polish Corps and 10th Corps with the primary task of developing route 9 as a Class 70 road.

Under command of the Deputy Chief Engineer (Works) Eighth Army, were two Road Construction Companies, one Field Company, three L. of C. Companies, part of a Harbour Construction Group and an oil pipe line construction group. Their chief tasks were road maintenance, replacement of Baileys on the main roads by permanent structures, the extension of the oil pipe line and repairs to essential local utility services. An H.Q.A.G.R.E. and three Airfield Construction Groups were allotted to Eighth Army for construction and maintenance of airfields required by the Desert Air Force and for the repair or construction of additional airfields North of the river Po.

Bridge Company units and G.T. Platoons were allotted to Corps before the start of operations, a reserve being held under the hand of the Chief Engineer of the Army. Army bridging dumps were established at Forli and Ravenna holding a total of one hundred Bailey Sets, nineteen Bailey Pontoon Sets, twenty-nine Folding Boat Sets, and a quantity of Assault Boats, Storm Boats, Raft superstructures, etc. Replenishment of these dumps was from the advanced Engineer Depot at Ancona under Army Group Control.

16. The Po Valley Battle

Before reaching the Po, Eighth Army had to cross the rivers Senio, Santerno Reno, Sillaro and Idice and several canals. These rivers all of which flowed between high flood banks, varied in width between flood banks from 150 ft. in the case of the Senio to 600 ft. in the case of the Reno.

After preliminary operations in the Commachio area, which included the building of a 250 ft. Bailey Pontoon bridge over the Reno by the 56 Divisional Engineers, the main attack across the Senio went in on the night of 9th/10th April, 5th Corps being on the right and the Polish Corps on the left. The attack met with success and thereafter operations developed rapidly, the river Po being reached by 6th Armoured Division on 23rd April. The rapidity of the advance was in a great measure due to the work of Divisional Engineers and of the Armoured Engineer Regiments in the preparation of assault crossings over the many rivers and canals and also to the speed at which Corps, Army and G.H.Q. Engineer formations followed up with high level bridges.

The work of the New Zealand Divisional Engineers and 20 G.H.Q. Troops during the first 12 days of these operations are typical examples, illustrating the scale of bridging operations. During the night of the assault over the Senio the New Zealand Engineers built three low level Bailey bridges, two high level Bailey bridges and a scissors bridge, all under small arms and mortar fire which knocked out several lorries carrying bridging equipment. By the 22nd April, 12 days after the beginning of the operations, the New Zealand Engineers had taken part in assault crossings over four rivers and two canals in the course of an advance of some 50 miles. During these 12 days they had built thirteen low level Bailey bridges, nine high or medium level bridges of between 80 and 120 ft. span, one Scissors bridge, and one "Ark" bridge and, in addition, had dozed twelve assault crossings for tanks across canals. In the same period of 12 days 20 G.H.Q. Troops, consisting of three Field Companies, built sixteen bridges of a total length of 2,000 ft. including one 500 ft. Class 40 bridge.

Fifth Army had started their main attack on 16th April and in spite of considerable opposition, 10th Mountain Division reached the Po at San Benedetto by the 23rd. Bridging on this axis, although considerable, was on a smaller scale than on Eighth Army front.

Enemy resistance had now become disorganized, especially in front of Fifth Army. On the front of Eighth Army, 5th Corps on the right were opposed on the river Po, but in front of 13th Corps on the left there was considerably less opposition. The Americans got a bridgehead across the Po on the night of 23rd/24th April, and by the evening of 25th April had completed a 1,000 ft. treadway bridge across the river. On Eighth Army front, 13th Corps (6th Armoured Division and the New Zealand Division) established bridgeheads during the night 24th/25th April and 5th Corps (56th Division and 8th Indian Division), established bridgeheads against considerable opposition on the night 25th/26th April.

By the afternoon of 25th April the New Zealanders had constructed a Folding Boat bridge 500 ft. long across the Po and by midday on 27th April they had completed a 400 ft. Folding Boat bridge across the Adige. The first Bailey Pontoon bridge (1,090 ft.) across the Po was completed by Eighth Army Troops at Pontelagoscuro on the night of 27th April, having taken 40 hrs. to build. Another Folding Boat bridge was completed by 5th Corps Troops on the evening of 26th April and a second Bailey Pontoon bridge, 1,110 ft. long was completed by 13th Corps Troops on the evening of the 29th.

In the meantime Fifth Army Engineers had completed three more Treadway bridges, one Bailey Pontoon bridge and one Heavy Pontoon Bridge over the Po. By the 29th, two Bailey Pontoon bridges each about 400 ft. long and a second Folding Boat bridge 490 ft. long, had been completed by Eighth Army across the Adige. The South African Corps Troops Engineers started work on the high level Bailey bridge (Springbok) at Pontelagoscuro on 26th April and it was opened to traffic on 4th May. This bridge, consisting of four spans, was 1,010 ft. long, carried on Bailey panel piers built on the foundations of the piers of the old bridge (see plates 5 and 6). It required 750 tons of Bailey equipment, using the reinforced Bailey designed by the South Africans and referred to previously.

At Ostiglia the American Engineers constructed a two-way Class 40 timber pile bridge, which was completed on 19th May, after twenty days work. An additional bridge consisting of Bailey equipment on barge piers, designed to allow for a rise and fall in the river of 25 ft., was built by 10th Corps Troops R.E., near the site of Springbok Bridge at Pontelagoscuro.

Beyond the Adige little organized resistance was encountered but nearly all the bridges across the rivers of the Venetian plain were found either damaged or destroyed. The end came on 2nd May.

During the period 9th April to 2nd May, on Eighth Army front, 252 bridges were built, amounting to a total length of just under 5 miles.

On Fifth Army front, 120 bridges, including 85 Bailey bridges and 11 Treadway bridges, had been constructed.

17. Bridge Construction

I doubt if in any other campaign has bridging been on so big a scale relative to the size of the forces engaged or so diverse in type. 2,494 Bailey bridges including two suspension bridges were built, making a total length of 50 miles. This figure does not include the many other types of bridges which were built nor does it make any allowance for a number of Bailey bridges which were not reported and of which there is no official record. 1,717 Bailey bridges were dismantled of which a large proportion were replaced by permanent or semi-permanent bridges. By the end of March, 1945 nearly all the Bailey bridges on the main roads between the line Bari–Naples and the line Rimini–River Arno had been replaced. The replacement of bridges on the East Coast road was a particularly heavy task. This road crosses either a wide water course or a river flowing between high flood banks at least every five miles. The new bridges were generally multiple brick arch design or reinforced concrete (see plate 8). Most of the labour employed was Italian, working under the direct supervision of military engineers, all transport, plant and materials being supplied from military sources. In areas for which the American engineers were responsible timber bridge construction was used extensively to replace Baileys.

18. Supply of Bridging Equipment

130,000 tons of British bridging equipment were shipped into the country, an average of 6,500 tons per month. Despatches out of Engineer Base Depots averaged 6,000 tons per month, the peak monthly tonnage being nearly double that figure. Nearly all floating bridging and rafting equipment shipped into the country arrived in a damaged condition and had to be repaired in Engineer Stores Base Depots before being issued. Sorting and checking of these large tonnages of bridging equipment and despatch by rail or sea in correct loads at a rate to keep pace with demands was not made easier by the fact that few of the R.E. Stores personnel had ever seen Bailey bridging equipment before. A series of courses were, therefore held at our S.M.E. to instruct them in Bailey bridging. Needless to say, the movement of bridging equipment forward of railhead or sea-head and its distribution within Armies were vital matters and required a large amount of transport in addition to that belonging to the Bridge Companies. During the pursuit of the enemy beyond Rome, when the leading Divisions of Eighth Army were more than 200 miles in front of railhead, 26 G.T. Platoons R.A.S.C. (780 lorries) were employed on the transport of bridging equipment for one Army. Additional G.T. Platoons were employed on the carriage of other essential engineer stores. The Po Task Force, assembled to build a pontoon bridge and a high level bridge, contained 500 vehicles including tippers. The large amount of transport which in modern war is required for engineer work has made it necessary to provide the Chief Engineer of an Army with the means to control it. In Eighth Army a C.R.A.S.C. and headquarters were therefore, placed under the direct command of the C.E. I think that this has now been accepted as normal practice.

19. The Formation of Headquarters A.G.R.E.

Engineer units working under the direct orders of the Chief Engineer of an Army and sometimes of a Chief Engineer of a Corps had become so numerous during the course of the campaign that the need for a headquarters higher than that of a C.R.E. was apparent. Proposals for the formation of R.E. headquarters, organized to command two or more formations of engineer units, were submitted to the War Office early in 1944. They were eventually approved. Such was the origin of the A.G.R.E. which is now regarded as an indispensable part of the war organization of the Royal Engineers.

20. Expedients to Meet the Shortage in Engineer Reinforcements and Engineer Units

Reinforcements which could be made available for Italy from England, were at one time insufficient to make good the wastage. We had therefore, to resort to various expedients to maintain the strength of Engineer units. All the L. of C. Engineer units were combed of their " A " category young officers and O.Rs. These officers and men were then given a course at the S.M.E. and posted to Field Units. In order to make good the consequent deficiencies in the L. of C. Engineer units, they were diluted with Italians, an Artisan Works Company thus consisting of a H.Q. and two British Platoons, plus two Italian Platoons. We also obtained several thousand gunners from disbanded A.A. units. These were also given a period of training at the S.M.E. and posted to Field units, where they proved to be most efficient sappers. Lastly, in the early Spring of 1945, in order to try and make good the withdrawals of Engineer units from this theatre to North West Europe, we took three Pioneer Corps Companies, gave them a small cadre of Engineer Officers and N.C.O's., placed them under command of a C.R.E. and started to train them as Field Companies. The Director of Labour was most co-operative and filled these three Companies with the pick of the Pioneer Corps in Italy. They gave promise of becoming most efficient Companies, but before they could be tried out in battle, the war had ended.

21. Airfield Construction (See map 2)

There were only 14 existing airfields in Italy, South of the Northern Apennines, which had all-weather runways. All were damaged by bombing or enemy demolitions. Furthermore, before they could be used by the Allied Air Forces, the runways had to be extended and taxi tracks and hardstandings provided. By the end of the campaign, 68 all-weather airfields had been constructed and a further 96 fair-weather airfields.

The group of fields in the Foggia area and the heel were for the Strategic Air Force. They were built entirely by American Aviation Engineer Battalions. More than 150,000 tons of P.S.P. were used in their construction. By March, 1944, more than 500 heavy bombers a day were operating from these fields and by December, 1944 as many as 2,000 planes a day were operating.

The remaining 36 all-weather airfields were built for the Tactical Air Force and Transport Command. The Tactical Air Force, with its Headquarters at H.Q.A.A.I., commanded the Desert Air Force, which supported Eighth Army, and the 12th Air Force which supported Fifth Army. Construction of airfields for the Desert Air Force was carried out by two, and later three, British Airfield Construction Groups under command of a H.Q.A.G.R.E. working under direction of the C.E. Eighth Army. A similar organization composed of one British Airfield Construction Group and one or two American Aviation Engineer Battalions carried out airfield construction for the Air Force supporting Fifth Army. The work was co-ordinated by a D.C.E. Airfields at H.Q.A.A.I. working under the general direction of the C.E.A.A.I.

P.S.P. laid on a foundation of 6 in. of hardcore or sand, was used for the construction of nearly all these airfields.

22. Oil Supply

On map 2 are shown the oil pipelines constructed during the Campaign. For the Strategic Air Force alone 700 miles of pipeline were constructed, and a further 1,085 miles of pipelines were put down to serve the Army and Tactical Air Force. The pipelines East of the Apennines, except those serving the Strategic Air Force, were constructed by a British Pipeline Construction Group and those West of the Apennines were constructed by American Pipeline Companies.

23. Engineer Work Behind The Armies

No account of Engineer work in Italy is complete without some mention of the work that had to be done behind the Armies. It is not always appreciated that, as far as Italy was concerned, slightly over half of the total strength of Engineers was employed behind the Army areas. American responsibility was limited to a share of the port of Naples and thence a narrow strip of territory along the west coast, including all the ports on that coast. The remainder of the area was administered by British L. of C. District H.Q.'s.

24. Ports

In Italy all port construction and repair was under the C.E. and not the responsibility of the Director of Transportation. Fortunately Bari, Brindisi and Taranto were captured intact, but there was a vast amount of work in the clearance of the Naples dockyards, the repair of the water supply system and the installation of a complete new lighting and power system. Even at Bari, considerable work had to be done. Three Lighter Quays of a total length of 1,030 ft. had to be constructed. A 50,000 cubic yds., fill was required behind an existing quay. A grain elevator was dismantled at Naples and re-erected complete at Bari.

25. Works Services

Accommodation for Depots, Workshops, Camps, Hospitals, etc., was a big undertaking. The following figures give some idea of the amount of new construction completed during the first nine months, between September, 1943 and May, 1944 :—

Depots and Workshops ..	1,600,000 ft. super.
Camps and Depots ..	Accommodation for 100,000 men.
Hospitals	20,000 beds.

In addition, approximately an equivalent area of existing buildings were repaired and reconstructed for Depots and Hospitals.

26. Roads and Bridges

The Italian organization for the maintenance of roads and bridges had completely disappeared. There was no local transport and the production of all materials such as bricks and cement had ceased. The whole responsibility for organizing road maintenance, reconstruction of bridges, etc., had, therefore, to be undertaken under our direction and supervision. Over a thousand miles of essential roads had to be maintained in the L. of C. and, in addition, many hundreds of new bridges had to be constructed. Labour was Italian, but all transport, plant and material, as well as supervision, was provided from Army sources.

27. Electric Power

Italy is one of the most highly electrified countries in the world. Water supply and sewage systems are largely dependent on electric power, as are industry, domestic heating and cooking. Reconstruction of the electric power system to provide the bare essential quantity of power was therefore a matter of vital importance. Fortunately, the Sila group of power stations and two smaller stations near Naples were captured intact. In Central Italy, out of 800,000 k.w. plant capacity, less than 10% was captured in working order. German demolitions were not, however, 100% effective, and it was found possible to repair by canabalization some of the plant. An Allied Engineer Committee was set up to examine the problem, to make plans for a phased programme of reconstruction and to allocate the work to the various agencies. Strict rationing of power was enforced. As an example of improvization, during the early days at Naples, the generators (600 k.w. D.C.) of three Italian submarines were coupled in series. This direct current was converted to alternating current at a Tramway Sub-Station by inverting a convertor set. In this way pumps that supplied water to part of the town were operated.

28. Engineer Stores and Local Production

Appendix II, shows the tonnages of Engineer stores shipped into this country, and gives an idea of the tonnages which had to be handled through Engineer Base Depots. Appendix III, shows the quantities of the more important items of Engineer materials which were produced in the country.

Local production of Engineer materials was a feature of the Italian campaign and eventually reached a total of some 40,000 tons per month. In the Bari area a Steelworks was found intact, although the Siemens-Martin open-hearth furnace at the works required to be rebuilt before it could be used. There were also a number of intact Cement and Brick works which were not at that time working. In the Naples area, out of the ruins, it was found possible by canabalization to repair and to put into operation a Steelworks, Foundry, Rolling Mills and Machine Shops. Later, when we captured Terni, it was found possible to restore a part of the big Steelworks there. Nail and screw factories and wood-working shops in Naples were taken over, as was the whole of the timber industry in Calabria.

Industry in Southern Italy was completely disorganized. There were continual labour disputes. In order to put one factory into operation, it was usually necessary to strip factories belonging to other firms of such machines or plant as were undamaged. Control of all potentially productive engineering works was, therefore, assumed by the Director of Works at H.Q.A.A.I. The commanding officer of 80th South African Engineer Base Workshop was given the task of organizing production and of executing the work of reconstruction. His Company, later reinforced by 93rd South African Engineer Base Workshop, found the management and supervisory staff for all factories and engineering works.

A Bailey type bridge was produced locally. In design it was identical to the Bailey bridge, but was composed of heavier steel sections to compensate for the lower tensile strength of the steel available. Production reached a peak of forty-five 60 ft. spans in a month. It was used for the replacement of standard Bailey bridges in cases where there was not time, or it was not practical, to build a permanent brick or concrete structure.

29. The Engineer Training Establishment

As few of our Engineer units had much previous experience or training in bridging with Bailey equipment, the provision of Engineer training facilities in Italy was a matter of the greatest importance. The Headquarters E.T.E. was established in January, 1944 at Capua on the river Volturno. Under its command was the S.M.E., situated also in Capua, the R.E. Training Depot located in a re-constructed Prisoner of War camp nearby and the Indian Engineer Training Depot. Later a Polish S.M.E. was established in the same area as a satellite. Some three or four miles up-stream from Capua, a Bridging camp was built, capable of housing one divisional engineers.

A large amount of work in the repair, reconstruction and alteration of buildings in Capua was done in order to provide a high standard of comfort and amenities for the students who came down from the front to attend courses at the S.M.E. These amenities included an Opera House, Officers Club and a very fine Institute for other ranks.

The river Volturno provided excellent training facilities. Nearby there was ground suitable for the training of Mechanical Equipment Operators. The main courses run at the S.M.E., were Bridging, Mine Warfare and Mechanical Equipment. A number of American Officers and other ranks attended the S.M.E. Courses.

At the R.E.T.D. all reinforcements were given a short period of training before going forward to Units. Special courses were also arranged for training Officers and other ranks of L. of C. Engineer Units before posting them as reinforcements to Field units. A large number of Gunner Officers and other ranks, who were transferred to R.E. from disbanded Anti-Aircraft Regiments, were also trained at the R.E.T.D. There is no doubt that the E.T.E. played a big and important part in maintaining the efficiency of the Engineers in Italy.

30. At the conclusion of the campaign, Field-Marshal Alexander sent the following message to all Engineer units of the Allied Armies in Italy :—

"Seldom have Engineers been faced with a more difficult task than in the Italian campaign.

By surmounting every obstacle which has confronted you, from the beaches of Sicily across the mountains and rivers of Italy to the Alps, and by developing with such success local production of equipment and material, you have in no small measure contributed to our Victory.

Feats of engineering without parallel in any other campaign have been performed.

You may well be proud of your achievements.

I congratulate you on your magnificent work."

APPENDIX I

Numbers of Divisions Engaged

Spring, 1944

	British	British Empire	Polish	U.S.	French	Italian	Total
5 Corps (directly under command H.Q.,A.A.I.)	—	2	—	—	—	—	2
8th Army ..	3	5	2	—	—	1(a)	11
5th Army							
(1) Main Front ..	—	—	—	3	4	—	7
(2) Anzio ..	2	—	—	4	—	—	6
Total ..	5	7	2	7	4	1	26(b)

Total Number of Allied Divisions 26
" " " German " 23

Spring, 1945

	British	British Empire	Polish	U.S.	Brazilian	Italian	Total
8th Army ..	3	3	2	—	—	3(a)	11
5th Army ..	—	1	—	7	1	1(a)	10
Reserve ..	1	—	—	—	—	—	1
Total ..	4	4	2	7	1	4(a)	22(b)

Total Number of Allied Divisions .. 22
" " " German " .. 28(c)

Notes:—

(a) Italian "Gruppi" about 75% of the strength of a British division.
(b) Independent British Armd. Brigades not included.
(c) German divisions at considerably reduced strength.

APPENDIX II

A. Engineer Stores Tonnages

Total Tonnage of Imported Engineer Stores	692,000 tons
Average Tonnage Imported Monthly	34,600 tons
Maximum Monthly Tonnage Handled at one Main Stores Depot	45,000 tons
Total Tonnage of Imported Bridging	130,000 tons
Equivalent Shipping Load of Bridging	300,000 tons

B. Peak Theatre Holding of Main Items of Mechanical Equipment

Tractors with Dozer Attachments	1,000
Excavators (Crawler)	173
Autopatrols	111
Blade Graders	72

APPENDIX III

Local Production

Average Tonnage Produced per Month		35,000 tons
Italian Labour Employed	(Number)	15,000

Total of Chief Items Produced

Steel Ingots		51,084 tons
Steel Rolled Section		32,595 ,,
Steel Rolled Plates		13,921 ,,
Asbestos Cement Products		3,599 ,,
Cement		198,897 ,,
Nails		3,544 ,,
Timber		257,502 ,,
Steel Bridges (Bailey Type)	(Number)	290
Huts	,,	4,316
Stoves and Ranges	,,	58,128
Shedding		2,000,000 sq. ft.
Screws		11,461 Gross
Nuts and Bolts		23,327 Gross
Bricks	(Number)	13,000,000
Glass		58,128 sq. m.
Cement Bags	(Number)	1,600,000
Chesses (Bailey)	,,	30,000
Platypus Grousers (for Tanks)	,,	19,099

Compressed Gases :—

Oxygen	1,061,807 cu. m.
Acetylene	344,086 ,,
Hydrogen	25,200 ,,
Nitrogen	26,177 ,,
Carbon Dioxide	55,519 Kg.
Anhydrous Ammonia	159,786 Kg.

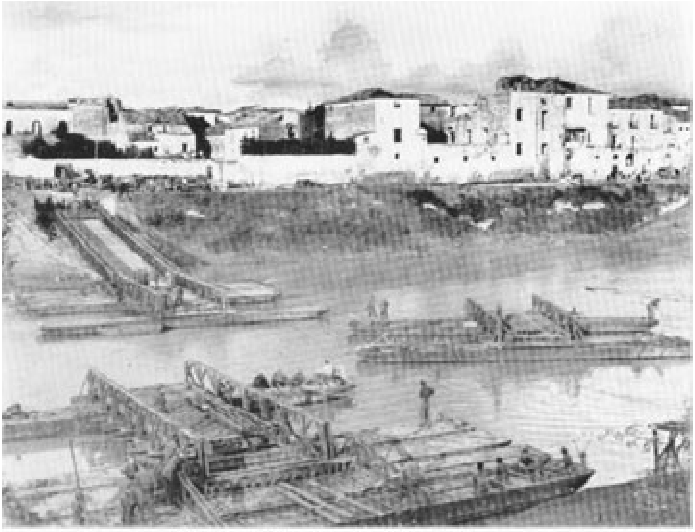


Plate 1.—Bailey Pontoon Bridge at Capua.

Plate 2.—High level Bailey Bridge at Capua.

An outline of engineer work in the Italian campaign

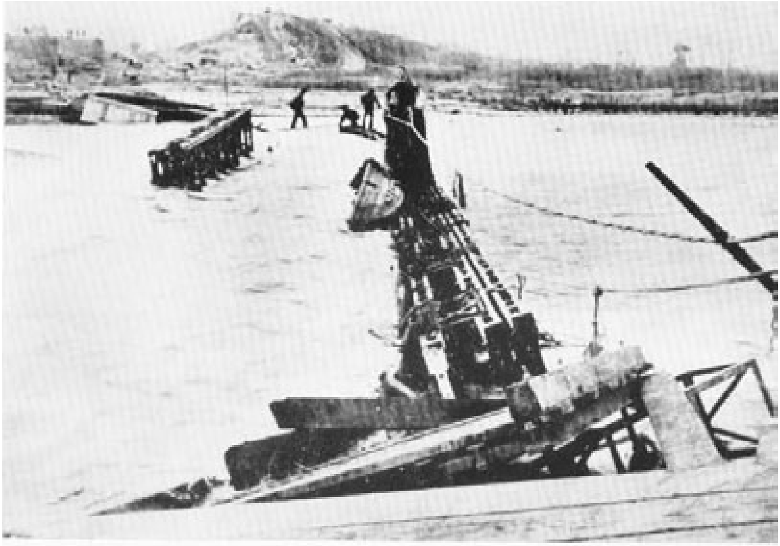


Plate 3.—Effect of spate on 4 Dec. 1943.

Plate 4.—Launching 1,200 ft. Sangro Bridge.

Plate 5.—Launching Springbok Bridge.

Plate 6.—Springbok Bridge on 7th day after work started.

Plate 7.—Timber cribbing on Route 67 in Northern Apeninnes.

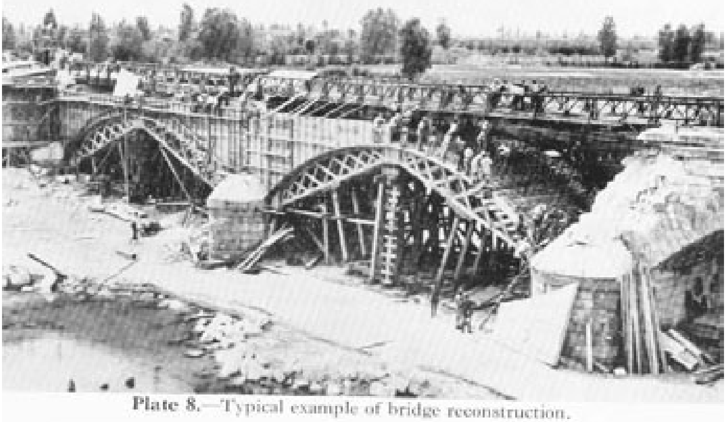
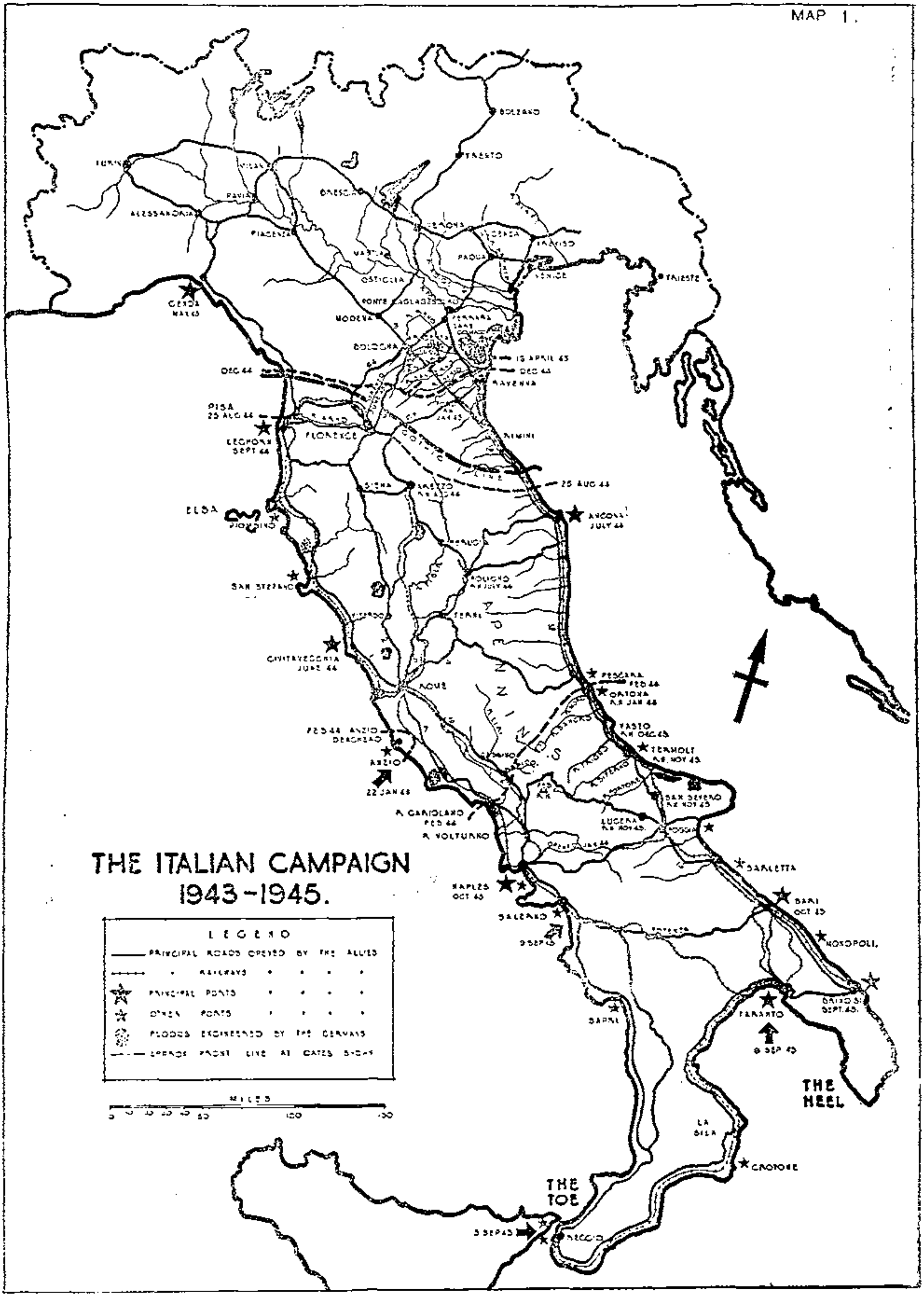
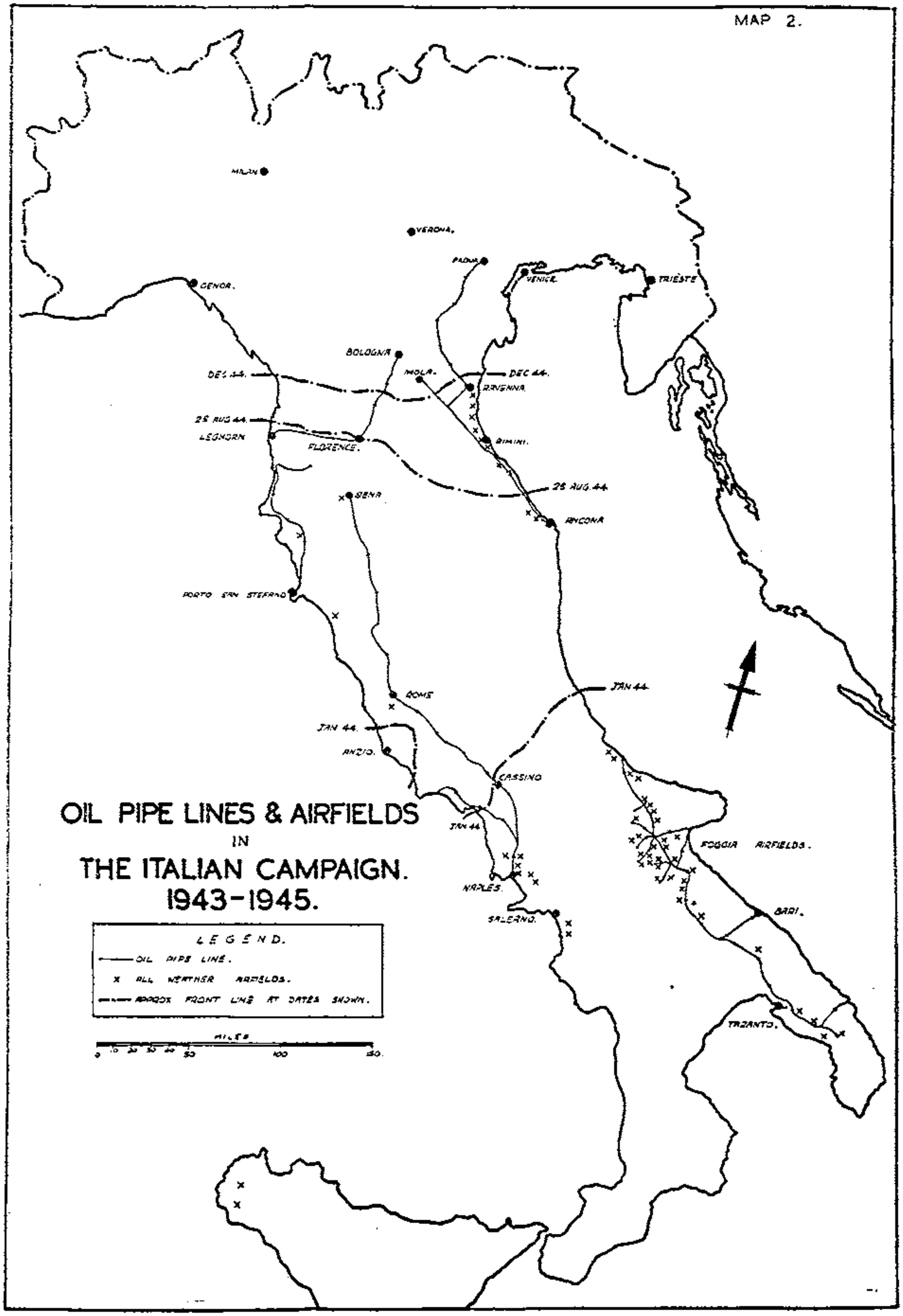


Plate 8.—Typical example of bridge reconstruction.


MAP 1.
THE ITALIAN CAMPAIGN
1943-1945.
LEGEND
PRINCIPAL ROADS OPENED BY THE ALLIES
RAILWAYS
PRINCIPAL PORTS
OTHER PORTS
FLOODS ENGINEERED BY THE GERMANS
ENEMY FRONT LINE AT DATES SHOWN
MILES
BOLZANO
TURIN
PAVIA
ALESSANDRIA
BRESCIA
VERONA
PIACENZA
PADUA
VENICE
TRIESTE
OSTIGLIA
MODENA
BOLOGNA
RAVENNA
RIMINI
DEC 44
PISA
25 AUG 44
LEGHORN
SEPT 44
FLORENCE
GOTHIC LINE
25 AUG 44
SIENA
AREZZO
ELBA
PIOMBINO
ANCONA
JULY 44
PERUGIA
SAN STEFANO
FOLIGNO
TERNI
VITERBO
APENNINES
CIVITAVECCHIA
JUNE 44
ROME
PESCARA
FEB 44
ORTONA
VASTO
TERMOLI
ANZIO
22 JAN 44
R. GARIGLIANO
FEB 44
R. VOLTURNO
SAN SEVERO
LUCERA
FOGGIA
BARLETTA
NAPLES
OCT 43
SALERNO
BARI
OCT 43
MONOPOLI
TARANTO
THE HEEL
LA SILA
CROTONE
THE TOE
REGGIO


MAP 2.
OIL PIPE LINES & AIRFIELDS
IN
THE ITALIAN CAMPAIGN.
1943-1945.
LEGEND.
OIL PIPE LINE.
ALL WEATHER AIRFIELDS.
APPROX FRONT LINE AT DATES SHOWN.
MILES
0 10 20 30 40 50 100 150
MILAN
VERONA
PADUA
VENICE
TRIESTE
GENOA
BOLOGNA
IMOLA
DEC 44.
RAVENNA
25 AUG 44.
LEGHORN
FLORENCE
RIMINI
SIENA
ANCONA
PORTO SAN STEFANO
ROME
JAN 44.
ANZIO
CASSINO
NAPLES
SALERNO
FOGGIA AIRFIELDS.
BARI
TARANTO

PAIFORCE PROMENADE

By Lieut.-Col. G. V. Micklam, R.E.

THE puny revolt in Iraq had just been smothered. Raschid Ali had fled. The little garrison at Habbaniya, its old training aircraft riddled with holes after their miraculous impersonation of fighter bombers, had with a sigh of relief seen the shiny barrels of the obsolete Arab artillery flickering a swift retreat towards the bridge at Fallujah. The general idea was to inspire those gunners with a keenness for the homelike comforts of Baghdad as fast as teams could gallop, in a devil-take-the-hindmost and Olympian " Musical Ride."

On 31st May, 1941, the first Indian " Excavating " detachment arrived in the Shatt-al-Arab, on the B.I. ship *Varela*. After a hurried consultation with the boarding Embarkation Staff, everyone was set on the alert, with the troops tucked out of sight. It was thought that when the ship steamed up river, the as yet unrepressed Persians on the Iranian bank, with Nazi money jingling in their pockets, might snipe the decks. Guns were, therefore, trained upon the shore, and there was an air of expectancy, a feeling of embryo medals sprouting from the hair on every chest.

Anticlimax. Not a shot rang out. Not an aircraft appeared. Not a flash of buckle or bayonet was seen. The only military stage effect was given by the serried ranks of a million date palms, covering off and standing to attention all along the banks. For fifty miles or so we steamed past them in review. No breath of wind stirred the fronds. The only sounds were the shouts of children from the occasional native hut or hamlet, the throb of our engines at low revs. and the splash of those mysterious gushers from the ship's side—said by knowalls to come from cooling pumps, but suspected by us to be Captain Snook's bath water running out. For, as we carefully pointed out to him, it was so dirty.

As a relief from all this forestry, two impressions stand out. First, Abadan. This famous home of oil looks like the innards of a radio, built to a gigantic scale with pipes instead of wires and with the addition of dozens of tall smoking chimneys. Black retorts and cupolas take the place of shiny valves, and mysterious fins and cylinders are attached to them at various points. To one side are grouped some rows of storage tanks, reminiscent of large gasometers, connected at ground level by a maze of pipes and a battery of sluice valves. On the other side trim bungalows, be-lawned and flower-bedded, fringe the bank. Big oil tank ships were snuggled up to various wooden jetties, filling up to serve a distant fleet, one guessed. Overhead swung a score of barrage balloons.

The same thought rose spontaneously in all our minds. " My, what a target—all this mass of apparatus, this blood bank of a Navy's life essence, concentrated on a tiny island in an obvious bend of the great river." It all looked horribly conspicuous.

The next impression was a contrast. A few miles further up the river, the wide brassy sweep of the Karun joins the Shatt at the tidy grass banked little town of Khorramshahr. This was before the river front was marred by jetties, cranes and railway yards for " Aid to Russia " schemes. Gay, white, yacht-like Persian gunboats were as ever tethered to the bank. We later heard that these craft had to be unceremoniously scuttled at their moorings, to demonstrate that a lion's tail should not be twisted. A pity, for it must have felt to our men like sinking children's toys on the Round Pond.

A few hours later we found ourselves off Basra. Here came our first acquaintance with the "Muddle," the good old Basra "Muddle," which was to repeat itself *ad nauseam* for the next two years. A flap was on. Port officials in white ducks and a temper giving one order, and N.C.O.s. in khaki shorts and another temper giving quite a different one. "Look here, old boy, you must rush your men in little blobs down the gangway, double along the quay and fling yourselves behind that pile of packing cases as a first rallying point. Here you will meet guides, who will nip round No 4 shed with you and lead you to the rendezvous, where you will find some lorries waiting to take you off to camp. Not a light to be shown, old boy, not a match to be struck. Oh, by the way, I suppose you know that the few remaining coolies will be off duty, so you will have to leave a hundred men behind to unload the ship. You'll find some railway wagons over there (a wave of the hand)—some with K.Q.N. and some with S.B.J. chalked on them. Don't for Heaven's sake touch the K.Q.N.s., or the old man will tear a strip off me tomorrow, but bung your stuff in the S.B.J.s. And remember we *must* have the quay clear by dawn, as several more ships are coming in tomorrow." With this the E.S.O. went off, adding as a Parthian shot, "Oh, by the way, the Field Cashier will come aboard tomorrow morning to collect your ship's Imprest, so don't go off till you have seen him, old boy."

So apparently it was all taped ; tactical landings, rendezvous, guides, lorries, wagons, S.B.J. code, including "Tom Cashier" and all. Feeling thoroughly all-buoyed-up, we happily set about detailing parties, thinking we were being practically wet-nursed and "jolly good show chaps."

And so it was, chaps—except for the slip ups. We later found, to take a minor point first, that the Cashier was blissfully uninformed as to his role for the morrow. So far as he knew, his orders were to sit at the receipt of custom all day, under a cooling fan and the rich blue dome of the Port Offices and await our arrival with the money bags.

In the meantime chaos supervened. Instead of mooring up at No. 4 berth as planned, the ship was ordered by some independent minded Dock authority into No. 1, some hundreds of yards away. Here was a pretty how-d'ye-do—all the chalk marked wagons waiting on the wrong siding, no locos available and nobody about to help us get them, all the lorries wrongly parked and unaware of it, and the guides preparing to lead parties from the wrong ship. The quayside crane on No. 1 was, we found, locked up, the unwarned operator drinking coffee in a dive halfway across the town, and pitch darkness due in an hour.

To add to the fun it was found that as the ship's derricks swung the nets would foul the crane gantry. What to do ? Well, first we urged our ex-burglars to show their skill. Such worthy folk abound in the R.I.E., posing as locksmiths and laughing at love in rather vulgar pushto as they twiddle bits of wire in a keyhole. They were told to open that crane, or they would not be admitted into that maiden and flower-bestrewn paradise which their next world kindly provides for men who open cranes. As a second string, one of those innocent and methodist Sapper officers, had, he thought, a brilliant idea. Since Mahomet could not move the crane away, was not the answer to warp the mountain back five yards on her mooring cables ? This proposal, brightly and lightheartedly put, was met with horror from the bridge. "What ? Demean ourselves by moving six thousand tons of crack liner for an asterisked five ton crane ? " The Pygmalionesque reply boomed out, "Not bloody likely. You find that coffee swilling son of a Margil mummy and move the crane."

Luckily the brigands soon succeeded in their felony, and after playing about with various switches and handles a third grade blacksmith suddenly made the crane move off. His exultant and opportune claim for an electrician's rate of pay was greeted as a huge joke by his friends, and everyone was happy.

In due course we found and guided the guides, and off went the troops, well bunched into a perfect target, into the gathering gloom and so temporarily out of our story.

Unloading went on all night, with alternating British and Indian troops in two-hour shifts. The loads came out higgledy piggledy in the nets, and grew into a huge pile on the quay. It was impossible to sort out the B.O.D. equipment from the mech. equip. stores, or signal crates from gunner boxes, despite the fact that someone found and connected up a blue electric floodlight. As no shots ensued, we began to use our torches. Railway wagons were examined up and down the quays, and empty ones man-handled over points and sidings to come as close as possible to the stores. Then the stuff went in as quick as we could heave, and no jig-saw technique about it. Occasionally an incautious Sepoy found himself immured in the dark belly of a wagon between a dozen crates, and had to bleat for rescue. Sometimes a crash on the far side of a truck would warn the over-eager loading party that some careless fellow had left the far doors open, so that stores were simply falling out again. The letters S.B.J. were perhaps originally missing from these wagons but a fortuitous stick of chalk in someone's pocket soon put that right.

To make matters more exciting, in an Iraqi rake you cannot turn one wagon end for end, as if you do the couplings will not match. One is female, and the other male, a very clever ace up Transportation's sleeve. With this they can trump any other upstart Sapper who makes some silly suggestion about marshalling methods. Luckily the locomotives are bi-sexual, and can be attached at either end.

As dawn broke the last nets came out of the hold, and in half-an-hour or so we thankfully sat down to breakfast. We had an uneasy feeling that we had used up twenty wagons where professional loaders might have used fifteen, but there seemed no point in calling attention to it, so doors were hastily closed and locked to hide the shambles within before we went.

Next we paid a visit to R.E. House, that haven with an ice chest, on the river bank, to find out where and what our future tasks might be when our machines arrived.

A big base was to arise upon the desert plateau of Shaiba, about eight miles outside Basra, just as in the war of " Mespot " thirty years ago. Our detachment was earmarked for the earth work—road formations, drains, railway cuttings, bomb traverses and the like. During the morning the C.R.E. turned up—waving his famous horsehair whisk—and, oh joy, he had his staff car with him. Transport was the major problem of those days.

Off we went through the palm groves, past Makina hospital, and then breaking out upon a wide plain of greyish sand flecked in patches here and there with the white menace of saltpetre. Little as we knew it then, this plain was as treacherous for vehicles as the Goodwin Sands for shipping. Cars and light trucks skimmed smoothly over the deceptive crust, working the surface to a deep grey skin, indistinguishable at first sight from an old tarred highway. But let a lorry skid its wheels, or a tractor pass, and this crust was broken ; the vehicle slumped down into a sticky, buttery, oozing substratum, and ceased to function. Other trucks would unsuspectingly come to towing rescue only themselves to be bogged as they took up the strain.

Did one but realize it, here was soil de-stabilization on a giant scale, a natural obstacle to cover Basra from a Panzer raid. Unfortunately it lay too close to the port for tactical effectiveness.

Beyond Makina and spread out over an acre or two we came across half buried stacks of what we thought was road metal. But what were all those unusual flashings and twinklings as we passed? Believe it or not, those stacks were in fact a mass of broken bottles, relics of the Army of our fathers back in 1917. Later when we were grading roads we turned up many more with our blades. Well, now we know what Daddy did in the Great War, and we made a joyful mental note to hold it over him in this one, if he did not produce our beer.

As we neared the plateau, which rises some forty feet above the plain, we saw it covered with dense yellow fog. The C.R.E. glanced at his watch and said, "Ah yes, it's after nine, that's the daily sand-storm." Apparently this scourge of Shaiba lasts through the months of May and June or so, in a continuous performance from nine till four. A parching wind swirls up the sand, and drives it stingingly across your face, up your shorts, down your shirt, into your tin of M. and V. and through every crevice of your tent. Ordinary glare glasses are useless, and only anti-gas eyeshields enable men to work between those hours. Dim figures, stealing ghostlike from their tents, lean against the storm, a hand thrust forward like the final tragic picture of our gallant Captain Oates.

During a lull we found the detachment sitting depressedly around a solitary 400-gallon tank on a crib of sleepers by the railside. To right and left the metals just disappeared in the murk. Owing to the "Muddle," there were no tents or stores, and though the tank had taps the water did not flow in till 10 o'clock.

That night the weather again pulled our leg. We started off by lying in a perspiration on our bedding. At midnight there were rustlings and stirrings throughout the bivouac, as we all reached for a blanket, then another, and finally put on every garment we could find to stave off the cold. This is apparently the normal swing of temperature at the time of year. Such unexpected night coolth in the desert enables the refreshed men to carry on through the blistering day without undue strain in temperatures over 115° F.

Next day we borrowed a truck and drove into Basra to see if we could pick up our new transport. We had merely been given a list of the types and B.A. numbers of the vehicles allotted. After inquiry we found ourselves in a large open space of 15 acres or so, in which pairs of trucks and lorries and station wagons were dotted in an attempt at dispersion. No responsible official appeared to be about. As each batch of vehicles came off the M.T. ship, they were driven out of the Docks by a few duty drivers, and just abandoned at the park. The drivers returned for more. Small groups of Officers and B.O.R.'s from units seeking transport could be seen wandering from vehicle to vehicle trying to identify their numbers. When they spotted one with one of their numbers on the list, they simply leaped in and drove it away. No signature was sought, no record made of their departure. Accustomed as we were to all the checks and signatures required in India before one could even draw an inner tube or spanner, it seemed to us an extraordinary situation. Here were lakhs of rupees worth of new machines standing unguarded and unaccounted for, so far as we could see, Here too, we found first evidences of that clever sabotage, whereby the tyre pump on almost every vehicle was missing. This was one of the most awkward deficiencies in Iraq and Persia over the next two years. With such a shortage of Embarkation staff, and the rush of ships presumably this lack of control was inevitable. How lucky that the Arab taxi drivers had not had time to cotton on to our procedure in those first few days. They could, perhaps, have left us wheelmarks as a souvenir, but certainly nothing else.

Once equipped with a little transport, things assumed a better hue—for we could even collect our own rations instead of relying on others to do so.

We were also able to explore the desert and trace to their lairs such important people as the G.E. and the B.O.W.O.

In due course our mechanical equipment arrived at the docks, much of it in crates, and we set to work. Day followed day in a steady routine—first parade at four a.m., the rat-tat of the petrol starting engines ten minutes later, followed by the successive coughs of the Diesels beginning to fire. Then clank, clank, clank as the tractors moved off to their various tasks, not to return till nearly sunset for their evening maintenance. Each operator had two shifts, one of four and one of three hours, and each machine had two operators, thus keeping going for a total of fourteen hours in every twenty-four. There were only two officers, so these were also out for seven hours each. One would then supervise the evening maintenance, while the other dealt with office work and planned the next day's task. The most unpopular shift was called the Hell Shift and was from 1200 to 1500 hrs. roughly, depending on the jobs. It was arranged that every man had a variety of machines to drive, a different type every day. The result was that they found it very interesting and any man could after a few weeks operate with confidence any of our machines. We discouraged specialization as being too risky in case of casualties. The men worked splendidly, and curiously enough the only one who had heat exhaustion was the Q.M. Havildar, who was employed for most of the day on dull routine in the shade of a tent.

After a few weeks the situation became very threatening. The Germans were almost on the Caucasus, and it was thought that they would soon break through and come sweeping down the deserts of Iraq on to Basra. We were only a handful of troops, mostly Engineer and Departmental, and it looked as though we might have to drop our picks and shovels and make a " last stand " —not a pleasant prospect with only salt water or the wastes of Kuwait behind us. However, we were cheered by the thought that at least we ruled that salt water.

The white hot priority task then became to establish a literal " last ditch " in the form of a continuous tank trap from At-Tuba on the Hammar Lake swinging in a 32 miles curve round Basra southwards to an arm of the Persian Gulf. This trench was to be covered by a series of concrete pill boxes and artillery positions, and included within its sweep the main patches of tamarisk plantations in which defending forces might conceal their reserves, and beyond which lay only the unbroken featureless desert. From memory the ditch was to be of a cross section strangely reminiscent of the pictures of " standard fire trenches " which feature in most of our fighting and engineer pocket books, but on a far larger scale as in the sketch on page 212.

An impression of the size may be gained by visualizing that the bottom portion was large enough to take a D-8 (the largest) Caterpillar tractor, towing a 12 yd. scraper, and that both machines disappeared completely from view when seen from ground level a score of yards or so away from the trench. It was in fact one of our mild amusements to order all our machines into the trench when an inspecting officer was due. We would then take him for a walk across what appeared to be a desolate piece of flat desert, and point towards the horizon saying " the work is over there in front of us, Sir." Just as he was getting apprehensive of a six-mile walk in the burning sun, after a sharp look at us, or suggesting the use of a car, there would be a roar and a rumble, and out of the ground some 30 yds. ahead of him would suddenly appear four or five of these huge machines, like outsize hippopotami emerging from a pond. Another sharp look would then come our way, but we were all of course as solemn as income-tax collectors.

No materials were available for revetment of the trap. For the excavation we had two elevating graders, four 12 yd. scraper sets—with D-8 tractors

—two motor graders, two-blade graders and one or two other miscellaneous machines. The technical planning and methods used to guide the operators were perhaps unusual, and will form the subject of a separate article.

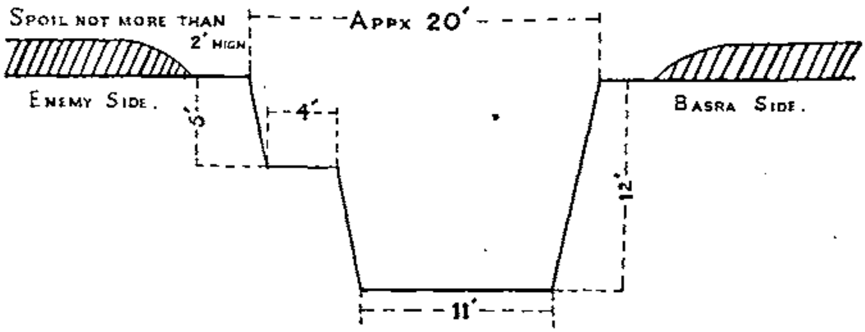


Fig-1.

Memory Sketch - Cross Section of tank obstacle.

Scale - ¼" = 1 feet.

By the time we had completed a few miles of this obstacle, it was decided that the emergency was over. Stalingrad had been relieved. We were promptly ordered to pack up and return to Shaiba base to finish off work on some minor installations. This was just routine stuff calling for no comment, and brought to a close the first stages of an interesting time in what was later known as Paiforce. Ahead lay ticklish nightmare incidents, such as the accidental cutting by a bulldozer near Kirkuk of the World-important oil pipe-line to Haifa. Britannia may rule the waves, but it can now be revealed that on this occasion the Sappers thought they had immobilized the Mediterranean Fleet. But that, as they say, is another story, over which we draw a tactful veil.

ANTI-MINE DEFENCES FOR RIVER BRIDGES

By Capt. A. E. L. Crosthwait, M.B.E., B.A., R.E.

1. Types of River Mine

On several occasions the Germans used floating mines in attempts to destroy the temporary bridges installed by the Allies. These mines were either floated down the river, when the Germans occupied areas upstream, or were dropped from aircraft. Several such attempts, were made on the Canadian and British bridges over the River Rhine in the Nijmegen area from September, 1944, onwards. A Class 40 Bailey Barge Bridge was broken by a mine, which caused a gap of over a 100 ft. in this 1,000 ft. bridge.

The Huns used several different types of mines ; two of which were as follows :—

(*a*) Floating sea mines, circular or oval in shape, and fitted with several contact type detonating fuses. These mines were usually dark in colour, generally black, and floated almost entirely submerged, just the top and one or two of the fuses showing above the surface. They were usually released upstream of the bridge to be attacked and timed to pass through the Allied occupied area after dark. They generally exploded on contact with any hard surface, and might sink, or cause leaks, in several barges or pontoons, even if they hit and were detonated on a mooring cable. They did not necessarily explode if they grounded on mud, or were caught in nets.

(*b*) Floating, aerial bomb type mines. These were generally of cylindrical shape, and had two to five detonating fuses, and nearly always a time fuse inside. Two of these mines are known to have come ashore on mud banks, and blew up some 12 hours after being spotted.

This type of mine generally floated under water, and in some cases two mines were tied together with some 20 to 50 ft. of cable. This cable was intended to catch round the anchor cables of the floating bridge, or even around the piers of a permanent bridge, thus making the two mines swing under or on to their target. If the contact fuse did not cause detonation, the time fuse operated.

Other types of mine may be used, and even one-man submarines with torpedoes. The submarine may well come from enemy occupied areas downstream of the Allied positions, thus avoiding the upstream anti-mine defences. To prevent this, we installed anti-mine defences on the Rhine downstream of Nijmegen, as well as upstream. It is also thought that a magnetic type of fuse was installed inside some of the mines, especially when they were directed against steel barges, as they were on the Rhine, or against steel piles or piers of fixed bridges.

2. Methods of Mine Protection

After the successful mine attack on the barge bridge at Nijmegen, the following arrangements were made to prevent the occurrence of another such "accident."

(*a*) *A Timber Boom.* The object of this boom was to detonate the floating mines. Tree trunks up to 15 in. in diameter would have been suitable, but luckily some large quantities of squared timbers were available. Approximate sizes were 12 in × 12 in. up to 18 in. × 18 in., some 40 ft. long. A hole was drilled about a foot from each end with a diameter large enough to take the S.W.R. which was used for linking them together. The S.W.R. was passed in a spiral manner through the holes at the ends of adjacent pieces of timber, and fixed by using three bulldog clips to join the loose ends of the wire. The length of wire used was adjusted so that the timbers were not more than 12 in. apart when floating. An anchor mooring was arranged at the junction of every third timber (i.e., some 120 ft. between anchors). To make a stronger joint at these points chain may be used instead of S.W.R. The length of the anchor cable $1\frac{1}{2}$ in. (S.W.R.), should be three to four times the estimated depth of water at high tide or flood level. If the river bed is very muddy, two anchors in kedge may be used, joined by some 30 to 50 ft. of cable.

The boom should be arranged so that it floats in a more or less straight line at some 45° or 60° to the direction of flow of the river current. This assists its positioning, as the upstream end is attached to a holdfast on the bank. Also the angle enables weeds, branches, and other floating debris to work clear of the boom. It was, however, found that debris was apt to get caught in the joints between timbers. This tends to increase the resistance of the boom to the water, and may cause the anchors to drag. Unfortunately mooring buoys were not available, as they would have assisted the positioning of the boom, and greatly facilitated the adjustment of the angle to the direction of current flow, and correction for displacements due to dragging anchors. It was found that the river current "tugging" on an improvised wooden buoy tended to submerge it completely, so these could not be used.

A brief outline of the methods used for placing the boom in a river, some 1,500 ft. wide, with a swift current is as follows:—

(i) A site for the upstream bank holdfast should be selected which can be approached by a winch lorry, or a D-4 tractor, if possible. About six lengths of timber were joined together, with an anchor mooring attached to the centre, and a chain loop through the holes in the ends of the first and sixth timbers. The boom was towed upstream by a tug, which anchored itself some 100 ft. from the bank, slightly downstream from the bank holdfast. A motor boat then brought out the bank holdfast cable, and it was attached to the upstream end of the boom. A winch lorry, or D-4 tractor, then pulled in the cable slowly, and the tug crew paid out the boom until the end reached the distance required from the bank. This distance depends on the curve of the river, and the presence of any anti-erosion groynes sticking out from the bank into the current. The direction and speed of current, and the depth of water also effect the assessment of the boom's starting point.

(ii) When the bank holdfast cable has been made fast, the tug casts off all the boom timbers, but retains the mooring cable which it pays out as it steams upstream. A reserve towing cable may be attached to the mooring point on the boom, but must be kept quite separate from the anchor cable. The use of such a reserve cable depends on the speed of the current. By a little slow manœuvring, the three inshore timbers of the boom can be induced into practically a straight line at some 60° to the line of the river current, with the anchor cable fully paid out. The anchor can then be dropped the position of the boom being retained either by the reserve cable, or by the motor boat, until the anchors reach the bottom.

The pull of the current may cause the anchors to drag a little, so the boom may drop back into an angle of some 45° to the line of the current.

The unmoored three pieces of timber now hang freely downstream more or less in the line of the current.

(iii) The tug then collects another three or six lengths of joined-up timber, this time with two mooring cables and anchors. These lengths are attached to the end of the portion already placed. The tug pays out the anchor cables, having cast off all the timbers, and tows them upstream. It manœuvres so that the direction of the line of the new portion of boom coincides with that already moored. It will be found that such operations in a swift current tends to alter the existing angles. Alignment is checked from the bank. The alignment allowed in this case should be about 70° to the current, to allow the anchors to slip a little downstream.

(iv) The next lengths of boom are installed in a similar way, and the downstream end may be moored to another bank holdfast.

As it may be necessary to permit tugs and motor boats to pass through the boom, it may have to be installed in two halves. The gap should be about ⅓ the distance from the bank. The downstream part of the boom must overlap the gap, but if it is some 50 ft. wide, tugs and motor boats should easily be able to zig-zag through. The type of current, and other local circumstances, may well permit a gap near the downstream bank end of the boom.

At Nijmegen the timber boom was placed some half mile upstream of the barge bridge, the gap being at the downstream end, some 150 ft. from the bank. The boom lay at some 60° to the line of the current. Timber and reeds became caught in it, which resulted in the formation of slight bulges in the 1,000 ft. line of the boom, due to the dragging of the anchors. This was cured by mooring the whole boom from a road bridge upstream of it. From time to time sappers proceeded on duty in motor boats behind the boom, clearing the caught up weeds and timber as much as possible. Also it was easy to change the angle at which the boom lay across the Rhine by altering the lengths of the mooring cables from the road bridge.

(*b*) *Wire-netting Booms.* The object of this type of boom was to catch the submarine type of mine, and to prevent the use of one-man submarines. They were successful, and are known to have caught at least two mines. They consisted of spherical mooring buoys attached to 1 in. to 2 in. S.W.R., with about 15 to 20 ft. between them. The spacing depended upon the size of the buoys that were available from shipyards all over Holland, and on the type of netting used. Sommerfeld road track was used at first, but was found to be too stiff, which made it difficult to handle and manœuvre when in the boom form. Finally a commercial type of flexible, stranded, steel wire, square mesh netting was found most suitable. The size of the mesh can be as large as is available, so as to let floating weed, etc., through, but any size will do to catch mines.

The S.W.R. connecting the buoys is also threaded through the top of the net and is held in place by a few bulldog clips. The dimensions of the nets used will influence the spacing of the buoys, so as to prevent the need of cutting the nets into smaller sizes. Counter weights should be attached at about 10 ft. centres to the bottom of the nets. They should be suspended on light S.W.R., which is interlaced through the meshes of the nets, so that they will hang some 6 ft. below the bottom.

The booms were placed in echelon to allow tugs to pass. The echelons varying in length up to 100 yds.

These netting booms were placed in position in a different manner to that used for the timber booms. The moorings were put in place first at some 50 to 100 ft. apart, the distance depending on the speed of current, and length of boom to be installed. The mooring buoys were arranged so that they floated in a line at some 60° to 90° to the direction of the current flow. There will be a sag in the middle of the boom, due to current pressure, so the end moorings should be placed so that the anchor cables are at some 60° outwards from the line of the boom. It was found that the handling of these booms by tugs was quite easy after a little practice, but great care must be taken to prevent a towed boom from fouling the tug's propellor. In fact it was found better to carry these booms on the deck, or on a raft. To enable them to be carried on deck shorter lengths may have to be made. But they are very easy to join together, using shackles or bulldog clips and S.W.R., after they are floating and moored.

(c) *Pontoon Booms.* A railway bridge downstream of the barge bridge at Nijmegen had been partially demolished. The girder spans were supported on piers, one span having been dropped into the river. A boom made of pontoons was placed in the gaps not covered by the dropped span, leaving a space through which tugs could pass if necessary. The pontoons were some 20 to 30 ft. apart, and had an iron pipe about, 1½ in. diameter, connecting their sterns at deck level. The pipes had X.P.M. or Sommerfeld track suspended from them, the metal sheets being wired along their edges to the pipes. Weighted wire netting was also used. However, it was finally considered that, although this boom was probably suitable enough to prevent one-man submarines surfacing at night in order to work their course through the demolished bridge, yet too much maintenance was needed, and too much valuable equipment had been used ; so it was taken to pieces and dismantled. This work incidentally, was rather tricky, and taught our Sappers much watermanship, which was extremely useful training!

These booms were covered by light guns (e.g., Bofors), to deal with craft breaking surface.

3. Improvised Anchors

There was a shortage of anchors of all types as a result of this boom work, and Bailey Box Anchors were improvised as follows, and were found to be effective on a muddy river bed. Two panels were fixed to decking in the normal manner, and the two open ends were sealed up with another Bailey panel across each end, fixed by wire lashings. The box so constructed was then lined with X.P.M., or fine mesh wire-netting, whichever was available, and the box filled with rubble. The top of the filled box was then covered over with X.P.M. or wire-netting. These "anchors" are very heavy, and are best manœuvred on Bailey rollers. They were carried on the deck of a barge, or on pontoon rafts.

One box anchor was normally used for the anchorage of three or four boom mooring buoys. Two of these boxes were connected together by a chain or S.W.R. and dropped about 100 yds. apart. Mooring cables were attached to the chain or S.W.R. at the correct intervals.

Great care is required when towing rafts carrying these heavy box anchors. On one occasion when a tug was manœuvring three rafts into position it was attacked by low-flying aircraft. When taking evasion action the sudden turn upset one barge and three men were drowned.

4. Effect of River Ice on Booms

During the winter a quantity of ice was swept down with the river current, and sheets formed in places where the water was more or less slack. The netting booms tended to catch the ice. It was possible to open the booms periodically at places, and so clear themselves of the ice, but this entailed a great deal of maintenance under trying conditions. As it was appreciated that the enemy were unlikely to use mines under such bad conditions, as the ice tended to alter the average rate of river current speed periodically and this would upset the time fusing of the mines, and also sheets of ice might well cause them to detonate, so the opening of these booms under this condition was not considered to be tactically dangerous.

The timber boom also tended to hold up and collect the ice. As a result quite a considerable sheet of ice was formed downstream of it, which enveloped nearly the whole length of the floating barge bridge. This produced a great strain on the bridge moorings. Attempts were made to break up the ice by using the tugs and also with explosives. The latter method was not very successful.

It was found extremely difficult to clear the ice away from the timber boom, and it was very lucky that it was moored from the permanent bridge, which enabled the moorings to be checked and altered in length as required.

The pontoon booms had been removed before the ice came.

5. Removal of Mines From Defences

So far as is known, no damage from mines occurred to the barge bridge, after the installation of booms. One wire-netting boom had a gap blown in it by a mine. This was quite easy to repair. Another mine, of the aerial bomb type, was caught in another of these booms, and was drawn up to the surface and seen during one of the routine boom inspections. It was removed as follows:—

A folding boat was anchored directly upstream of the mine. In the boat was one person, a coil of cordage, and a boathook. A motor boat with a crew of two, was standing by downstream. The anchor cable of the folding boat was slowly paid out, and the current carried the boat down towards the mine. The cable was made fast when the stern of the boat had approached as close as seemed safe to the mine. It was then possible to lean out over the stern, and to touch the mine. It had been the intention to pull the net and mine towards the boat by using the boathook. The mine had no visible contact detonators, and was cylindrical in shape. On the surface there was a lug-hole, so the cord was tied through it. The anchor cable was then taken in, while the cord attached to the mine was paid out. The motor boat was signalled to come alongside. The person in the folding boat went aboard the motor boat, fastening the cord to the boat's towing ring. The mine was then pulled out of the net, and slowly towed upstream towards the shore. The motor boat pulled it between two groynes, which had plenty of mud on their sides. Then the motor boat broke down, so the mine drifted on to the mud, and grounded, remaining entirely submerged. Unfortunately it blew up that night, on its time fuse, so it was not possible to examine it. Luckily another one came ashore on another occasion, and it was possible to inspect it before it blew up.

There had been instructions issued to all the infantry river and bridge guarding parties to shoot up all mine-like floating objects. This they efficiently did, but I regret to state that we lost quite a few of our spherical mooring buoys as a result.

6. Naval Anti-Mine Methods

When the crossing of the Rhine was being planned it was suggested that a wire-netting boom should be placed across the river above the bridging sites. The Navy then suggested that we should use their methods for dealing with small submarines.

Briefly this consisted of picking up the location of any floating or submerged metal objects by means of a small Radar set. This set not only located the object, but the rate at which it was moving could also be calculated.

The set was located well upstream and the information received from it was passed to a destruction party lower down the river. This party was provided with rocket guns, and these were fired at the time at which it was calculated that the object would be opposite to them. The explosion of a number of these rockets in the water was calculated to destroy any mine or small submarine.

The great advantage, from a military point of view, of this anti-mine method, is that the detecting and charge firing parties can be perfectly camouflaged. As the enemy will not know where they are, or even if they exist, he may well waste considerable energy floating mines, etc., down the current.

The necessity for calculating the speed of the current at various distances from the bank caused certain difficulties in connexion with this type of mine detection when the upstream portion of the river, where the radar set was installed, was under enemy observation.

For the Rhine crossing operation it was decided to drop floating buoys at intervals across the river above the site selected for the Radar set. As the enemy were thought to have this part of the river under observation it was decided to use a recce. rubber inflated boat to place the buoys. This could be taken to the site in a Jeep and so be as inconspicuous as possible.

After the Naval party had been installed and camouflaged, we went to our selected upstream site, inflated our boat, loaded the buoys, and paddled out into the river. Starting near the far-side, some five buoys were launched more or less equally spaced from bank to bank by eye. It was, at first, quite amusing to paddle up the river ; but not at all amusing when a few shell splashes occurred in the neighbourhood. We thought that a fragment might puncture and sink our boat, and we had left our life jackets behind on account of the hard work required paddling. We were also wearing gum boots. In spite of the wet shell splashes, we got back safely, and then went off to our bridge site. This bridge was to be named London Bridge after completion. I understand it was successfully completed, but I never saw it, because the Jerries managed to hit me with a piece of shrapnel while I was returning in my Jeep from our paddling in the Rhine.

7. Conclusion

In conclusion, great credit must be given to the Dutch who helped us so much. They provided the steam and diesel driven tugs, and also the crews to operate them. The crews worked regularly, even under shell fire or air attack, in spite of the fact that they were all civilians. Also practically all the materials used were obtained from shipyards all over the country. The people showed great hospitality to us, and their contractors helped us over L. of C. and other work, by showing where material was available, and providing labour and expert advice. Farmers and their labourers helped in the repair and drainage of roads. In fact we were extremely lucky to be operating with such a friendly and hospitable nation.

THE REPAIR OF CAEN POWER STATION

By Lt.-Col. A. B. Scrase, R.E.

1. Introduction

THE Departments of Manche and Calvados depended before the war mainly on power imported on the high tension grid, and the combined effects of allied bombing, battle damage and German demolition left this area in the summer of 1940 almost completely devoid of electric power.

There existed in the area only two generating stations of any size, namely, the Union Electrique de l'Ouest station at Caen and the privately owned S.M.N. Steelworks station at the nearby village of Colombelles, both of which were known to be heavily damaged by allied bombing and by shell fire during the battle.

Portable generating plant was in short supply and urgently required further forward and there was an important demand for power in the Caen area for working the port, the railway workshops, the town water supply, and for supplying the works of the " Air Liquide " Company who were required to produce oxygen for military needs. Power was also urgently needed for military requirements in the town of Bayeux which was without electricity at this time.

A reconnaissance was made on behalf of the Director of Works, 21st Army Group, of both these stations during the third week of July, from which it appeared that, while they were very heavily damaged, neither had been deliberately sabotaged and there was a reasonable hope of putting part of the plant into commission.

The Steelworks Power Station was not only more heavily damaged, but it had not been run for four years, and there were more technical uncertainties as to the possibility of a successful repair. The decision was accordingly made to repair Caen Power Station and the local C.R.E. was instructed on 31st July to commence clearing the debris covering the station. Shortly afterwards War Office were asked to approve a new establishment for a C.R.E. Works (Power) who could tackle such jobs and build extra high tension lines or any such work beyond the capabilities of a normal C.R.E.

The preliminary clearing was by this time well in hand and on 18th August a temporary D.C.R.E. (Power) was appointed, pending the arrival a few weeks later of the new C.R.E. and his staff. Work was at first carried on with such local units as were available, but this proved unsatisfactory, and, on the representation of the D.C.R.E., H.Q. 549 E & M. Company, with No. 14 (" A " Type) No. 81 (" C " Type) and No. 49 (" C " Type) E & M. Plns. under command, moved to Caen during the first few days of September to work under the D.C.R.E. on the repair of the station and the re-building of the L.T. and H.T. overhead lines feeding the nearby military or militarily important loads.

2. Caen Power Station as it Was

Although considerably larger than any other public utility station in the vicinity, Caen was not very big by modern standards, and the plant was not ultra-modern.

The main items of plant were as follows :

(*a*) *Boilers.*

Four generally similar, three drum, coal fired, water tube boilers with a maximum steaming rate of 27 tons per hour, pressure 450 lbs. per sq. in., and steam temperature 425° centigrade. One "Velox" oil fired flash boiler capable of 40 tons per hour.

(*b*) *Turbo Generators.*

All 2,800 volts, 3 phase, 50 cycles.

No. 1—16,000 kva.	..	Modern and efficient.
No. 2—16,000 kva.	..	" " "
No. 3—2,000 kva.	..	Obsolete and not capable of generating.
No. 4—6,250 kva.	..	Less efficient than Nos. 1 and 2 but used occasionally.

(*c*) *Converting Machinery.*

One 500 kw. and one 1,000 kw. rotary convertor supplied D.C. at 500 volts for the tramway system and for the docks.

(*d*) *Station Auxiliaries.*

The normal auxiliaries including a 110 volt secondary battery for circuit breaker operation and warning devices.

(*e*) *Coal Handling Plant.*

A travelling gantry type coal transporter picked up the coal and dropped it on to a belt conveyor, whence it was lifted by a bucket elevator on to another conveyor at the top of the boiler house from which it was fed to the boiler hoppers and automatic weighing machines.

(*f*) *Cooling Water.*

Was normally drawn from the R. Orne, the level of which was artificially maintained at a sufficient height by means of a barrage. It could in emergency be drawn from the Caen–Ouistreham Canal.

(*g*) *Transformers and Switchgear.*

The necessary equipment for providing outgoing lines at 2,800 volts (City H.T. distribution) 13,500 volts, 15,000 volts, 30,000 volts, and, via an outdoor sub-station, connexion to the main H.T. grid at 60,000 volts.

3. The Damage

Apart from damage by shell fire the station received at least two direct hits from heavy bombs (one at the front of the turbine house and one at the rear of the boiler house), as well as several others in the close vicinity; as a result of which:—

(*a*) The roof, the front wall, and much of the filling of the remaining walls were blown out (Photos 1 and 2).

(*b*) The foundations of No. 1 turbine and the two rotary converters were sheared and these machines rendered useless.

(*c*) The two rear boilers, Nos. 3 and 4, were damaged beyond repair.

(*d*) The cooling water ducts were blocked and buried at the point where they entered and left the station.

(*e*) The two fuel oil tanks containing several hundred tons of heavy boiler fuel were punctured and the oil found its way into the cooling water ducts and spread throughout them.

(*f*) The heavy overhead gantry crane crashed on the turbine floor (Photo 3) destroying the exciter of No. 2 Set and completely severing it from the turbine coupling.

(*g*) Innumerable splinter holes were punched in practically every oil, steam and water pipe.

(*h*) Nearly every joint was strained and later found to be leaking.

(*i*) The intricate control panel and some of the auxiliary plant of the automatic Velox boiler were destroyed, and the latter rendered beyond local repair.

Photo No. 1. Caen Power Station—Front View.

Photo No. 2. Caen Power Station from the Rear.

The repair of Caen power station

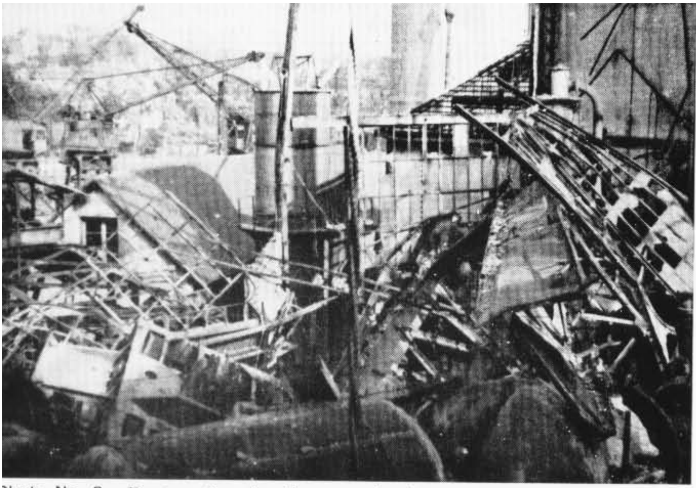


Photo No. 3. Front portion of turbine room showing part of No. 1 Turbo Alternator.

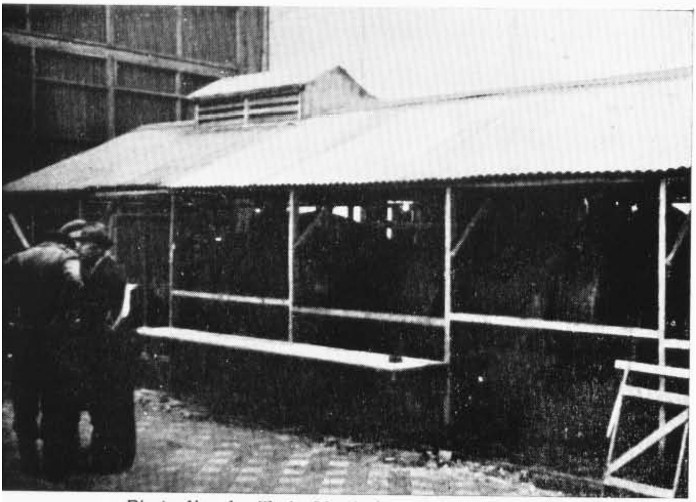


Photo No. 4. Turbo No. 4 after weather proofing.

The repair of Caen power station 2 & 3

(*j*) Practically the whole of the machinery, including a very large number of electric motors, had been subjected to three months "weathering."

(*k*) In addition the Orne Barrage had been deliberately destroyed by the Germans, which meant that cooling water could no longer be drawn from the river, but fortunately the alternative arrangements for drawing from the Canal were intact apart from the damage to the ducts.

4. Plan for Repair

A more detailed inspection after removal of the debris confirmed the original belief that the plant to concentrate on was No. 1 Boiler and No. 4 Turbine, and the more important of the essential tasks to be done before this part of the plant could generate appeared to be as follows :—

(*a*) Trace the electrical circuits of the auxiliary plant and renew the cable where required. This turned out to be a formidable task requiring much patience.

(*b*) Dig out the cooling water duct. This was accomplished with a mechanical equipment, and at a later date an A.T. Company were called in to reconcrete the duct and make a proper job of it.

(*c*) Evacuate the oil from the ducts. This oil would have been very detrimental to the operation of the condensers and its removal presented a considerable problem. Eventually the bulk of it was removed by self-priming pumps drawing from specially shaped " vacuum cleaner " nozzles and the balance was flushed alternately into the R. Orne (tidal) and the Canal (supposedly constant level) until it was judged safe to pump through the condensers.

(*d*) Overhaul the turbine. It was not considered worth while to attempt to lift the main covers without the crane, and the repairs were limited to the exciter, governor, oil cooling and lubricating system and the turbine auxiliaries.

(*e*) Completely overhaul and test No. 1 Boiler, including safety valves, water level alarms, feed pumps and motors, forced and induced draft fans and motors, the automatic stoker and the coal handling plant.

(*f*) Weld, or otherwise repair, holes in steam and other piping and blank this off where it led to destroyed parts of the station.

(*g*) Provide temporary shelter from the weather for all exposed machinery, pending the repair of the roof (Photo No. 4).

5. Auxiliary Power and D.C. for the Docks

A Meadows 230 volt, A.C., 12 kw. generating set was available from the beginning for lighting and testing, but was, of course, quite inadequate to " get the station away," which required something of the order of 200 kw. Also about this time the need for D.C. power to work the cranes at the Caen Docks became really urgent and it was evident that this demand could not wait until the turbine was running. Arrangements were therefore made to send up one of the 400 volt, A.C., 275 kw. rail-mounted, diesel engine generating sets which were then in the theatre. The first of these arrived early in September and was followed up by three more.

The problem of providing the D.C. had still to be solved, as all converting plant in the station had been destroyed. (Apart from the damage to their foundations the two rotary converters had been subject to the close range blast of the bomb which fell within a few feet of them.)

Preparations were made to move from Cherbourg a motor generator which had been in use for charging the batteries of German submarines, but before this became effective a locally available expedient was found which temporarily solved the problem.

The somewhat complicated auxiliaries of the Velox boiler included a Ward Leonard set with a 300 H.P., 2,800 volt, motor, and the separately excited generator driven by this would give up to 440 volts which was sufficient for the 500 volt cranes. This part of the Velox equipment was undamaged and served to provide D.C. for the docks until at a later date a 250 kw. British rectifier was installed. The 2,800 volt station bus bars were energized from the rail-car generators via one of the rotary converter transformers, which had been only slightly damaged, and although the 300 h.p. motor had "direct on line" starting and could only be started by switching on at no volts and bringing the rail-car voltage up very slowly this was quite a simple operation.

A point worth recording is that in this heavily blitzed area, where the distribution system was in places almost untraceable, more manhours were needed to restore the distribution than to repair such of the power station as was repairable, and at every stage more power was available at the station than could be utilized.

D.C. power to the dock cranes, and A.C. power to the capstans, was a comparatively simple distribution problem, as these were all close to the power station, and these supplies were given in the middle of September.

6. First Run-up of No. 4 Set

No. 1 Boiler and No. 4 Turbine and all the essential parts of the station had been continuously worked on by 549 E. & M. Coy., with some valuable assistance from the French staff who gradually filtered back, since their arrival on 2nd September, and on 13th September things were sufficiently advanced for a trial run.

The Turbine ran up to speed quite sweetly although the alternator failed to generate, but so many faults in the way of previously undiscovered steam leaks presented themselves that it was obvious that further work would be necessary, apart from curing the electrical fault, before allowing full pressure in the mains or attempting to generate.

The next test was fixed for the 21st September and all went swimmingly until an attempt was made to parallel the alternator with the rail-car generator in order subsequently to take the latter off the bars and make the station "self supporting."

The paralleling was done by the French chief electrician and as far as could be judged by instruments he made a perfect job of it. None the less there was a violent explosion in the bus bar chamber feeding the auxiliaries to this set and a sustained arc was found to have burnt away a considerable length of copper bar and destroyed the evidence of its cause.

Many other small faults were apparent, and as more power than could yet be distributed was available from the rail-cars it was decided to shut down for the necessary repairs.

The station was ready for running on 11th October and again all went well until the attempt was made to run the Turbine in parallel with the rail-car generator. This time the paralleling appeared momentarily to be successful but after a delay of about 15 sec. an even more violent explosion occurred in the starting panel of the No. 4 condenser group which did considerable damage and the test for that day was over!

It was eventually found to be due to a faulty cable which was old and had been subjected to blast, and apparently it broke down under the slight voltage ripple produced by running these very different types of prime movers in parallel.

The French worked all night on the damage inside the cubicle and the Sappers worked all night on laying a new cable and the following day all was ready for a further test. The French manager was thoroughly scared at the idea of any further attempts at paralleling, and as there might well be further weak points in the system it was decided to run only the boiler auxiliaries from the rail-car, and to run the turbine to atmosphere and attempt to generate sufficient power to start the condenser group motor from this source.

This proved successful after one false start, the remaining auxiliaries were shut down and transferred to the turbo alternator, and the station was at last self supporting and able to export such power as could be distributed, which at this time was only a small fraction of the internal station load.

7. No. 2 Boiler

Apart from the necessary repairs to all the fittings and auxiliaries it was found necessary to rebuild the brick arch and completely reline the furnace of No. 2 Boiler. Fortunately the necessary materials were available in the power station store and the boiler was steaming on the 22nd October, enabling No. I to be shut down for further repairs which had by this time become necessary. Both boilers had their share of troubles, and it was at one time necessary to keep one of them running for several days with water pouring into the furnace from a split economizer tube and the chimney belching steam. Considering what they had sustained in the way of blast it was perhaps remarkable that this was the worst thing that happened.

8. No. 2 Turbo Alternator

As mentioned previously the exciter had been wrecked and severed from the set by the wreckage of the overhead crane which had to be cut up by oxy-acetylene and removed piecemeal.

The problem of exciting this set was not easy, as although it appeared that the exciter of No. I set was repairable, the two sets were of different design. However, a new bed plate and coupling were designed and the former was cast successfully at the railway workshops.

The governor was also seriously damaged, and casting a new body for it presented such difficulties that eventually a body was fabricated by welding.

A question which only a test would answer was whether the fall of the crane across the alternator, and its shearing of the exciter coupling, had affected the alternator rotor shaft. This appeared improbable in view of the massive proportions of the latter, and fortunately this view proved correct and the turbine was run up successfully on the 10th November, and by the 21st it was on load.

On about the same date the 250 kw. Mercury Arc Rectifier took over the D.C. load from the much abused Ward Leonard generator, which had suffered a number of commutator "flash-overs" as a result of short circuit, on the dockside.

9. Further Work

Supplies had been given to all important local military consumers before the end of October, and the 30,000 volt line to Bayeux (repaired by the Supply Company) was on load on the 1st November and any further distribution of power was a French responsibility.

Only improvements and tidying up work remained to be done at Caen, and on 27th November, C.R.E. (Power) and most of his staff moved up to Antwerp on to a new job.

Experience had shown, however, that the French labour was not yet fully reliable, and as there had been more than one unnecessary " shut down " it was decided to retain a Major from the C.R.E.'s staff, together with a Subaltern from the E & M. Coy, a Mechanist, and four electricians and fitters for such time as the importance of the military load justified their retention in a supervisory capacity.

There was a further reason, in that at the beginning of November the decision was made to put the Velox boiler into commission again with the assistance of the manufacturers. (Societé Electro Mechanique de Le Bourget, Paris.)

This step appeared to be essential because with one of the two coal fired boilers off the line for cleaning, the station output would be limited by boiler capacity to about 3,000 kw., and there was every indication that the load would grow to at least this value.

The repair of the Velox boiler included also the repair of at least one of the 500 ton fuel oil tanks and the laying of a Victaulic pipe line from the tank to the docks, and this was a job for which the French staff had neither the facilities nor the materials; and for which it was necessary to obtain the assistance of the railway workshops.

As regards the boiler and its extensive control apparatus the scheme was to send all damaged parts to Paris for repair or remanufacture as necessary, and for the plant to be reassembled on site by military personnel working under the direction of a skilled erector from the makers.

There was an inevitable time lag but no serious difficulties, and when at last on 23rd February the boiler was again complete it performed perfectly and the station could rely, if required, on a continuous output of about 6,000 kw. (Before this figure was actually reached connexion had again been made through the 60,000 and 220,000 volt networks with the hydro-electric stations of the Massif Centrale and the station reverted to its pre-war role of a peak load station, for which the Velox boiler, with its remarkable performance of reaching full output from cold in about 20 mins. was eminently suited.)

All military personnel were withdrawn at the beginning of March and so ended half a year's work on the repair and control of a French power station by the British Army.

THE GIBRALTAR RUNWAY

By Col. T. W. R. Haycraft.

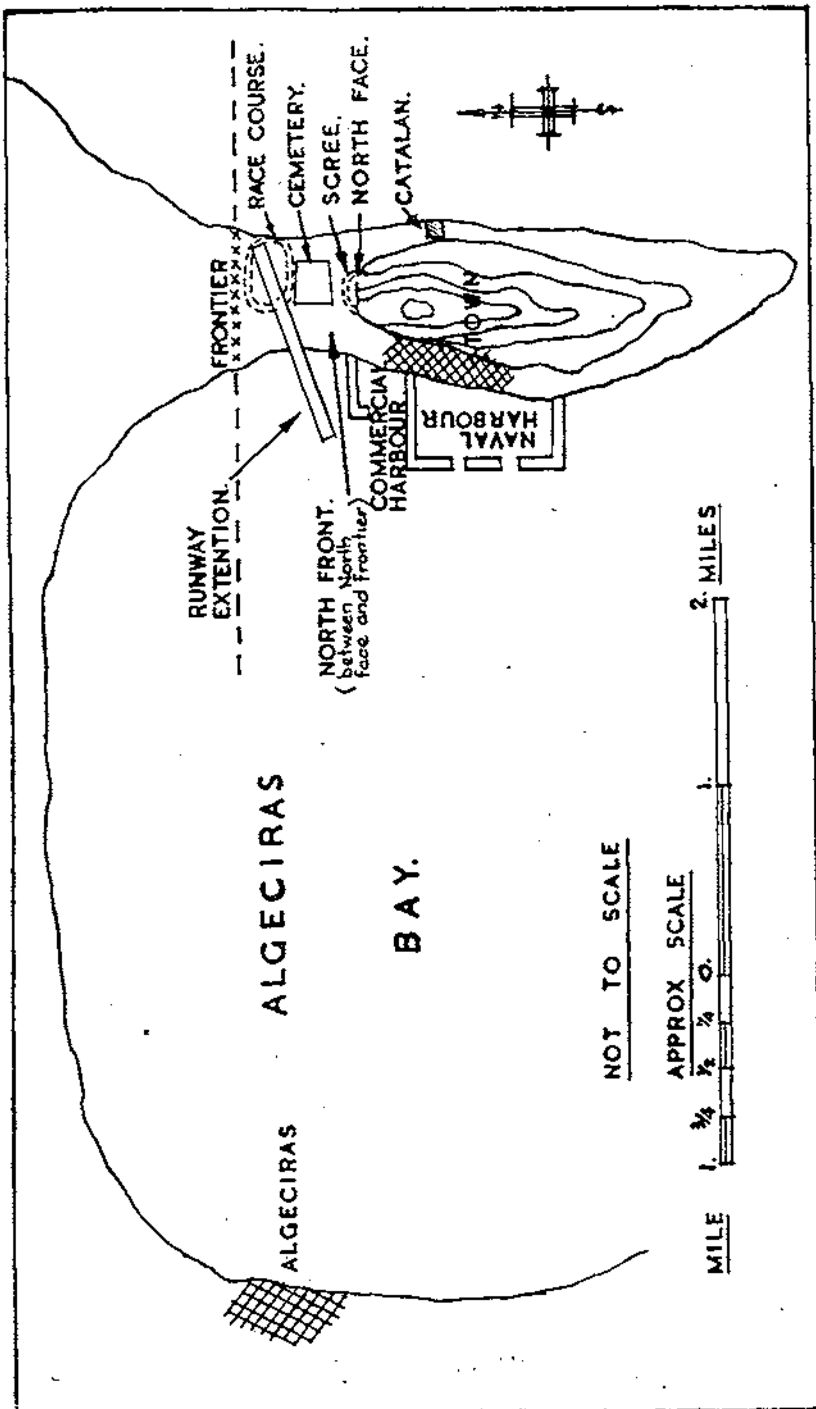
A RUNWAY with a bad name in the R.A.F. and which has been the scene of more accidents than most is the one at Gibraltar. Here Marshal Sikorski met his death in a Liberator a few seconds after taking off ; many an aircraft lies on the bottom of Algeciras Bay and much scrap lay on the North Front. A short history of this runway and of how it was extended into the sea may be of interest to officers of the Corps, many of whom will have staged there between England and the East.

In April, 1936 a firm of consulting engineers submitted a report to the Air Ministry on two proposals for constructing a runway at Gibraltar. One scheme comprised a reclamation 800 yds. × 200 yds. in Catalan Bay on the East side of the Rock, with a taxi track 800 yds. × 70 ft. leading to it from the North Front. This is a lee shore for more than half the year with a sea scend of 300 miles ; during gales a wave amplitude of 16 to 20 ft., may be expected. The surface was to be 6 ft. above High Water, protected by a heavy rock rubble bank another 8 ft. higher. The other scheme was for a reclamation 1,100 yds. × 300 yds. running out from the North Front into Algeciras Bay parallel with the Spanish Sea frontier. This was to be 4 ft. above High Water with a surrounding rubble wall another 2 ft. higher. The cost of either scheme was about £500,000 and the amount of fill about 750,000 cub. yds. The first scheme was far the more difficult and its success the more problematical, and any future extension was also more difficult. Neither of these proposals was implemented at that time.

On the outbreak of war in 1939, the race track on the North Front was closed down and an East and West runway built from sea to sea across the North Front, a length of 900 yds. Under favourable conditions this gave a take-off barely long enough for stripped Wellingtons staging between England and Malta. The waves lapped over wrecked aircraft at both ends of the runway, which must have been a grim sight for pilots coming in to land. The runway cut across the race track but avoided the cemetery. As will be seen from the sketch, aircraft coming in from the East or taking off Eastwards necessarily passed over Spanish territorial waters. After the fall of France Spanish machine guns often opened up on these occasions, but presumably with no intention of making a kill as the writer never heard of any damage being done.

Owing to the presence of the rock the wind on the North Front is always either in the East or West—more or less. The actual wind varied along the runway and the wind sock in the middle was no true indication of the wind at either end. Apart from this a South wind, though it gave a resultant East or West wind over the portion of the runway covered by the North Face, always produced gusty conditions at the ends. Altogether it was about as nasty a runway as could well be imagined. The only way to improve wind conditions and avoid flying over Spanish territorial waters would have been to take the runway through the cemetery. For political reasons this was not pressed. It is to be hoped that the Gibraltarians realize the price that was paid in lives on the altar of their susceptibilities. Someone suggested burying the cemetery in sand (to be removed after the war) and carrying the runway over it. This would have involved raising the whole runway about 10 ft. and was deemed impracticable.

In the autumn of 1941, as a result of the threat to Malta, it became imperative to route aircraft direct to Egypt without touching there and the 1936



RACE COURSE.
CEMETERY.
SCREE.
NORTH FACE.
CATALAN.
FRONTIER
RUNWAY EXTENTION.
NORTH FRONT. (between North face and Frontier)
COMMERCIAL HARBOUR
NAVAL HARBOUR
ALGECIRAS BAY.
ALGECIRAS
NOT TO SCALE
APPROX SCALE
MILE 1. ¾ ½ ¼ 0. 1. 2. MILES

report was revived. The requirement was now for 1,500 yds. and a runway of 900 yds. was now in existence. It was, therefore, decided to extend the existing runway into Algeciras Bay to a total length of 1,500 yds. on a width of 100 yds. This was to be done by taking the scree lying against the North Face, the large rock to be dumped along the sides and end and the small stuff in the middle. The sides were to take their natural slope ; no revetting was to be attempted. It was realized that heavy seas would do a certain amount of damage and that this would have to be made good by further dumping. A heavy sea can only occur with a strong South West wind—a rare contingency. The surface was to be given a water bound finish using tunnel spoil. Although the acreage of reclamation would be less than recommended in the report the surface would have to be about 10 ft. above High Water to conform with the existing runway and not 4 ft. as suggested in the report.

An excavator Coy. R.E. arrived from England in the spring of 1942. The company was about 300 strong, including a Canadian Section with diamond drilling equipment. The Company also included a strong workshop section, a very wise provision where equipment would be subjected to hard usage and there were no local repair facilities. Equipment consisted of six 47 R.B. excavators, D.7 and D.8 angle dozers and some 50 3-ton trucks with V-8 engines. Some of these were Ford trucks with strong, low, steel sides, and stood up well. The rest were Thames trucks with light, flimsy, sheet iron sides which soon collapsed. Later a consignment of 10-ton trucks with really tough bodies was received. All trucks used were tippers. The men were nearly all recruited straight from civil life where they had been doing the same work. The digger drivers were absolute wizards, and it was fascinating to watch them juggling with 5-ton rocks. All ranks were tremendously keen. Work was organized in two shifts. Often the drivers off the morning shift would get a meal and a sleep and go on the job again to see how the other shift were getting on, particularly if the relief driver was a new hand.

The scree on the North Face consisted of a very random mixture of conglomerate rock, gravel, sand and limestone boulders, more or less cemented together by lime water percolation. The whole scree was full of fissures, large and small. It was impossible to judge from the surface what it would be like underneath. The scree lay at its natural slope of 1/2 and contained 1,750,000 cub. yds., calculated by survey from a base on level ground. The diamond drilling section was equipped with drilling machines, 3 in. diamond crown and casing and 2 in. diameter gelignite cartridges. Due to the mixed and fissured nature of the scree much time was wasted clearing jammed drills and withdrawing casing. The bores often fell in between withdrawal and charging. Also it proved impossible to judge the correct charge for a given burden. In most cases either the charge was dissipated in fissures or the spoil was thrown all over the North Front, causing a great deal of damage and much alarm. The whole place was packed with aircraft in transit and much annoyance was caused moving them out of the danger area. Rate of progress was far too slow and this method was abandoned.

The Canadian officer undertook to bring down the scree by hydraulicing, of which he had some previous experience, using for this purpose the pumps supplied for static flame throwers. These flame throwers were intended to stiffen up the defences at certain important points, but their installation presented many problems, their range was unsatisfactory and no-one had much faith in them. The pumps were rated at 900 gallons a minute at 500 ft. head, direct coupled to de-rated Rolls Royce Kestral engines. The R.A.F. drove and maintained the engines. Two pumps were installed with intakes from the sea, one at each end of the scree. Rising mains were 6 in. vitaulic with 4 in. flexible oil pipe at the ends. Nozzles were home-made. The best results were obtained, not by soaking the scree from above as one would imagine, but by attacking a vertical face from below. The jet would be played on a face for perhaps half an hour without any visible effect and then, without any warning 200 or 300 tons would come down, leaving a vertical face further up which was attacked in a similar way. After a little practice the hydraulicing party were able to keep the diggers and trucks fully supplied. The party would work at one end of the scree all day and the diggers at the other. The following day they changed places, the wet scree having drained off during the night. The scree being much disintegrated by wet was easier to handle than dry. Probably the greatest advantage was that the scree having come down and drained off, was perfectly safe to work at whereas, working in the dry scree, there had been much danger of a serious fall damaging the machines. The extra weight of the wet material was of no consequence as the loading of trucks was limited by volume rather than by weight. At a later date the hydraulicing was taken on by another Canadian who showed that volume of water, rather than head, gave the best results. He doubled the rising main and connected through a Y junction to a larger nozzle, thereby increasing the delivery at the expense of head.

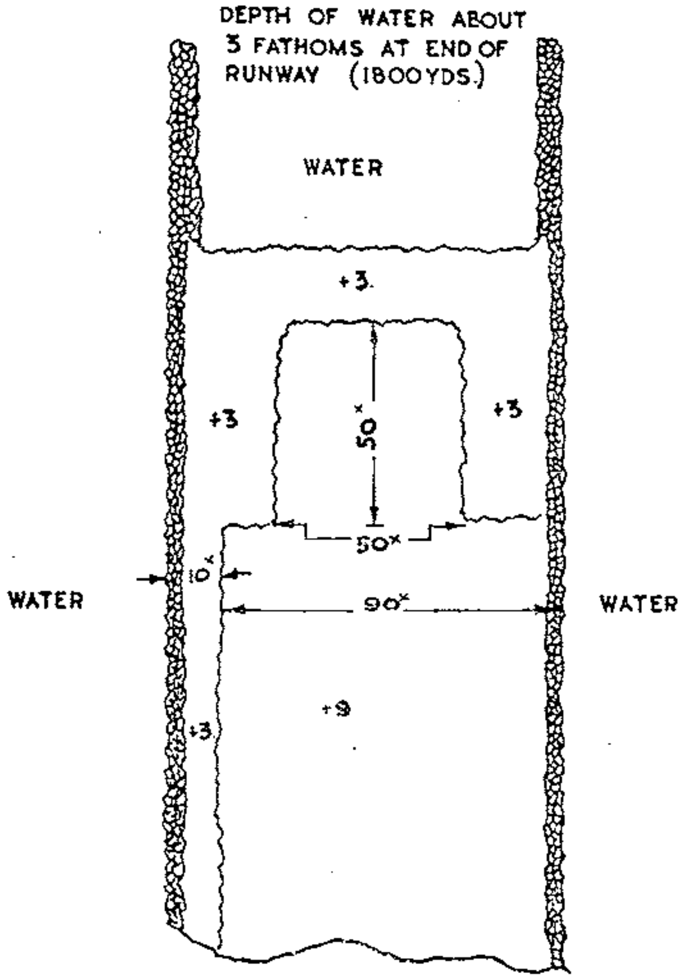
In spite of the protests of the Brigade Commander on the North Front all road blocks were removed. Dump trucks were given absolute priority on the road—and used it! They drove all out, often spilling rocks off the top of the load as they went. Any vehicle meeting them was well advised to leave the road!

In order to enable work to proceed with the least interference from aircraft using the runway work proceeded on two levels. The risk of accident was accepted. One aircraft was lost after removing the cab of a lorry at night. The driver was in the cab but got away with a shaking. It also had the advantage of consolidating at two levels. When the lower level had advanced 60–70 yds. beyond the higher, operations at the lower level were stopped and the higher level advanced 50 yds. on a width of 50 yds. This required about 6,250 cub. yds. and was completed in the morning shift with every available machine and truck working all out. The surface was completed by the afternoon shift. The A.O.C. then inspected and the extra 50 yds. was opened for flying. All men working on the site collected round while the A.O.C. explained the air situation.

As the runway advanced, progressively heavier aircraft could be routed, or aircraft need not be stripped, or they could fly through to Egypt without stopping at Malta. At the same time as saying what could now be done, the A.O.C. announced what the result of the next 50 yds. would be. On the important occasion when Hudsons were able to cut out Malta (where large numbers had been lost) Lord Gort attended in person and congratulated the Company. These milestones, and the picture painted at each, contributed immeasurably to the speed of the job. On one occasion the Air Chief Marshal, Commanding Middle East Air Force, gave an impromptu talk to the men on the job describing the results of the runway extension from personal experience of the other end. When he had finished the men cheered and doubled back to their machines.

During the interval until the next 50 yds. advance was made the new extension was widened to 90 yds. (leaving 10 yds. on the lower level for traffic). For this purpose the runway was not closed, but traffic was controlled by a red-flag man.

As will be seen in the sketch the edges were extended well ahead of the middle. Large rock only was used in these horns which became self supporting solid causeways, instead of merely providing a hard edge to the runway. Before the arrival of labour and equipment an attempt was made to obtain



SKETCH TO ILLUSTRATE THE METHOD OF EXTENSION. HEIGHTS ARE IN FEET (APPROX) ABOVE WATER LEVEL.

a suction dredger belonging to the Belgian Government and known to be lying at Boma, at the mouth of the Congo, complete with equipment and crew. This was a self-propelling unit capable of doing 5 knots and reputed to be one of the biggest in the world. Clearance was obtained from the Belgian Government in London but, after consideration, the Navy decided against the project. The dredger would have had to coal at Freetown, where German submarines were known to operate, apart from which such a slow and vulnerable target would require a larger escort than could well be spared at that time. This was a great disappointment as the sandy bottom of Algeciras Bay would have provided an ideal fill for the centre portion of the runway, and would have removed any fear of subsequent settlement and saved much time and labour.

The total length of runway required was laid down by the Air Ministry as 1,500 yds. All senior R.A.F. officers passing through agreed that a length of 1,800 yds. was essential. The yardages of fill required were 750,000 and 1,500,000 respectively. The runway was eventually completed to 1,800 yds. The trouble about the Gibraltar runway is that pilots coming in from the West have to touch down as on to a carrier without the experience of the R.N.A.S., without the batsman and without the ship's own wind. They have also to contend with possible cross wind and gusts. Consequently they are apt to waste the first 300 or 400 yds.—and the overrun at the East end is into the sea. No wonder it takes years off them! The writer saw many amazing skid stops, but all were not so successful. Some of these were burnt out though, amazingly, with little loss of life.

One or two incidents are worth mentioning. The R.A.S.C. dumped a large quantity of condemned condensed milk at the end of the extension one night when nobody was about. No one knew what the possible effect might be, but there was no time to dig it out again. Milk oozed out of the ground and covered everything. Hundreds of tins floated out into the bay and were a hazard to flying boats for days. A sunken Hudson was buried under the fill. No quick method of crushing it under water could be devised. It was never known whether it collapsed or whether the fill bridged over it to settle at a later date.

An Air Marshal passing through raised the question of basing a fighter squadron at Gibraltar. This was at a time when it was thought that the Germans might establish an air base at Ceuta. A scheme was prepared for tunnelling into the North Face, after the scree had been removed, for the accommodation of workshops, equipment, ammunition, accessories, and one or two complete aircraft, what remained of the scree being used to make pens in the open. The layout allowed for a whole flight to taxi straight out on to the runway, wheel right or left according to wind, and take off quickly while the airfield was under attack. The rock here was of very good quality and would have stood without support on a span sufficient to take a Spitfire. The scheme was submitted to the Chiefs of Staff but was turned down.

This account would not be complete without a tribute to the Naval party from one of the battleships in harbour who carried out an excellent survey of the bottom, on a 25 yd. grid, on the projected line of the runway extension.

AIRFIELD CONSTRUCTION DURING THE INVASION BATTLE—PART II

By Brigadier G. T. Denison, O.B.E.

(This article was written in November, 1943, but publication was withheld for security reasons. Certain details of organization which are mentioned no longer apply.)

1. Introduction

IN the March, 1943 issue of *The Royal Engineers Journal*, the writer of this paper published an article entitled, "Airfield Construction during the Invasion Battle." This article was based largely on conjecture, as no practical experience was available. Since then the writer has had the extremely good luck to command an Airfield Construction Group which was involved since D-Day in two invasions in C.M.F. The object of this paper is to supplement the previous article.

2. Principal Engineer Tasks in an Advance

In the forward areas during an advance the two principal tasks which face the Sappers are :—

(*a*) Maintenance of road communications.
(*b*) The establishment of air bases.

Task (*a*), which is the job of divisional, etc., engineers, comprises clearing of mines and booby traps, removal of road blocks, repairing of craters, construction of diversions, and, above all, heavy bridging.

Task (*b*), which is carried out by airfield engineers, comprises the construction of new airfields, or the repair of captured enemy fields. A general priority cannot be given to either task as this depends on the battle situation at the time.

During the first stages of a sea-borne invasion absolute engineer and " G " priority is usually given to the task of getting the first few airfields operational in the shortest possible time. The reasons for this are two-fold :—

(*a*) In the early stages of the invasion, although the enemy may know that an invasion fleet is on the way, provided they do not know exactly which sectors of their defences will be involved, the selected beach areas should very quickly be overrun. In that case the enemy will probably not have sufficient time to do serious damage to the road communications in the area as he withdraws. Bridges may well be captured intact, and this can be aided by airborne attack at or just before H-Hour on vital bridges in the proposed bridgehead.

(*b*) The establishment of airfields at the earliest possible moment becomes of vital importance. The maximum range at which single-engined fighters can operate from their bases is about 160 miles. Such a distance, however, involves many great disadvantages ; the fighters time over the target area is very limited ; they have to set out with auxiliary long-range petrol tanks, which are discarded in flight ; the expenditure of these tanks becomes very high indeed and might even affect operations ; lastly, any seriously damaged aircraft, or one which runs out of petrol, is faced with the unpleasant possibility of a forced landing in the sea. It is conceivable that an invasion might take place beyond this 160 miles radius of our fighter fields, although the writer trusts he will not be involved in such an undertaking. This would involve fighter air support being supplied by aircraft carriers, which has the following serious disadvantages :—

(i) The carrier-borne aircraft is generally not such a good machine as the land-based fighter, and is therefore a doubtful match for the most modern types of enemy fighter.

(ii) The rate of loss of aircraft through unlucky landings on the carrier is appalling. This is probably due to the very high tempo at which the pilots are worked.

(iii) The Royal Navy views with extreme distaste the operation of their aircraft carriers for long periods close to a hostile shore, or within easy range of enemy aircraft. They will probably impose a time limit of 72 hours or even 48 hours for operations in such an exposed position.

It follows, therefore, that during the early landings the establishment of the first airfields is almost certainly the priority engineer task.

Once the beach head has been established, and a few airfields are functioning within it, then as the advance continues maintenance of road communications probably becomes the primary engineer task, while airfields are secondary.

In action, as opposed to exercises, one thing which is very gratifying to the sapper engaged on airfield work, is the fact that all members of the staff and services fully realize the importance of the work ; they are extremely interested and most helpful. The writer has never approached a Chief Engineer with a cry for help without that assistance being granted. Conversely, every effort is always made to help out the field units when they are in difficulties.

3. Enemy Methods of Airfield Construction

At this stage it may be of interest to consider the type of airfield the enemy produces ; there are two types, grassed surfaces, i.e., "natural" fields, and the all-weather type with a hard surfaced runway or runways. The first thing the sapper notices is the complete lack of mechanical equipment, or any evidence to show that it has ever been used. Ground preparation appears to be done by hand, by harrowing, using small 20 h.p. Fiat agricultural tractors to tow chain or toothed harrows, the whole being polished off by intensive rolling. The result is that in almost every case their rapidly prepared fighter type natural Airfields have a surface which is so rough that our aircraft cannot operate from them. Even the old established and reasonably good grassed airfields we took over are very rough indeed and it is only with great difficulty that the Air Force can be coerced into using them. The R.A.F. usually asks the Sappers to regrade such a field ; this always involves stripping and destroying the turf, which thereby renders the field very liable to become completely unserviceable for long periods after rain.

On the other hand the enemy's hard surfaced runways are good. They are, generally speaking, shorter than accepted practice in the United Kingdom, the samples met with varying from 1,200 yards long to 1,600 yards, but they are rather wider than ours, varying from 55 yards to 63 yards in width. Construction is good, usually 6-inch slab concrete on 12 inches of hand pitched stone. The concrete slabs are small, thereby helping repair work, and are in the region of 16 feet long by 10 feet wide. Normally they do not break bond, so that the corners of four slabs meet at a point ; this is shoddy work as these corners generally crack off after a time. Expansion joints are provided by leaving the form work in place and sealing with bitumen ; this provides a simple expansion joint which is quick to make and adequate in view of the small slabs. The finished surface is good, sometimes plain concrete, at others surface dressed, using tar spray and stone chippings or natural asphalt. A camouflage surface, such as is provided at some stations in the United Kingdom by using wood or rubber chippings, has not as yet been encountered.

The enemy provides good drainage on all his airfields, taking great trouble even over his advanced fighter airfields, and the ditches are piped or culverted. On the larger grassed fields a proper drainage system, in which he uses a large number of French drains, is produced. His ideas of side drains to hard surfaced runways is, generally speaking much better than ours. We tend to make this all-important side drain a French drain, which always chokes up; the enemy makes a proper rectangular drain, 2 feet wide and at a suitable depth to produce a run off. This drain is covered by masonry or concrete slabs, with 9 inch by 1 inch slits to allow of water running through, spaced at about 18 inch centres. The slabs are very slightly dished to collect water and direct it into the drainage slits.

As far as flying obstructions are concerned the ignorance shown by the enemy airfield engineers is astounding. They seldom site a runway to give the best flying approaches, and even when they have constructed a runway or a good flying strip, they then go out of their way to spoil the flying approaches by placing aircraft dispersal pens, new buildings, telephone, etc., wires right at the end of a runway. A classic example of stupidity of this nature was seen at one very important airfield with an excellent concrete runway where the enemy had actually suspended vital signal wires on tall poles across the concrete runway about two hundred yards from one end of it!

This bad habit of the Germans of blocking flying approaches with signal wires, high tension cables, etc., always leads to difficulties as far as the Sapper is concerned. In order to make the airfield at all reasonable these wires must come down. Opposition is usually met with from all concerned, their argument being, "If the Germans used that runway with the wires at the end of it, why on earth can't we?" A very reasonable argument on the face of it, but the wires still come down. This is not an isolated case; it almost invariably happens at any captured airfield.

Recently the writer has noticed a most significant and gratifying fact. Some of the latest constructed enemy airfields are on really bad sites from every point of view except that of camouflage; the sites from the camouflage point of view have been excellent. At one nearly completed site the camouflage was marvellous but the road access, flying approaches, general nature of the soil and dimensions of the airfield were absolutely shocking. The inference is obvious; as we now have almost undisputed air superiority in the theatre of operations, the enemy are forced to subjugate all other considerations to that of concealment. Camouflage of airfields always indicates a passive form of defence; an active form of defence is infinitely more valuable, which is provided by air superiority supported by very strong ground A.A. protection.

4. Enemy Methods of Airfield Demolition

The first thing one notices in a reconnaissance of a captured airfield, which has been demolished, is that the enemy can have given no study to the problem, as they have not evolved any properly worked out system or special methods as we have done. In each case the enemy engineer on the task would appear to have been left to his own devices. Three different types of demolition were encountered, which are described below:—

(a) Deep and systematic ploughing. The object for one assault landing was an old enemy airfield which they ploughed up about one month before the invasion took place. The ploughing covered the whole field, to a depth of 18 inches, and strong sun had baked the clay furrows. However, exactly 48 hours after the first British soldier crossed the airfield it was repaired sufficiently to allow of the operation of three fighter squadrons—this in spite of a delay of 24 hours in getting mechanical equipment ashore.

(*b*) Hasty demolition of grassed fields. This was done by cratering, the explosive used being generally a 50 kg. or 250 kg. bomb dug into the ground and fired electrically. Many did not appear to be properly primed, and were discovered and removed by the Sapper repair parties. In addition, the whole field was obstructed with wreckage.; aircraft were run out on to the field and burnt, petrol tank waggons, heavy lorries, steam rollers, cars, etc., were dealt with similarly, and when first seen the airfield generally looked an untidy mess. This sort of demolition hinders but little the rapid production of a strip good enough for operations as a start. Two extreme cases are quoted. In the first, speed was essential when a flying strip 1,000 yards long by 50 yards wide was produced in six hours by 150 men, one roller, two bulldozers, and six 3-ton tippers. As the enemy were 1,500 yards from the edge of the airfield while the repairs were being carried out and as they were on hills overlooking the airfield, the writer decided not to risk more men or plant in such an exposed position. In the second case speed was not of such great importance, the difficulty being to get on to the site owing to badly congested roads. A similar sized strip was produced by 13 men with one 3-ton lorry and no plant in 48 hours. This last example involved filling eight craters about 15 feet in diameter and 4 feet deep with hardcore and removing four large wrecks. Although it is a quick task to locate and repair one strip, off which between three and five squadrons can operate, it is a long and laborious task to restore the whole airfield.

(*c*) Deliberate demolition of concrete runways, with many deep craters. One good example may be quoted :—A very fine concrete runway was taken over in damaged condition. This runway was 1,300 yards long by 63 yards wide, with an excellent drainage channel on either side. There were 27 craters, each about 15 feet in diameter and 4 feet deep, in the runway, and five large explosions in the side drain had destroyed a total length of about 400 yards. The writer was asked his views and stated that although the runway could be made operational in two days by simply back-filling the craters with hardcore, topping with fines, and rolling, this would be but a temporary expedient. He strongly advocated the cutting back of the damaged concrete to the first undamaged slab, the proper filling of the craters and giving the whole surface a new concrete slab. This would involve the pouring of some 2,500 square yards of 6-inch concrete, the finding of the necessary 80 tons of cement, the collection from a long distance of the concrete mixers, and allowing for the time for the concrete to cure, the runway could not be operational for ten days.

After heated argument this latter course was adopted which proved fortunate, as this runway from the moment of completion onwards was in continuous use. In fact all world records were broken when on one day with only 11 hours daylight 532 landings were made on this runway and roughly the same number of take-offs. The aircraft using it ranged from Air Ops. to Flying Fortresses. If, in the first place, a quick job had been made, this runway would never have stood the pounding it finally received.

Wherever there are airfield buildings, the German makes a thorough job of destroying them. In the North African campaign the enemy planted large numbers of Tellermines and S-Mines on their airfields. The writer has been lucky, as in the two campaigns he has been in up to the present, the enemy have been singularly unenterprising with mines on airfields. On only one airfield, on which the unit was working, were Tellermines encountered; about 100 had been laid, but only on the small approach and accommodation roads on the airfields and they caused three vehicle casualties. Why this airfield had not been extensively mined and booby-trapped is not known, as a vast stock of prepared charges, pull, push and release mechanisms, and 48 of the very elaborate 21-day clock time mechanisms (J-Fedor 504) were captured intact. The enemy meant trouble but probably did not have time to carry it out. However, he did produce one quite ingenious trap by placing Tellermines under heaps of stone near the perimeter track; these were soon discovered but at the cost of one D4 bulldozer blade.

5. Effects of Weather

Weather, and the likelihood of heavy falls of rain are vital factors in airfield construction. There are definitely two types of fields :—

(a) Dry weather field.
(b) All weather field.

Dry weather fields, even for heavy bombers, are constructed by grading runways, taxi tracks and dispersals out of the local countryside which may be a poor grass, stubble, vineyard, olive grove, a tobacco field, or even tomatoes and melons. No form of mat, such as Sommerfield Track, is provided because in dry weather, if the work has been carried out properly, the earth will take any aircraft load.

All weather fields are very different. Sommerfield Track is not nearly strong enough and the practice is either to lay Pierced Steel Planking (P.S.P.) on a 6-inch layer of stone, or to carry out full scale runway construction.

A dry weather airfield can be produced fairly quickly, but an all weather field takes a long time. For fighter all weather fields to accommodate 80 fighters some 3,000 tons of P.S.P. are required and, if a stone base has to be provided, at least 40,000 tons of stone will be needed in addition.

6. Some Facts and Figures

In the United Kingdom the Sapper is controlled by the various figures given as "Air Ministry Minimum Requirements"; fortunately these do not apply in operations. Naturally the Sapper must give the Air Force the best field he can under the circumstances. The writer has been in the unfortunate position owing to operational conditions, of giving the Air Force absolute minima. These are quoted for interest. At one fighter field the longest run practicable was 900 yards (A.M. minimum 1,200 yards). There was a swamp at one end and a 20-foot wide ditch at the other. Flying approaches were not good at one end, as 5.5-inch guns and 25 pdrs. were within the approach funnel and were firing almost without intermission (this is the perfect example of a psychological flying obstruction), but at the other end the approach was over the wide ditch and the sea. Eighty *Spitfires* operated from this field but four crashed on the first day and after that the crash rate averaged one a day. It was found that crashes were reduced when a line 100 yards inside each end of the strip was marked out, and any aircraft landing, which had not touched down before it reached the 100 yard mark was signalled to by the control officer firing a red Verey light, whereupon the pilot had to open up and make another circuit.

Single runways or landing strips are the rule, two runways are absolutely exceptional. The average fighter field has to cater for 100 aircraft, but as many as 320 fighters have been based on a field with a single runway. The congestion of aircraft on the ground in the latter case broke all rules of dispersal and considerably worried the C.R.E.

For dry weather strips the minimum width the British units produced was 80 yards, although American units go down to 50 yards, and at least 100 yards was always aimed at. On some occasions even a 200-yard wide strip was provided. The reason for wide strips is dust. A single aircraft operating on a dry weather strip raises a dust storm which may take some minutes to disperse. Speed in getting a squadron airborne is all-important, so if wider strips are provided more machines can take off together; the resulting dust storm does not take much longer to disperse than for a single machine. From a 50-yard wide runway, owing to this dust, it is dangerous to fly two machines off simultaneously, but off a 200-yard wide strip six machines can be flown off at once.

Where all weather runways are provided dust does not present a problem; here it is the question of the supply of material, and time of construction. One P.S.P. runway only 33½ yards wide (A.M. Minimum 50 yards) was put down on one airfield and this was used by *Spitfires*, *Douglas D.C.* 3s, and even *Beaufighters* at night. Two *Spitfires* have taken off abreast on this runway but this is definitely not advocated.

The length of the runway mentioned above was 1,300 yards, which is short for night fighters; the Air Ministry specification for the main runway on a night fighter airfield is 2,000 yards.

As far as flying obstructions are concerned the Air Ministry standards of a slope 1 in 80 for bombers and 1 in 50 for fighters should not be relaxed, but for operational reasons these have been reduced to 1 in 50 and 1 in 30 respectively for short periods.

It must be remembered that the minimum standards, as laid down by the Air Ministry, are safe even for mediocre pilots, so that in operations a risk can, and often must be taken. The difficulty arises in balancing the crash rate against the operational urgency of the task. It is extrememly doubtful whether the R.A.F. would continue to accept a crash rate of 5% for every series of landings, even under the most urgent operational necessity. On the other hand, in 1940 the Germans operated in Norway off a corduroy runway made of split tree trunks and accepted a crash rate of 25%. Such wholesale destruction of their aircraft may have a considerable bearing on their lack of air support today. Even today the Germans operate off emergency landing grounds so rough that our Air Force would never accept them. A possible explanation is that the under-carriages of German machines are more robust than ours, with a wider wheel base.

7. What can be Expected of an Airfield Construction Group

Like all engineering problems, airfield construction depends on several factors such as :—

(*a*) The season—summer or winter conditions.
(*b*) Hours of daylight.
(*c*) State of the moon.
(*d*) The weather.
(*e*) Soil conditions.
(*f*) Type of cultivation on which the fields have to be built.

Before a recce is carried out it is quite impossible to give accurate forecasts of requirements of men and equipment or time to complete a task. However, as a rough guide the following example is quoted.

In a period of 17 days one group carried out the following work:—

(*a*) Restoration of a permanent enemy airfield, including removal of wreckages, the repair of craters in a concrete runway and taxi track, improvements to dispersal, removal of dangerous buildings, removal of Tellermines, etc.

(*b*) Construction of one bomber airfield.

(*c*) Construction of three fighter-bomber airfields.

(*d*) The maintenance of three existing airfields, two of which were severely blitzed during the period mentioned.

This work was carried out during the summer, the weather was dry throughout, the temperature between 105° and 110° F., and there were 14 hours of daylight, therefore night work was not necessary. Cultivation was mostly stubble with a little plough, and the soil was hard baked clay with numerous fissures, each two to three inches wide and about 4 feet deep. The bomber airfield represented about 1,000,000 square yards of prepared surface, the runway being 2,000 yards long by 200 yards wide, while each of the fighter-bomber airfields required 600,000 square yards of prepared surface, the runways being 1,500 yards long by 200 yards wide. As the area had several large drainage ditches running through it, some thousands of yards run of piped ditches and culverts had to be provided. Other small problems were involved, such as the removal of several hundred tons of cut corn, demolition of buildings to clear flying approaches, and the construction of improvised bridges on the access roads to take heavy loads.

8. Suggestions About Opposed Landings

An opposed landing, particularly on D-Day, is very interesting, but, as is always the case with airfield work, it is quite impossible to lay down rules of conduct. The first point that arises is when should the various elements of the group be landed?

If an airfield is the Divisional or Brigade objective, which is usually the case, the reconnaissance party should land with the H.Q. of the battalion ordered to capture the airfield. A suitable composition for this party is two officers, two other ranks; one jeep, and one motor cycle. This is conveniently small and can go anywhere. On one occasion such a recce party was flown a distance of 500 miles, the jeep and the motor cycle packing quite easily into the *Douglas D.C.* 3.

In addition to the reconnaissance party or parties, a certain number of men and transport should also be landed on D-Day. Quantities cannot possibly be assessed in a paper of this nature, as these are entirely dependent on the circumstances of the operation to be undertaken. It is suggested, however, that a large proportion of the men should be sappers, as opposed to pioneers, and transport should mostly be tipping lorries.

The problem of the equipment that the men should carry requires thought; this must obviously be made as light as possible. On the other hand it may be a ship's order that big packs will be carried ashore; if this be so, they should be dumped on the beach and a guard left over them. Hand tools such as picks, shovels and matchets must be carried, a suggested distribution among 10 men being 7 shovels, 3 picks and 1 matchet, mine detectors and wire for pulling away mines must be carried by the sappers; it is particularly important that the mine detectors should be properly waterproofed. By the time the essentials are put on to the man he is becoming rather heavily laden and the question of arms arises. It is absolutely essential that the men be capable of fighting as infantry, but it becomes quite impossible to carry the heavier items, such as Bren guns and Anti-tank rifles; these must be put on to one of the early vehicles to arrive. Each man should have either a rifle and fifty rounds or a Tommy Gun, Sten, or other form of light carbine.

The question as to what should be despatched in the first transport to arrive is easier to answer. Once again hand tools as above must be taken allowing a large margin to replace those lost in the water, and to equip from external sources working parties who may be collected for work on the airfield. A stock of additional hand tools such as stone forks, 14 lb. sledges, felling axes, and hand earth rammers must be provided. At least a ton of explosive should arrive early at the airfield; R.A.F. ground strips and Banderols are also necessary.

A more difficult question to answer is—when the mechanical equipment should be landed. In our first opposed landing we experienced but slight opposition, the airfield was soon captured, and the working parties deployed on to it. The airfield had been ploughed up completely, but there was no mechanical equipment available until the afternoon of D plus 1 day. In the second case, mechanical equipment was scheduled to be landed early on D-Day, the opposition was distinctly strong, and owing to various factors equipment was not landed until the afternoon of D plus 1. In both cases the airfield was completed at least twelve hours before the R.A.F. was in a position to use it. This mechanical equipment is so valuable that the writer is strongly of the opinion that it should not be landed before the morning of D plus 1 day. If it be landed then, the group should be able to have the airfield ready for operations by the time the R.A.F. are prepared and stocked with servicing facilities to use it.

The landing of much mechanical equipment for airfield work on D-Day means running a very grave risk of loss. It is a slow business unloading from a landing craft, in comparison with standard army vehicles, and if strong opposition be encountered the equipment may easily be lost. Also an airfield construction group requires a certain amount of elbow-room in which to work, and until the fighting units have established a reasonable bridgehead, the impeding of their movement by heavy equipment should be avoided on D-Day.

9. Movement of an Airfield Construction Group

It has been discovered in action that the original groups, with their four Pioneer Corps companies and very little transport, were much too unwieldy to move quickly. The suggestion that the personnel of the group should march proved quite impracticable for the following reasons:—

(*a*) The moves were far too long; airfields in the forward areas are wanted quickly and must be finished by the time the men would have taken to march to them.

(*b*) Operations have been carried out largely in mountainous or very closely cultivated country. In both cases it was difficult to get off the roads and roads have been scarce. Under these circumstances, when the few roads are jammed with traffic, marching troops are firmly discouraged. It was, therefore, decided to reduce the groups to two Pioneer Corps Coys. and at the same time make the whole group 100% mobile by giving it one Tipper platoon (32–3 ton Dennis tippers) and one General Transport platoon R.A.S.C. This increase in mobility more than compensates for the loss of the two companies, which under the old organization would have spent most of their time in the unproductive and dull task of walking along a road.

In action, the group, or part of it, always seems to be on the move, and it soon gets good at it. However, too much time can hardly be spent in training for this. Mechanical equipment is always being moved and this presents the greatest difficulties, some of which were described in the previous article on airfield construction.

It is unfortunate that in the Army there is no distinction between the "heavy goods" driver and the man who drives a jeep, both being drivers I.C. In the field the "heavy goods" drivers of the mechanical equipment section in an airfield construction group not only accept a tremendous responsibility, but are also the hardest worked men in the Group. On one occasion a tank transporter, loaded with a 66-Blade grader, and two Matadors, with their trailers loaded each with a D-7 angledozer, had to proceed without lights along a mountain road by moonlight. The road was deserted only because it was considered too dangerous for the normal divisional vehicles to use it after dark. The risks these men took, and the skill with which they negotiated the hairpin bends were beyond praise. Also the skill required to control these heavy vehicles when backing into landing craft must be of a very high order.

During long movements of a group in mountainous country it is usually much easier to move the mechanical equipment by sea if possible. All types of mechanical equipment, including a trenching machine and a K-30 Rooter, have been off-loaded on a difficult beach with a sandbar in the way. It is, however, difficult to deal with the heavy roller; a leading and preventer tackle must be rigged while negotiating the ramp of the craft. The easiest way to provide this is to tie the roller between two D-7 tractors and then walk all three vehicles over the ramp together. To a well-trained group a sea trip presents no difficulties; and when it saves a long and difficult journey through mountains it is to be advocated, but waterproofing of the mechanical equipment must be thorough.

10. Mechanical Equipment

The backbone of the group is the mechanical equipment section. Mechanical equipment is the answer to rapid airfield construction providing the ground be firm, but mechanical equipment must be kept off soft ground at all costs.

The most useful piece of equipment for work in the forward areas is the auto-patrol; others which are extensively used are the heavier tractors fitted with angledozers, 8-yard scrapers, blade graders, and 8–12 ton rollers. When more permanent work is contemplated then excavators with drag line and skimmer equipments, trenching machines, rooters, and dumpers will be needed, but these machines are best kept in a central mechanical equipment pool for use if required. A group working in a forward area cannot encumber itself with such plant, which it probably will not require.

When moving on to a captured airfield, there are in addition three pieces of plant which are almost essential:—

(*a*) A three-ton self-propelled crane on pneumatic wheels such as the Coles crane or the crane used by the Americans. An excavator drag line fitted as a crane is not the same thing at all, as it is not mobile enough on the ground and requires transporting to the airfield; and on a trailer it is a dangerous load in mountainous country.

(*b*) Electro-Magnets fitted to a bulldozer blade. These are required for picking up the tons of small shell and bomb splinters which cover a captured field. To do this by hand is a long and laborious business and is not sufficiently thorough. If left on the field these splinters will cause many aircraft accidents through punctures to tyres; incidentally much trouble is caused by these splinters puncturing the large wheels of auto-patrols and scrapers during the construction stage.

(c) A corporation road-sweeping brush of the revolving type. On two occasions the author's group had to sweep by hand concrete runways in order to remove the mass of small stones, pieces of aircraft, etc., on the runway. To sweep 80,000 square yards using bass brooms is distinctly dull, takes a long time, and might hold up the war. Where there are no concrete runways there are often perimeter tracks, hangar floors, etc., which also require sweeping.

For dry weather fields water spraying vehicles are urgently required. These airfields are astonishingly dusty and this dust must be kept down for two reasons. The first is to avoid producing a dust storm over the field, and the second to prevent the scouring action of aircraft slip-streams removing the soil which is packed into hollows in the ground during construction. Watering the field during the night tends to overcome these difficulties.

11. Camouflage and Dispersal

Today the answer is do not waste time on camouflage. Not so very long ago we were fighting with our backs to the wall with limited resources, and the enemy had air equality, if not air superiority. In order to safeguard our limited resources we had to adopt every means including camouflage, although in the case of airfields this is rather akin to the defensive methods of the proverbial ostrich. Now we are on the offensive ; we have almost undisputed air superiority which must be maintained at all costs. We have plenty of aircraft and the best method of maintaining our air superiority is to produce airfields as quickly as possible off which the aircraft can operate.

There are two points about camouflage which may be of interest :—

(a) Dry weather airfields are quite impossible to camouflage as they are dusty. They can be seen for miles by the pall of dust hanging over them. In the days of Moses, if you were lost you aimed for the pillar of smoke, but nowadays for a pillar of dust.

(b) One of the most important things in airfield construction is to mark the landing strip clearly ; the opposite to camouflage. Up to two years ago the writer was particularly keen on airfield camouflage. Today, now that we are attacking, camouflage must go by the board unless it can be fitted in without interfering with speedy offensive action.

On the other hand dispersal is important. This also is a defensive method of protection, but even if we achieved 99% air superiority there is still a chance of the really determined raider getting through, particularly at night, and dropping bombs on an airfield. Casualties of machines and personnel are avoided by adequate dispersal : but as we continue to attack, and as our air superiority rises, so may the requirements of dispersal be relaxed. Dispersal also holds up the production of airfields ; it is suggested, therefore, that more airfields be produced at the expense of dispersal, but that they should be heavily protected by A.A. guns. Incidentally the production of more airfields also helps the requirements of dispersal.

12. Aggressiveness

This must be inculcated into the group at all costs, particularly in reconnaissance. The writer considered it a point of honour that his reconnaissance parties should be the first allied personnel on a really important airfield. Airfield Construction Groups are, theoretically, Line of Communication troops; if they work well forward their morale goes up 100% and so does their work.

Aggressiveness with men must be encouraged, as it gets the work done more quickly and raises morale. On the other hand, where mechanical equipment is concerned caution must be exercised. Equipment must never be needlessly exposed, because one machine put out of action may be equivalent to the loss of 250 men. Where it is reasonable to expose 100 men it is definitely not reasonable to expose several machines which are quite irreplaceable.

Under no circumstances should shelter trenches be dug on the site of the work, when enemy attention is getting too hot, work should be suspended for a time. The writer's group has worked in full view of the enemy, and well within mortar fire, for a period of one week; when the mortar fire became too unpleasant, work was knocked off for a period. If shelter trenches are dug on the site, time is wasted in digging and men go popping into them at the first opportunity which does not improve morale. On the other hand, slit trenches in bivouac areas must be dug early; a man off duty must be protected at all costs, so that he can obtain a good rest.

13. Royal Engineer Stores and Tools

In the forward role an airfield construction group does not require many engineer stores, as most of the work can be more quickly carried out by improvisation, using local materials. The chief requirements are:—

(*a*) Drainage. A stock of Armco piping, say one 3-ton lorry load, 2 feet diameter, would be invaluable. Up to the present it has been almost unobtainable.

(*b*) Hardcore gravel, stone, etc. Required in large quantities but always readily available from demolished houses, river beds, and small quarry stocks or waste.

(*c*) Cement, usually picked up locally, for repair work.

(*d*) Explosives. These are used continuously for clearing flying approaches, dealing with dangerous structures, and obtaining hardcore. The stock carried should not be allowed to fall below one ton.

(*e*) Ground strips. These are a R.A.F. supply; at least 200 are required at the start of an operation. Incidentally they make very good table cloths. A few wind socks should also be carried. The R.A.F. Servicing Commandos are supposed to supply and place both the above but they are usually forgotten. It is a Sapper job to put down permanent markings.

(*f*) Tools. The undermentioned stocks of the hand tools most used are suggested in a group:—

Shovels R.E.	400
Picks	200
Stone forks	100
Matchets	100
Hammers, sledge, 14 lb.	100
(7 lb. sledges are no good)	
Hand rammers	50
(10 power rammers would be much better if obtainable)	
Banderols	200

When all-weather fields are being produced, very large stocks of drainpipes, P.S.P., cement, bitumen, etc., will be required, requirements depending on the situation and the methods of construction to be adopted. A proper plan must be prepared, and methods of shipping, unloading, and transporting to site arranged with " Q " on a high level.

14. Running Sand as a Sub-Soil

At one airfield which had been captured from the enemy a most interesting phenomenon was encountered. The airfield was a good grass field about 1,200 yards long by 1,000 yards wide, with a well established root mat. The enemy had put a considerable amount of work into it as the airfield buildings were extensive but he made the great mistake of siting the airfield on a sub-soil which was running sand.

A short time before we took over the field it was subjected to two heavy raids by our heavy and medium bombers. During the course of these raids some 130 tons of bombs were dropped into the target area and slightly more than 350 craters were formed on the landing field. It was not realized at the time why the enemy did not restore at any rate a portion of the airfield.

On arrival the reason became obvious; each crater when originally formed was probably 30 feet in diameter and from 10 to 15 feet deep, but as it was formed in running sand, this sand had flown into the crater and practically filled the hole. This sand having come from the sides of the crater had caused a general subsidence of the earth all round. The net result was that each crater was in the middle of a large hollow dish about 50 yards in diameter and 2 feet deep at the edge of the crater; the crater itself had the usual lip and inside was full almost to the top with soft sand. Rapid repair work was quite out of the question. Repair might have been carried out by digging out the sand, timbering the sides and bottom of the excavation, back-filling the whole with hardcore, and then filling the entire dish also with hardcore. This would have been a very big task, so the airfield was abandoned by both the enemy and ourselves.

The lesson is obvious; avoid a site on running sand if you expect the enemy to bomb the field.

15. Improvisations

Drainage affords most scope for improvisations. It is never worth carrying earthenware field drain pipes as normal stores, as they will soon be broken, and local materials can nearly always be found. Hollow tile bricks make very good drains. Concrete piping can often be found and large down pipes from buildings have also been used. Bamboo fascines are quite effective.

Larger drains and culverts can be made from the heavily reinforced oil drums the enemy leave lying around in large numbers. The ends of the drums have to be cut out and much ingenuity has been exercised when a unit was faced with some hundreds of drums to deal with. The work can be done with a hammer and cold chisel but it takes about half an hour per drum; it can be done using a pick; the clay spade of the compressor is a good method; an oxy-acetylene flame is quick but it wastes gas which is difficult to replace; methods using explosives have been tried with varying success.

Captured concrete mixers are almost invariably found either without an engine, or fitted with an electric motor where there is no hope of an electricity supply for a long time. Excellent results have been obtained by using International tractors and an improvised belt drive from the power take-off on the tractor to a pulley fitted on the mixer. On one large concreting job three captured half-yard mixers were run in this way.

Airfield markings of a temporary nature can always be improvised. The writer was at one time reduced to using bed sheets obtained locally. Tiles, asbestos sheets, etc., can be used, but do not use sheets of corrugated iron; they are dangerous and may easily puncture aircraft tyres.

Explosives can be economized by using captured enemy material. The German made-up charges were excellent but they did not have large stocks in this theatre. For demolishing houses, Tellermines and captured bombs are effective.

Mechanical equipment gives endless scope for improvisation. A trammel or drag, which is a framework of 6-inch to 8-inch I girders towed behind a tractor, proves quite successful on certain soils which are not too clayey, but a trammelled surface is always very dusty. If rollers are scarce multi wheeled trailers, heavily laden and towed by a Matador can be used. When there is time, concrete rollers can be made up.

Apart from improvisations the uses to which an auto-patrol can be put are legion. A good method of dealing with small undulations in a field is to use the scarifier on the auto-patrol; this method is slow, however, as the scarifier only gives a 4 feet wide cut. The auto-patrol can cut V drainage and can even put a 45° slope on a bank 8 feet high. The auto-patrol is the most useful machine for rapidly constructed airfields, but there are never sufficient available.

A reasonable surface can be obtained by "back floating" with bulldozers but it requires skill. The tractor is run in reverse, dragging the blade backwards along the ground; this gives a much better finished surface than by using the bulldozer in the normal manner. Even after "back floating" the surface will require grading with auto-patrols in order to give the desired finish. The Americans use sheep's foot rollers extensively for consolidating the top six inches of the soil, particularly in areas of fill. These are most useful for this purpose and have now been supplied to British units. They can be improvised, using a concrete drum with large studs let into it, but the result is poor; a better method is to borrow one from the Americans.

16. Reconnaissance

During reconnaissance there is a tendency only to look for an area for the landing lane, and forget dispersal. When the work is being carried out the dispersal represents twice as much work as the strip; therefore, reconnaissance should be carried out with an eye to the dispersal and the work involved as much as to the landing lane. The proposed dispersal areas must be carefully examined on the ground.

The field company engineer can be of great help to the airfield engineer by reconnaissance. Not so much in airfield reconnaissance as by reporting, through normal Engineer channels, the locations and approximate quantities of engineer stores in the area. As the divisional engineers are in their normal duty constantly going around the whole of their area, they are in a better position to locate useful stores. Unfortunately there is a tendency for stores which would be invaluable for airfield work to be overlooked, as they are not required by field companies. The particular items which will probably be required by the airfield engineer in the early stages are:—Any form of piping larger than 4 inch diameter, cement, bitumen, plant such as concrete mixers, tar boilers, road rollers, rock crushers, large stocks of bricks or hollow tile bricks and corrugated iron or asbestos sheeting suitable for the repair of hangar roofs. An approximate guide to quantities should be given. On one occasion the writer urgently required fifty tons of cement. A dump of cement had been reported to Corps some miles away and he went to investigate. On arrival he was rather annoyed to discover that the dump of cement amounted to about 10 cwts. of hydrated lime. Information as to quarries, whether plant or handworked, and the existence or otherwise of stock piles, is of great value.

19. Bomb Disposal

The author is of the opinion that a bomb disposal section is wasted in an airfield construction group but that a bomb disposal officer is essential during an advance.

The chief task of a bomb disposal section is to dig out U.X.Bs, but on an airfield this is never done. The most unpleasant place a U.X.B. can occupy is the middle of a runway. The writer was faced with this particular problem and dealt with it as follows :—

(*a*) By very quickly filling in the small hole caused by the bomb entering.
(*b*) Organizing a team of lorries full of stone and getting plant ready to deal with the crater when it arrived.
(*c*) Waiting for the bang and filling up the hole in about two hours.

During the periods between (*a*) and (*c*) above, which amounted to three days, the R.A.F. operated off the runway, although it took a considerable amount of arguing on the part of the writer to convince them that it was perfectly safe.

The alternative would have been to dig out this bomb, using a bomb disposal section. This would have taken two days, during which period the runway would probably have been completely unserviceable, or if it had been used the crash rate would have been high.

On the other hand, the bomb disposal officer is invaluable for the following reasons :—

(*a*) He accompanies the forward reconnaissance parties to examine captured bombs for new types before the rush of souvenir hunters arrive.
(*b*) His advice about moving bombs placed as traps or for cratering the airfield is invaluable.
(*c*) He destroys or renders safe captured bombs, being given a small party of Sappers recruited in the group to assist him.

18. Light Aid Detachment

A L.A.D. is absolutely invaluable. In the author's group there were approximately 170 vehicles or pieces of mechanical equipment. Admittedly 70 of these are R.A.S.C. vehicles, and are not an Ordnance responsibility, but for long periods the group had to work completely cut off from the parent R.A.S.C. unit, so the L.A.D. must help.

The L.A.D. always meets difficult welding jobs for the mechanical equipment section. The only welding plant provided is oxy-acetylene and the supply of gas in the field is difficult. It is therefore, strongly recommended that an electric welding plant complete with spares and accessories, such as the " Lincoln," be provided for L.A.Ds.

19. Pioneer Companies in an Airfield Construction Group

The existing Pioneer Corps organization, in which the company is divided into ten sections, proved to be unsatisfactory in practice for the following reasons :—

(*a*) The sections are each under a serjeant. In action a company commander cannot fight ten large sections.
(*b*) The four subaltern officers have no definite and fixed command. They, therefore, do not get to know their men as well as they should.

The existing company organization was, therefore, amended on to a platoon basis, which worked most satisfactorily.

The following system was put into operation :—

H.Q. Platoon.

(i) Adm. Sec. under Coy. second-in-command. Comprised Coy. H.Q. staff, Transport, Cooks, Medical, Water, and Sanitary personnel.

(ii) Operational section, under the command of one subaltern. This was sub-divided into the L.M.G. sub-section and the local reinforcements and training sub-section.

Three "first line platoons."

They comprised 1 subaltern and 63 other ranks and were maintained up to strength from H.Q. Platoon. Each first line platoon was sub-divided into five sections of 1 corporal, 1 lance-corporal and ten privates. On the staff of the platoon there were two serjeants, the senior trained to take over from the officer in an emergency and the junior trained in Q work. These platoons were, therefore, just as capable of working as detachments as those of a field company, which is most valuable, particularly when airfield maintenance has to be carried out. One platoon is normally sufficient for maintaining a dry weather field.

Training in the United Kingdom should aim at making Pioneer Corps Coys. as self-administering as are Sapper companies; this applies particularly to Part II Orders, field documentation, and second Echelon procedure.

20. Miscellaneous Points

(*a*) The writer regrets he is quite unable to give any form of engineering specification for the worst type of rise or fall which can be accepted on a runway. The only way to tell is by experience. It is doubtful if many sappers could write the engineering specification for a pretty face, but if presented to a young lady they could tell at a glance. The same applies to a runway.

(*b*) Jeeps are absolutely invaluable for field engineers. Motor cycles are of little value, as roads are full of pot holes and progress is slow in the extreme. Motor cycles, with their dimmed lights, are very dangerous to ride after dark, as the roads are used extensively at night by farm carts which never carry lights.

(*c*) An office truck, official nomenclature trucks "15 cwt. office," is quite useless. In hot weather it makes an excellent hot-house; in windy weather it is designed to create draughts which are apt to disseminate official correspondence round the neighbourhood. A converted 3-ton lorry is very much better.

(*d*) The headquarters staff, including the Orderly Room serjeant, must become map-minded. It is easy to tell a dispatch rider "to take this to Corps" late in the evening with a resulting journey of 40 miles, mostly in the dark over difficult roads, when Area Signals 5 miles away have a regular D.R.L.S. in operation.

(*e*) The times allowed for journeys over roads in a forward area, or those which have been fought over, must be two to four times as long as for similar journeys in the United Kingdom. Thus, if the turn round for lorries fetching materials to a site is worked out on road speeds of 15 m.p.h., deliveries to the site will probably fall sadly below expectations.

(*f*) An airfield construction group may spend its time moving from one formation to another (the author's group has been under command of 12 different formations or areas in a period of four months). It is essential to establish happy relations immediately with the formation concerned. The group is bound to cause a slight administrative headache to the formation, so any help the group can give is never wasted.

(*g*) The Pioneer Corps companies in the group have all the dirty work; they never get a rest but are always cheerful. See that they have passed on to them any pats on the back. There is a tendency to give any kudos for airfield construction to the Sappers, but the group is composed of Pioneer Corps, R.A.S.C., R.E.M.E., R.A.M.C., R.A.F., R.A.Ch.D., and A.C.C., as well as Sappers; they all serve an absolutely essential need.

(*h*) Hard and fast rules as to how an airfield should be constructed must be avoided at all costs. Each field must be considered on its merits. It is quite impossible to lay down a standard amount of mechanical equipment, men and materials, for a " normal " airfield, because such does not exist. On certain grounds it may be possible to produce a dry-weather landing strip with two cuts of an auto-patrol; on others it may be necessary to give two cuts with scrapers followed by four cuts with auto-patrols. Experience is the only guide; even then wrong guesses are frequently made during the reconnaissance.

(*i*) Properly used, the ordinary Army Signal Form cuts down office work considerably. It is as quick to write out a signal as it is to draft a letter; all typing is avoided and formalities are unnecessary in a signal. The author's adjutant once ran very efficiently a one-man group office for two weeks under difficult conditions immediately following an assault landing, using only a pencil and a signal pad. The Orderly Room staff and office equipment were sadly delayed, as the ship carrying them had the worst of an argument with a torpedo. In order to save office work further, half the messages sent out do not need a file copy, a note of action on the incoming letter being adequate.

21. Conclusion

Like all sapper work in the field, airfield construction is an extremely exacting task. On the other hand, it is a fascinating job. Every man sees the results of his work and it is rather thrilling to watch a portion of mixed farmland becoming a thriving and congested airfield within from two to four days. To see aircraft landing for the first time in a portion of country which was until recently in enemy hands is an experience worth remembering.

A MODERN ARMY CENTRAL HEATING INSTALLATION

By Lieut.-Col. B. Trott, O.B.E., R.E.

DURING the War, a large Ordnance depot was constructed in the Midlands, the area covered, due to dispersal of the various sub-depots, being some 15 sq. miles.

The heating of such a large depot presented a problem and the Director of Fortifications and Works decided that the method of heating should be by a High Pressure Hot Water System, with boilers normally operating at 160 lb. pressure per sq. in. (350°F.), though capable of operating at 200 lb. per sq. in., the whole plant to be fully automatic in operation, requiring a minimum of staff to operate it.

Owing to the distribution of the various sub-depots and the need to keep pipe heat losses within reasonable limits, the boiler plant was divided up into three boiler houses, each boiler house to be completely equipped with spare boiler plant to deal with its particular area. No inter-connexion between boiler houses was attempted.

The work was executed in three phases, the last of which was planned to be completed before the winter 1945/46.

Boilers. The type of boiler adopted was the La Mont Water Tube, manufactured by Messrs. Ivor Power Speciality Co., Ltd., each having a normal output of 20,000,000 B.T.U.'s fitted with an International Combustion chain grate. Due to the very difficult coal situation, the boilers were specially designed to operate on washed Anthracite Duff, a fuel which prior to the war was almost a waste product, having a gross calorific value of 12,500 B.T.U.'s per lb. of fuel.

These boilers have several novel features, nozzles being fitted to the inlet of each tube to provide controlled circulation to the water distribution and so ensuring that all parts of the boiler heating surfaces receive the correct amount of water, proportionate to the heat absorbed. The furnace ironwork consists of longitudinal side frames tied by transverse members, which not only support the moving grate during its passage through the furnace but also house the adjustable air valves by which air is distributed to the fuel bed. Spillage of fuel and excessive air leakage at the sides of the grate are prevented by side castings with flanges which overlap the side frame.

The fuel hoppers have a fuel cut-off gate and an adjustable fuel feed regulating shutter with an indicator registering thickness of the feed. The stoker is driven through a spring loaded clutch by a three-phase variable speed commutator motor of normal design.

Each boiler is provided with its complement of soot blowers, safety valves, water pressure gauges, high and low water alarms, etc.

Individual forced and induced draught fans are fitted, the forced draught fans being installed in the boiler house basement and the induced draught fans and grit collectors being installed in a special floor above the boilers. A dust collector is also provided for each boiler with a receiver arranged underneath, the dust recovered from the flue gasses being led back to the travelling grate stoker through a suitable opening in the rear arch of the stoker setting.

Each boiler has its own mild steel chimney, 60 ft. high, of the self-supporting type. Screen plates are fitted to the bottom of the boiler which serve a dual purpose of preventing undue radiation of heat and providing additional ventilation to the boiler house.

Duplicate electrically driven feed pumps are installed, each capable of supplying 600 gals. of water per hour against a pressure of 200 lb. per sq. in.; together with feed water tanks. A balance tank is installed to supply the water for cooling the water-cooled bearings of the draught fans.

No. 1 boiler house has four boilers; No. 2 boiler house three with room for a fourth and No. 3 boiler house two boilers. All boiler houses have been designed to permit of easy extension if this at any time becomes necessary.

A common storage/balance steam and water drum is provided in each boiler house. This is 20 ft. long and 6 ft. diameter, fitted with specially designed safety valves and is adequately lagged.

Automatic combustion control of the Hagen type is installed in each boiler house. This equipment is arranged to regulate automatically the fuel supply, the air for combustion and the draught, all in relation to the working pressure in the storage balance steam and water drum.

The system comprises a master regulator connected to the steam pressure in the drum by means of compressed air at 50 lb. per sq. in., which sends out a controlled pressure varying in relation to the pressure fluctuations in the drum. This controlled pressure is taken to the boiler control panels for individual control so that in the event of a drop in drum pressure the control pressure will fall off accordingly, the stoker speed is thus increased, the induced draught damper opened and by means of the furnace draught regulator the forced draught damper is opened. Similar control is exercised when the pressure in the drum rises, the separate units operating in the reverse direction.

Suitable relays and setting valves are provided on the control panels to permit of manual adjustment of the control gear; the relays between fuel and air permit of adjustments being made to suit the type of fuel being used. In the same way modifications to the draught can be carried out independently to suit varying boiler conditions.

A range of instruments are fitted consisting of C.O. Recorders, Draught Gauges, Flue Gas Temperature Recorders and Indicating Thermometers for the flow and return water temperatures of each boiler.

Coal Handling Plant

The coal handling plant consists of a wagon tippler, drag scraper, coal storing and reclaiming plant, belt feeder, elevator and conveyors to the storage bunkers in the boiler house.

The wagon tippler discharges the contents of a 10/20-ton wagon into the coal receiving hopper alongside. The tippling action is entirely automatic, no clamping devices being used to hold the wagon, thus reducing the length of time for the operation. The tippler motor is of 15 b.h.p.

A belt feeder is provided which transfers the fuel from the tippler hopper to the elevator boot. The feeder is a rubber and canvas belt with head and tail pulleys driven by a 5 b.h.p. motor with a worm induction gear.

The vertical elevator is of the spaced bucket and chain type, having a chain speed of 190 ft. per min. and this is also driven by a 5 b.h.p. motor. A discharge chute is provided at the top of the elevator with a flopper valve so that the coal discharged from the elevator can be diverted either to the inclined drag-link conveyor feeding the horizontal drag-link conveyer, direct to the boiler bunkers or through a chute to form the pile for the drag scraper.

The drag-link conveyor motors are each of 5 b.h.p.

The drag scraper is of the Saverman type, 1 yd. size, with a capacity of 20 tons per hr. It consists generally of the scraper bucket with bridle and rope attachment fittings. There is one mild steel head post and a number of tail posts suitably placed around each storage area. A 50 b.h.p. double drum winch for operating the scraper is installed, the control cabin being elevated to enable the operator to have a clear view over the whole fuel area.

Ashes from the hopper of the chain grate and the collected grit pass through and are quenched by water in a Babcock paddle ash extractor discharging into ash wagons. The wagons, which are of 1 yd. capacity, operate on 24-in. gauge tracks in the boiler house basement, they are tipped manually into the skip bucket of an ash hoist discharging into the ash bunker mounted outside the boiler house. The bunker which has a capacity of 800 cub. ft., is arranged with a duplex gate valve and is mounted at a height suitable to discharge direct into the standard 10/20-ton rail truck.

External Distribution Mains

The external mains which circulate the H.P.H.W. from the boiler houses were originally specified to be of the hot finish weldless type, but owing to war conditions a percentage of the piping had been lap welded which, although fairly satisfactory, has been found on fabrication to develop lamination faults. The piping has been welded throughout, except the fabricated expansion loops and bends which are flanged with standard flanges.

Special attention has been paid to the grading of the mains, vents being provided at every high point and pockets with blow-out and draining arrangements at every low point. Ordinary type " U " expansion bends have been used.

The mains are carried on suitable swinging hangers to allow maximum movement of the piping without transmitting the strain to the brackets and posts. The flow and return pipes run one on each side of a series of small concrete posts, the small bore pipes being one above the other. The general height of the pipes is 3 ft. 9 in. above ground level, but this varies somewhat with the ground level and pipe gradients. Where pipes pass over roadways or railways within the depot a clear height of not less than 16 ft. 6 in. is maintained. These crossings are not carried by the usual pipe bridge or gantry but larger piping is used at the crossing, which forms its own support. Where pipes cross the county roads, they are placed in ducts, suitably drained, below ground level.

The largest external main is 12 in. bore and all thermal insulation is by the use of glass silk, secured by hardboard, and enclosed in bitumen felt secured with galvanized wire-netting, the whole painted black bitumastic.

Internal Distribution and Heating Arrangements

All the internal H.P. piping is similar to that for the external piping, the L.P.H.W. Heating, Hot and Cold Water Supply, cooling water and sundry piping being of " light-weight " black quality.

Pipe hangers and clips are prefabricated and fixing follows normal modern practice.

A well for a test thermometer has been welded into each flow and return main where entering each building and on the flow and return branch of the last heater on the index circuit in each building. Test pressure gauge cocks are also fitted to the flow and return mains adjacent to each Thermometer pocket.

The method of heating is generally by Unit Heaters, Convector Heaters and L.P.H.W. Radiators, the former being controlled singly or in groups by line contactor starters operated by room thermostats.

All Unit Heaters are of the " Downstream " type constructed for use on H.P.H.W., the water inlet being at an average temperature of 320° F., fitted with a four-way diffuser to give correct heating at the working zone without perceptible air movement at head level. To ensure this it was necessary to stipulate precisely the mounting heights when ordering the heaters. Single-phase motors of the split-phase type incorporating a centrifrugal switch are fitted.

The convector heaters are also specially designed for H.P.H.W. with a mean inlet water temperature of 320°F. and with a temperature drop across the heater of 40°F.

The usual sludge pockets are fitted to both Unit Heaters and Air Convectors.

The L.P.H.W. radiators are of normal type.

Storage type calorifiers are supplied for the hot water services, these follow normal practice, the heating elements being of solid drawn copper tube. Each calorifier is also fitted with an electric heating element, wired at 400 volts 3-phase, for summer use. They vary in size from 20 gals. to 200 gal. capacity and the auxiliary heating elements from 6 k.w. to 20 k.w. The temperature of the hot water supply is controlled by thermostatic regulators.

Generally the plant has functioned to expectations, the automatic equipment in the boiler houses functions satisfactorily and the heat distributed in the various store sheds and buildings has been up to specification. The one disappointment has been in the coal handling plant. The specified water content in the fuel was not to exceed 10% and commercially a lesser figure than this is not practicable without the use of dryers, etc., which would considerably offset the value of the present cheap duff. During transit in the rainy weather the fuel collects moisture and often arrives at the site with a moisture content as high as 15%. With this moisture the present elevator equipment is far from satisfactory, but investigation is taking place to find means to remedy this.

When fully working, the total load on all three boiler houses will be approximately 160,000,000 B.T.U.'s with a daily fuel consumption of approximately 150 tons.

The cost of the complete installation was approximately £500,000.

THE RHINE CROSSING, REES, 23rd MARCH, 1945

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

THE attached photographs show the bridges, and the sites of the ferries, which were built by the Royal Engineers under command 13 (Brit.) A.G.R.E. during the assault crossing of the R. Rhine on the front of 30th Corps on and after 2100 hrs., 23rd March, 1945.

Photograph No. 1 shows a general view of the crossing site, and was taken opposite Rees, facing downstream. Rees itself is just out of the picture on the right bank of the river. The first bridge, in the foreground, is London Bridge, built by 8th G.H.Q. Tps., R.E. and behind it is Westminster Bridge which was constructed by 6th Army Tps., R.E. Just downstream are the sites originally chosen for the Poplar system of close support ferries, and rafts can be seen moored close to the bank. Owing to the difficulty of clearing Rees, which town allowed the enemy good observation of our side of the river, it was necessary during the operation to order 59th G.H.Q. Tps., who were suffering undue casualties to personnel and equipment, to alter the sites for these ferries, and they were eventually built round the bend, near the sunken barge

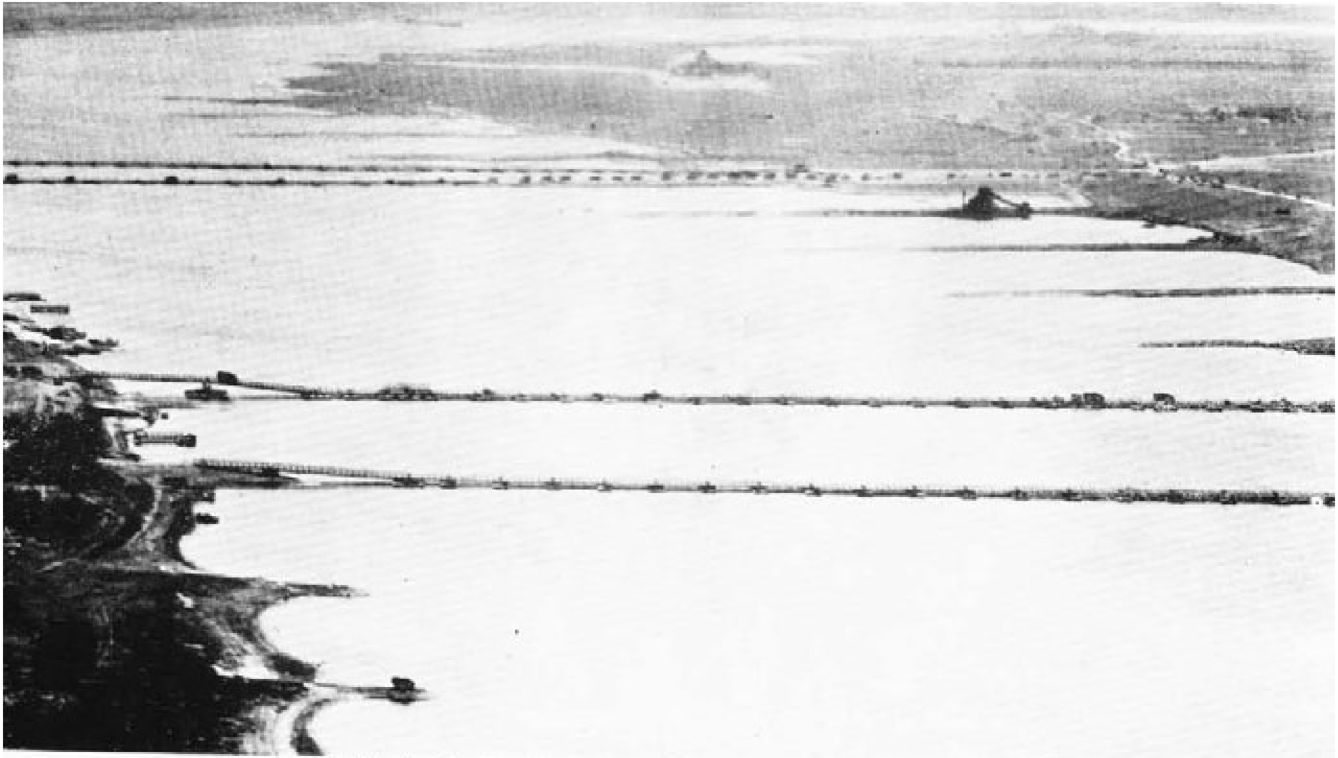


Photo No. 1—London, Westminster, Lambeth, Blackfriars in that order.

The Rhine crossing, Rees 23 March 1945

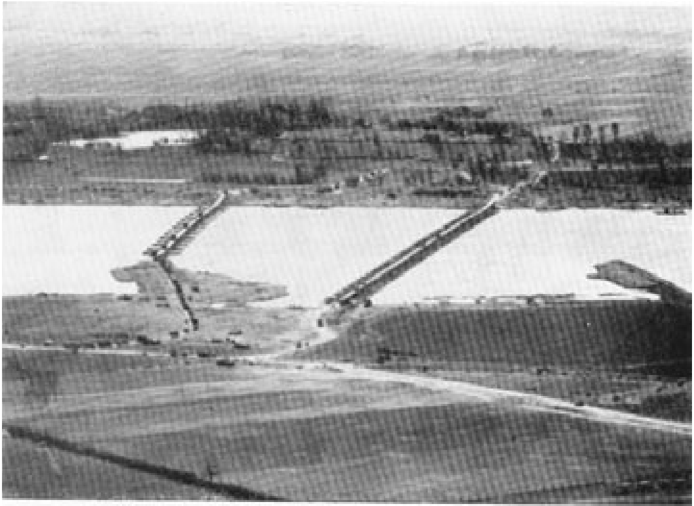


Photo No. 2—*Left*—Lambeth. *Right*—Blackfriars.

Photo No. 3—Westminster

The Rhine crossing, Rees 2 & 3

which can be seen in the photograph, jutting out from the left bank. The class 50/60 ferry, Gravesend, did however, manage to function at this site, although not without being damaged. It was built and operated by 5th Assault Regt., R.E. The third bridge is Lambeth Bridge, constructed by 30th Corps. Tps., R.E. and immediately behind it is Blackfriars, built by 2nd Cdn. Corps Tps., R.C.E. Just below Blackfriars Bridge is the site of the stormboat ferries which 6th Army Tps. operated with great success and very little trouble until the completion of the bridges made them redundant.

Of the above bridges, all except Lambeth were class 40 Bailey Pontoon. Lambeth, which was the first Bailey bridge to be erected during the crossing, was made class 15 in order to enable medium arty. (class 15 loads) to use it, rather than to ferry them over piece-meal in the Close Support ferries. This decision saved a great deal of time and enabled the guns to get over and free the bridge building area from artillery fire, which undoubtedly speeded up the construction of the remaining bridges.

The plan also included the provision of a Class 9 F.B.E. Bridge, Waterloo. This task was allotted to 18th G.H.Q. Tps. The site for this bridge was originally chosen between London and Westminster bridges, and it was to be built at the same time as Lambeth. As it was impossible to make a start on this owing to the opposition in Rees, it was eventually decided to build this bridge round the bend, downstream. In spite of the delay, it was the first bridge to be completed and can be seen, in the photograph, as a very faint line across the river just behind the sunken barge on the left bank. Traffic can be seen using the bridge. Another 50/60 class ferry, Tilbury, also operated at this point.

Photograph No. 2 was taken from the enemy (right) bank and shows Lambeth (left) and Blackfriars (right), and also the approach road which led from the home bund down to Lambeth and then upstream along the river bank to the ferry sites. This road was called Caledonian Road, and was built in Channel Track by 50th G.H.Q. Tps. Work was started before the assaulting troops of 51st Division actually crossed, and was finished during the night 23rd/24th March. The building of this road, which was the first job which had to be done, and which was an essential to the success of the operation, caused nearly one-third of the total casualties suffered by the engineers, but it was pushed through with great determination and gallantry.

Photograph No. 3 shows Westminster Bridge with Rees in the background. A few figures may be of interest. The table gives details of the bridges built, with times of construction. As work was impeded to a large extent at times by enemy small arms and artillery fire, the details may serve as a guide as to what can be expected, or planned for, in this sort of operation. The allotment of R.E. to the A.G.R.E. was one Assault Regt., seven Corps, Army or G.H.Q. Tps., one Bridge Coy, R.A.S.C. and five Pioneer Companies. In addition during the early stages, the A.G.R.E. Commander had the 3rd Div., R.E. in support, on whom he could call for work on the home bank. The R.E. Coys. of the assaulting 51st Div. were retained by that Division under their own command for work in the bridgehead on the far bank.

The total number of personnel directly under command of 13 (Brit.) A.G.R.E. was about 9,500, of whom some 8,000 were engineers. The number of vehicles available for carrying bridge stores was 500, and the calculated number of loads 1,500. The turn round was 16–20 miles. The total casualties were 155 officers and men killed and wounded. For their share in this successful operation, eight awards were gained by the Corps, and their work was described by the Commander 30th Corps in a personal message as "a good job magnificently done."

RHINE CROSSING—REES

TABLE—DETAILS OF BRIDGES BUILT

Bridge	Length	Built by	Start	Finish	Time	Equipment	Remarks
1. Waterloo Class. 9. F.B.E.	1,300 ft.	18th G.H.Q. Tps	25 Mar. 0800 hrs.	26 Mar. 0200 hrs.	18 hrs.	1 crib bay 2 trestle bays 1 half floating bay 60 floating bays 1 half floating bay enemy bank	—
2. Lambeth Class. 15. B.P.B.	1,206 ft.	30th Corps Tps.	24 Mar. 1500 hrs. Stopped 24 Mar. 2000 hrs. recommenced early 25th	26 Mar. 0830 hrs.	About 24 hrs. actual time wkd. 41½ hrs. in all	20 ft. ramp 120 ft. 6 in. landing bay 61 ft. 6 in. end floating bay 11—72 ft. floating bays 120 ft. 6 in. landing bay 20 ft. ramp-enemy bank	—
3. London Low level Class. 40. B.P.B.	1,174 ft.	8th G.H.Q. Tps.	25 Mar. 1700 hrs.	26 Mar. 2300 hrs.	30 hrs.	60 ft. approach span 110 ft. 6 in. landing bay 31 ft. 6 in. end floating bay 19—42 ft. floating bays 32 ft. floating bay 31 ft. 6 in. end floating bay 110 ft. 6 in. landing bay enemy bank	Limits River level variation possible Low—12.6 m. High—16.7 m. above N.A.P. (a)

Bridge	Length	Built by	Start	Finish	Time	Equipment	Remarks
4. Blackfriars Low level Class 40. B.P.B.	1,764 ft.	2nd Cdn. Corps Tps. R.C.E.	26 Mar. 1000 hrs.	28Mar. 1200 hrs.	50 hrs.	110 ft. 6 in. landing bay 41 ft. 6 in. end floating bay 45—32 ft. floating bays 41 ft. 6 in. end floating bay 110 ft. 6 in. landing bay enemy bank	Limits of river level variation Low—11.8 m. High—15.9 m. above N.A.P. (a)
5. Westminster High level Class 40. B.P.B.	1,402 ft.	6th Army Tps. R.E.	26 Mar. 1100 hrs.	29 Mar. 1800 hrs. opened by C.-in-C. 2nd Army	79 hrs.	20 ft. ramp 111 ft. variable landing bay 101 ft. 6 in. fixed landing bay 31 ft. 6 in. end floating bay 18—42 ft. floating bays 32 ft. floating bay 31 ft. 6 in. end floating bay 101 ft. 6 in. fixed landing bay 111 ft. variable landing bay enemy bank	Limits of river level variation Low—10.87 m. High—18.50 m. above N.A.P. (a)

(a) N.A.P.=Neine Amsterdam Point

MEMOIRS

BRIGADIER HENRY GEORGE PYNE, C.B., M.C.

HARRY PYNE was the son of George Masters Pyne and was born at Fermoy, Country Cork, on 23rd August, 1887. He was educated at Bedford, where he rowed for the school and was in the school Rugger XV. He won the Saddle at Woolwich and after completing the usual S.M.E. Course, he did a Mounted duties course at Aldershot and so commenced his great interest in the "horsey" side of life in the Corps.

On completion of this course he was posted to the 38 Fd. Coy. R.E. at Cork, and proceeded to France with this company in 1914. In 1916 he was made Adjutant of the 3 Div. R.E. in France and a little later he came home to be Asst. Dir. of Fortifications and Works at the S.M.E. For his services in France he was awarded the M.C. and was mentioned in despatches.

After the war he went to Egypt in 1920, as A.D.M.W. Egyptian Army but returned in 1921 to be O.C. 59 Fd. Coy. R.E. at the Curragh. The next year he was posted to the Mounted Depot at Aldershot, where he remained for four years till he proceeded to India in 1926; where he was first of all A.C.R.E. Meerut and in 1927 was appointed C.R.E. Delhi, which appointment he held till 1930 when he returned to the U.K. on long leave.

In 1931 he returned to the Mounted Depot at Aldershot once again; this time as O.C., and in which appointment he took such a great interest in the R.E. Coach, and was successful in winning many prizes in the various coaching competitions. He was also successful in winning prizes in many jumping competitions.

In 1933 he was appointed C.R.E. Gibraltar and was a familiar figure with the Calpe Hunt. On completion of his tour abroad he was appointed D.C.E. Southern Command at Salisbury in 1937, where he remained till May, 1939, when he went to India as Chief Engineer, Western District.

In March, 1940, he was ordered to fly home to take up the appointment of Chief Engineer 4 Corps and proceeded to Norway with this force. He was mentioned in despatches and after the evacuation of Norway he was appointed Chief Engineer 5 Corps but had to vacate this appointment in November, 1940, owing to a badly strained heart.

In February, 1941, he was appointed A.D.W. (Stores) at the War Office, and as such he had a hand in the tremendous task of organizing the supply of R.E. stores for re-equipping the Army after Dunkirk as well as building up the enormous quantities of new R.E. equipment required for all theatres of war and eventually for the invasion of Europe.

In 1942 he was appointed to be Chief Engineer, Southern Command, and as such he was responsible for providing the extremely large scale of accommodation, and all the subsidiary services that go with this accommodation, for the concentration of most of the American Forces in this country and the unprecedented arrangements required for the concentration and embarkation of the Expeditionary Force, both British and American for the invasion of Normandy. It is well known how successfully all these works were planned and accomplished, but few people know the gigantic task imposed on the Chief Engineer and his staff. For his share in this work he was awarded the C.B., which is now seldom awarded to anyone below the rank of Major-General.

In November, 1944, he contracted bronchial-pneumonia, which greatly aggravated his already overstained heart. Acting on his great sense of duty

Brigadier Henry G Pyne CB MC

he insisted on leaving hospital against his doctor's wishes in order to hand over his duties to his successor, and when he proceeded on final leave in December, 1944, prior to retirement, he was a very sick man. He retired officially on 12th January, 1945, and died on 26th December of the same year.

Harry Pyne was always cheerful but his quick brain did not suffer fools gladly and he was often outspoken in his replies, but none took offence at this and all realised the wisdom of his remarks. He will probably be remembered best for his love of horses and fishing. Such a love usually produces a character beloved by his fellow men, and this was certainly the case with Harry Pyne.

A.B.C. who knew him well during his early carer in the Army writes as follows:

"Henry Pyne and I were subalterns together in the 38th Fd. Coy. at Cork in the good old days before the first world war. He was the senior sub. when I joined the Coy. straight from Chatham in 1911, when the officer strength of a Fd. Coy. was just a Major and two subalterns. We were together for about two years. Though I saw him occasionally since then our paths never really crossed again so I feel hardly justified in writing an appreciation of his sterling worth and characteristics.

"He was undoubtedly a really first class officer of the best type and a wonderful chap to serve with under any conditions. He piloted me through my first outings with United Hunt, and as he was in the top rank, not only as a rider to hounds but also as a horsemaster, his precept and example were appreciated to the full. His frequent tours of service at the Aldershot Mounted Depot and with Field Units in the days when horses really counted testify to his love of the horse and his qualifications as an instructor.

"But, apart from this, he was in the first flight as an officer and as an Engineer. He was one of those fortunate few who combined a charm of manner, leadership of the best type and knowledge of his job. He commanded the love and respect of all who served with or under him, whether in peace or war. His loud, infectious laugh, his humourous, outspoken way of speech and his kindly smile endeared him to all his many friends. Ball games did not appeal to him. He was, however, a real expert with the dry fly and a first-rate shot. Life in Ireland in those early days was, for Henry Pyne, as for all the rest of us, a grand experience. While making the best of all that was available in the way of sport, he was using his ability and character to train for war a unit which was to take a worthy part in the early fighting in France during the early autumn of 1914."

In 1924 he married Betty (née Calthrop), a sister of Lt.-Col. E. E. Calthrop, M.C., R.E. and widow of W. Leigh Martin, who survives him. They had two children, a son Anthony, who is now an officer cadet at the R.E., O.C.T.U. at Bangalore, and a daughter Gillian.

C.C.P.

COLONEL ALFRED MONTGOMERY MANTELL

A. M. Mantell was born in 1860, became a cadet at the R.M.A. Woolwich when he was sixteen, and passed out with a commission in the R.E. in 1878. He was an exceptionally clever cadet and not only passed out first, but swept the board of prizes. It was said that the old Duke of Cambridge, in presenting the prizes on " Duke's Day," shook his cane at Mantell and said, " Young man, you are far too clever for the Army," but this legend may be apocryphal.

In 1881 he had the good fortune to be selected for service in Palestine under Conder, who was charged with the duty of exploring that territory to the east of the Jordan which we now call Trans-Jordan. The work was to be executed under the auspices, and at the cost, of the Palestine Exploration Fund. Conder was in charge, Mantell his second in command, and the assistants were sergeants Black and Armstrong. The small party reached Palestine in the spring of 1881, " and were engaged first in a tour through Northern Syria, which led to the recovery of Kadesh on Orontes." In August they marched down to Jericho, arranged matters with the local Arabs, crossed Jordan and arrived at Hesban (Heshbon) at the end of the month. They began a triangulation at once, occupying 21 stations, and incidentally fixing the height of Mount Nebo as 2,644 ft. above the sea. The country was in a disturbed state and the local Turkish authorities were not well disposed towards the undertaking. In fact, in October, the Governor of es-Salt ordered the party to leave the country. They continued to work until the 28th of that month and were then obliged to recross Jordan. They were only east of the river for two months yet they managed to do an almost incredible amount of work during that short time, surveys covering 500 square miles, archaelogical memoirs, photographs, sketches, copies of inscriptions, lists of place names, a collection of linguistic and ethnographical material, all of which will be found in the quarto volume entitled *Eastern Palestine*, published in 1889.

Mantell served in the Egyptian campaign of 1882 as a subaltern in the 18 Coy. and 26 Fd. Coy. and was employed in the Intelligence Department of the Egyptian Army in 1883. From 1888 to 1893 he was Instructor in chemistry and photography at the S.M.E. and in the latter year was posted to the Ordnance Survey in Ireland. In 1894 he was moved to Southampton where he took some part in the establishment of apparatus for the electrical duplicating of engraved copper plates. From 1902 to 1905 he again served in Egypt ; he was C.R.E. Cairo in the latter year. He retired in 1909.

He married the daughter of Mr. O. G. Dalby in 1885, and after his retirement he and his wife travelled in Europe for about three years, during which time he took every opportunity of perfecting his knowledge of German and Italian. His health was not good and he was unable to take any active part in the war of 1914—18. In 1920 they went to live at Bath where he became an active member of various literary societies, occasionally writing papers for them on philosophy, science and literature. It is said that, although he looked back with pleasure to his work in Palestine when he was a young man, archaeology was not his chief concern ; that was reserved for the physical sciences. But he had many interests. For the last five years of his life he was obliged to lead the life of an invalid, for he had been injured as the result of a fall, and could only get about in a wheeled chair ; but he kept his cheerfulness in spite of his disabilities. He died on June 25th, 1946, at the considerable age of 86. His wife and daughter survive him.

C.F.A-C.

BOOK REVIEWS

MY RECOLLECTIONS OF WELLINGTON COLLEGE

By George F. H. Berkeley

(R. H. Johns, Ltd., Newport, Mon.)

The writer of this book was at Wellington College between 1883 and 1889. This period was about 20 years after the school had been founded. The history of Wellington College written by Mr. Talloys is an official narrative and was much appreciated by Old Wellingtonians. This book, however, describes the life which was lived by the boys in the school at that period.

In athletics they held a very high standard. Gomer Williams and I. Johnson both won their Blues later at Cambridge, Croome, the Oxford hurdler, and F. S. Horan, the three-miler, had world wide repute. The latter won the half-mile against Yale in America. Berkeley describes their activities in these sports while they were at Wellington.

In Chapter III the author discusses the masters many of whom were still at the school when I arrived there in 1902. He sums them up very well and very fairly.

A large part of the book is devoted to cricket and long accounts are given of cricket matches and of the leading players. The author won his colours at cricket and is evidently a great enthusiast. In fact the greater part of the book deals with this game. It seems that a large proportion of the masters were also keen cricketers.

As regards his studies, Berkeley was on the classical side and the work of the modern side receives little mention though it is much the larger of the two. He does not seem to have taken much share in the rougher types of sport. These play such a large part in Public School life that the omission is rather a pity. Nevertheless Old Wellingtonians will read this book with interest.

G.Le.Q.M.

HERALDRY IN WAR

By Lt.-Col. H. N. Cole, O.B.E.

(Published by Gale and Polden, Ltd., Aldershot. 12/6)

All who served in the Army during the 1939-45 war will be interested in this book which gives illustrations and short descriptions of the many different badges used by formations and units of the Army. Everyone was proud of the particular sign he or she wore on their uniform and all were inquisitive regarding the signs worn by others.

Although in his preface Col. Cole states that in this edition he has confined the details of badges to those of Brigade formations upwards, and that even these are not complete, he is to be congratulated on the number of badges which have been included. Besides covering the ordinary Brigades and higher formations he has also included a very large number of Overseas Garrison H.Q.s, Districts and L. of C. Areas, as well as a number of Allied Contingents.

The notes under the pictures give some details of operations in which the formations took part, together with an explanation of the sign and the reason for its adoption where this is not obvious. Some of these notes will no doubt be expanded later to give fuller details.

In addition to its individual interest this book will no doubt form a most valuable historical record and foster esprit de corps for the future. C.C.P.

MAGAZINE REVIEWS

GEOGRAPHICAL JOURNAL

(Published by the Royal Geographical Society, London)

September-October, 1945

R. C. Farrow, a Chief Hydraulic Engineer of the Water Rights Branch in British Columbia, gives an enthralling account of surveys carried out in search of water power in the Coast Range. The country traversed is one of extraordinary difficulty, as shown by the fine photographs which illustrate the paper ; and the survey, which occupied the summer months of three years, required on the part of those concerned not only professional qualifications of the highest order, but also quite exceptional powers of physical endurance.

E. W. Gilbert and R. W. Steel contribute a paper on, " Social Geography and its place in Colonial studies." Social Geography may be defined briefly as the science of the distribution of population, the distribution and form of rural settlements and towns, and the way of life of social groups. The writers argue that this aspect of geography has been neglected in favour of economic geography (production, commerce, etc.), and that Colonial studies would benefit if more attention were paid to it.

Alice Garnett discusses " The Loess Regions of Central Europe in Prehistoric Times," and argues that whereas a theory has held ground that Neolithic man inhabited these regions because they were free from forest, there are grounds for believing that the disappearance of forest was not the cause, but the consequence of man's appearance ; in other words she indicates the " startling possibility " that primitive man himself cleared the forests, either by fire or by felling.

The centenary of the publication of Richard Ford's " Handbook for Travellers in Spain "—one of the early Murray handbooks—is celebrated by E. W. Gilbert in an interesting account of the man and his book, which has been described as " one of the best books of travel, humour and history in the English language."

There is a short note by Colonel de Gaury on an interesting group of tombs in al-Kharj, in Central Arabia.

November-December, 1945

The centenary of Sir John Franklin's expedition in the Erebus and Terror in 1845, in search of the North West Passage, is celebrated by a joint article, by R. J. Cyriax and J. M. Wordie. The former discusses the orders given to Franklin in the light of geographical knowledge at the time. The latter gives an account of subsequent voyages which were undertaken, either in search of Franklin or in connexion with the North West Passage, up to as recently as 1940–42, when Serjt. Larsen of the Royal Canadian Mounted Police, made his adventurous voyage in the patrol ship *St. Roch* from the Bering Strait eastwards to Baffin Bay, and 1944 when he went back again, from Halifax to Vancouver, in one summer.

J. H. F. Umbgrove contributes a highly technical article on, " Types of Island-Arcs in the Pacific."

Lt.-Commander P. C. Spink writes a further account (a previous one appeared in *Geographical Journal*, May 1944) of, " The Kibo Inner Crater and Glaciers of Kilimanjaro and Mt. Kenya," illustrated by very fine photographs.

An article, based on a report by Prof. Ahlmann of Sweden, gives an interesting account of the state of geographical studies in the Soviet Union. Leningrad and Moscow are the two chief centres of activity, and much valuable work is being done. E.M.J.

EMPIRE SURVEY REVIEW, April, 1946

(Published by the Crown Agents for the Colonies)

Sir Ernest Dowson and V. L. O. Sheppard contribute the first part of an account of the "Evolution of Land Records." The authors point out how grievously the effective record of rights and duties pertaining to land has suffered from the divorce between the legal and technical aspects of cadastral record; the surveyor looking on the graphic record as a prime necessity, while the legal mind often regards it as a tedious and costly refinement. Owing to the magnitude of the subject the account is confined mainly to the development of land record in England, though much interesting information is given about its history in other countries. The article is of the greatest interest. It is accompanied by a Bibliography of Cadastral Survey and Land Records which though admitted by the authors to be incomplete is undoubtedly of the utmost value.

There is an interesting description by Brigadier Sir Clinton Lewis on "Model Plane-Tabling," in which he explains how plane-tabling can be practised indoors with a model (which may be in relief, but is not necessarily so). The method has been found very useful for elementary instruction.

L. P. Lee discusses "The Nomenclature of Map Projections," in connexion with previous communications which have appeared on the subject. The same author has a short note on a simple method of computing scales of latitude and longitude on the Transverse Mercator projection.

There is a lengthy notice of "Geodesy in Egypt," by J. H. Cole, an official publication issued by the Survey of Egypt, and which follows usefully on the account of the Cadastral Survey of Egypt by Dowson and Sheppard which appeared recently. E.M.J.

JOURNAL OF THE UNITED SERVICE INSTITUTION OF INDIA.

(Published by The Civil and Military Gazette, Ltd., The Mall, Lahore)

January, 1946—The C.-in-C.'s lecture to the Staff College, Quetta, on *The future of India's Armed forces* naturally takes pride of place. To get the right type of officer is, of course, vitally important, and an academy to hold two or three thousand cadets is proposed. It would be run on the lines of West Point, and, in a four years' course, train for the R.I.N., the I.A., and the R.I.A.F. A photo of a model of the proposed academy is given as a frontispiece. The Supreme Commander of all the armed forces in India will be a member of any one of the three services, with a flag officer, a general officer and an air officer commanding each his own organization.

Parachuting into Mid-China is exciting. Twenty passengers, only one of whom had previous experience, baled out at 19,000 or 20,000 ft. and landed safely in country which the author compares with the North-West Frontier of India.

Preparedness a National Necessity is the winning 1945 Gold Medal Essay. The unpreparedness of the army in India in 1939 is treated at some length, and on that basis are the author's proposals for the future. The principal are: recruiting not to be confined to the pre-war classes; a higher standard of education for recruits; India to be self-sufficient as regards provision of officers; higher educational standards, especially as regards technical training; more cadet schools; larger reserves of officers; finally, and perhaps most important, a special planning staff at G.H.Q. to consider problems and formulate proposals for expansion.

Frontier Realities is an answer to *Frontier Myth* which appeared in the July, 1945, number of the *Journal* (see *R.E. Journal*, March 1946). "Any form of operation" says the author, "against a skilled minor tactician, with one's life as the stake, is first class training." He has experience in fighting Germans, Turks, Persians, Japs and Pathans, and considers the last the most skilful minor tactician. Points brought forward in *Frontier Myth* are ably disposed of.

Nuclear Energy and War written in October, 1945, is thinking aloud more than an essay, but well worth studying. The author regretfully comes to the conclusion that, if and when war does come about between two great powers, atomic missiles will be used, and that the only effective means of defence will be to live underground with immense stores of food and munitions. The colossal amount of work required to dig these underground fortresses is dismissed, perhaps rather lightly, by saying that atomic energy will be available. Mountain masses have special advantages for such sites for offensive and defensive purposes. Navies will have ceased, or almost ceased, to exist. The war will begin by batteries firing atom bombs at the enemy over thousands of miles of intervening sea and land, followed on the part of the successful power by an air-borne invasion to give the *coup-de-grace.* Victor and vanquished alike will come to the surface to find all their surface activities, including the growing of crops, destroyed. The author pertinently asks, will not nations, in view of the state of affairs resulting from such an appalling struggle, try to enforce their will on others by propaganda, infiltraion, and fifth column methods generally? One suggestion worth following up is the formation of an international body of scientists to work on atomic research and similar subjects, whose discoveries are to remain secret until U.N.O. or some such organization decides that they can be let out for the purpose of finishing off an aggressor.

Why not a Railway Transportation Corps? The point made is that in a major war, the present organization, viz., the Railway Training School at Longmoor, plus the Supplementary Reserve, and the services of R.E. Officers with railway experience in India and elsewhere, is quite inadequate. The idea is that these units should bud off, as the R.A.F. and Signals have done, to become the nucleus of a separate show.

An I.A. officer looks to the Future, is well worth study. The author, an Indian, prefers Basic English to Roman Urdu as a *lingua franca* for the I.A., for the reason that a continuously increasing proportion of recruits does not understand Urdu. The bulk of the article deals with the future supply of officers and settlement of ex-sepoys on the land. The immense obstacles in the way of Indian unity are touched on, but with little or no suggestion as to how they are to be got over; but, after all, that is not the purpose of the article.

F.C.M.

THE INDIAN FORESTER

(Published by The Civil and Military Gazette, Ltd.,
The Mall, Lahore.)

January, 1946.—War time difficulties of import have led to search in India for indigenous timber for pencils (for which the Baluchistan juniper has been found suitable) and for skis; for the latter no very efficient wood has been found locally.

A summary of the anti-erosion measures being taken in the colonial empire is worth studying. Erosion is bad in many regions, especially in our African colonies and protectorates. It is encouraging to learn that much has been done all through the war in initiating and developing preventive measures.

February, 1946.—Editorial Notes comment on the presence of Major H. W. Wright, R.E., of the Survey of India at the last silvicultural conference in connexion with a map of the Great Indian Desert, showing the increase and decrease of sand-covered areas between 1870 and 1935. Sand is unfortunately extending northwards into the Punjab and north-eastwards into the U.P. A second map, also prepared at Major Wright's instance, shows the water-table, which in some places is as much as 600 ft. below the land surface.

Laminated skis are being prepared in India from *shisham* and other woods, with some success.

Another note remarks on the alarming increase of the goat population of India, 60% within the last twenty years, without, however, any consequent cheapening of mutton.

A good deal of topographical mapping on the east coast of the U.S.A., has been carried out since Pearl Harbour, as an anti-invasion precaution. An extract from the *Journal of Forestry* describes how this was done, largely by foresters previously quite untrained in survey. Much of the ground was covered with giant redwoods, and platforms for stations were sometimes made at the tops of trees over 200 ft. above ground level. Parties often camped inside a hollow redwood, one of which is reported as being big enough for four men to sleep in a circle round a fire, leaving room enough for two more beds.

March, 1946.—Two articles deal with the reclamation of desert areas, in the Bombay Presidency and in the U.P. respectively. What strikes the layman most is the phenomenal growth of certain trees—in the case of one species, *Cassia Siamea*, an average of 5 ft. and a maximum of 10 ft. 8 in. in 15 months, including two monsoons.

New Brunswick is being aerially surveyed ; photos are being taken from a height of about 1,200 ft. on a scale of about 4 in. to the mile.

A report by Sir Harold Glover on *Soil Erosion in Baluchistan* is melancholy reading. Whole villages with their cultivable land have been laid waste by drifting sand. Natural vegetation would in time stop the drift were it not for uncontrolled grazing by domestic animals. F.C.M.

THE MILITARY ENGINEER

(Published by the Society of American Engineers)

February, 1946.—*Amphibian Engineers in Action—Part III—Corregidor to Tokyo*, by Brigadier W. F. Heavey. An account of the capture of the Philippine Islands, mainly of historical interest. The assaults followed a more or less standard pattern with landings from the various types of landing craft under cover of intense air and naval barrages, and with the aid of smoke and flame throwers. With the Japanese Air Force practically non-existent, American casualites were comparatively light.

The Rhine—A Major Bridge, by Col. William C. Hall. Another of the many descriptions of bridges across the Rhine. This bridge was particularly interesting in view of the improvisation involved. The bridge, was a triple single Bailey with the two ends supported on fixed piers consisting of improvised bents built on the piles of a demolished bridge, while the centre section was supported on floating barges. Launching and hingeing presented interesting problems and it is thought that the moving of 1,540 ft. of double single Bailey on 44 rollers during the launching process is a record.

March, 1946.—*Operation of Overseas Engineer Depots.* by Major G. A. Bass. The article covers the layout of a Stores Depot and the receipt, issue and stock-taking of stores. It is interesting to note that the example given of suggested layout is exceedingly compact, the emphasis being on efficiency of operation and conservation of traffic movement with no mention of dispersion to minimize bomb damage. In conclusion the author states that the operation of an engineer depot is a serious, vital and complex assignment often given to any engineer troop unit. It was one of the lessons of the War that amongst British Units all too little attention had been given to the subject of stores in peace-time training.

The Bailey Bridge, by Capt. John A. Thierry. An article embellished with excellent photograhs illustrating all the normal and special uses of Bailey bridge equipment. While giving the fullest credit to the Bailey bridge as one of the outstanding engineer developments of the War, the author regards it only as the pioneer which more nearly than any other, points the way to the ideal Military bridge. The Bailey bridge was designed on the assumption that all erection would be by man-power. Mechanical power is no longer a luxury, but an essential weapon, and he anticipates that the bridge of the future will be based on the utilization of mechanical power and so designed as to reduce the time of erection considerably.

These Childish Things, by Francis Chase, Jr. An account of the work done by model makers ; an extremely valuable contribution towards the winning of the war, since the models, made to scale and accurate down to the last detail (thanks to air-photography), were used for briefing for every type of operation. This undoubtedly saved many casualties in the assault and rendered bombing results far more accurate.

April, 1946.—*Combat Engineering*, by Lt.-Col. J. B. Lampert. An account of the Engineer work and mainly the bridging carried out by Divisional, Corps, and Army Engineer Units in the 120-mile advance by the XIV Corps of the VI U.S. Army from its landing in Lingayen Gulf to Manila 120 miles to the south. This advance, fighting the Japs all the way, took 26 days and involved many river crossings. Existing bridges had almost invariably been destroyed by the American Air Force or the retreating Japs, and the supply of standard bridging, such as Bailey and Pontoon, from a beachhead base, was never really adequate to meet the demand. A tremendous Engineer effort was, therefore, required to meet the bridging problem and maintain the advance—how it was accomplished is graphically described in this well-illustrated article.

The Emme Pyle Bridge, by Capt. C. W. Neuscheler. An account of the Phœnix like reconstruction of a bridge in Germany on the debris of the old bridge. The original concrete bridge had been well and truly destroyed by the Germans in retreat and neither the time nor the equipment was available for removing the debris. The new bridge had to be built on the same site and the problem of securing firm footings on the remains of the old bridge for the timber trestle piers was no easy one. How it was overcome and how the landing problem was tackled is well described and illustrated.

H.R.P.H.

THE ENGINEERING JOURNAL

(Published monthly by the *Engineering Institute of Canada*)

February, 1946.—*The Future of Radio Communications in Canada.* The author considers the application of radio to a variety of purposes. He explains that in the early days comparatively long waves were used for long distance transmission but it is now carried out more efficiently by short waves of high frequencies in the range 3 to 30 megacycles. As a direct result of war research he expects a greatly accelerated development of radio communication during the next few years.

The Evolution of Three Term Simultaneous Linear Equations by the use of Submatrices. This paper deals with a method of solution based on the division of the matrix of the co-efficients of the set of equations into submatrices. A numerical example is given for a seven span continuous girder of constant I.

Irrigation. A short article on the principles and practice of irrigation in the U.S.A. and Canada.

March, 1946.—*Performance, Installation, Characteristics and Design of the Rolls-Royce "Nene" and "Derwent" Gas Turbines.*

This article begins with a brief history of the development of jet propulsion gas turbines and then deals with their application to aircraft, dealing specifically with the two types mentioned in the title. The paper concludes with some technical data of the two engines.

Combined Action of Concrete Slabs and Supporting Steel Beams. The author states that the present practice in Canada is to assume that in composite beams the steel takes the whole load. He then explains recent modifications in design and the economies derived from allowing for the compressive load taken by the concrete.

The Engineer Family in the British Commonwealth. An address by Dr. P. Dunsheath, C.B.E., the President of the Institution of Electrical Engineers when he represented British Engineering Institutions at the sixtieth annual banquet of the Engineering Institute of Canada.

April, 1946.—*War Time Production of Precision Optics in Canada.* This is the first of four instalments of a paper describing the production of precision optical instruments in Canada. Four typical optical assembly trains are described, and various production methods in the manufacture of lenses are dealt with in some detail.

Trans-Canada Air Lines Radar Installation. The basic principles of Radar and its application to Airways are briefly explained. It is evident that the subject is still in its infancy.

Advantages of High Strength Steel as Reinforcement for Concrete. The author maintains that it is more economical to use a special alloy steel having more than twice the ultimate tensile strength of mild steel, and to load it up to a "*useful limit*" point where the strain in very slow tension tests reaches the value of 0.005 in. per in. The stress at the useful limit point is much greater than the elastic limit stress which has hitherto been taken to assess the working load in a ferro-concrete structure.

The author supports his arguments by a large number of test results.

Education of Engineers. Some useful remarks on a perennial subject.

W.M.

REVUE MILITAIRE SUISSE

(Published by Imprimeries Réunies, S.A., Av. de la Gare, 33, Lausanne.)

February, 1946.—*L'Armée dans la discussion publique*, by Colonel R.Probst, deals with the difficult question as to how much military matters touching important decisions may be discussed openly in public. While recognizing the need for free expression of opinions, regular officers are restrained by the necessity for prudence, and take the natural view that too much restraint is better than too little. But in the Swiss system, in which the Army is more closely linked with the people than ours has hitherto been, most military decisions touch the people as well as the soldiers. Staff officers and instructors are averse from free communications to the Press and like to avoid public criticism. And indeed they must do so. There is so much now-a-days in the military training of national armies which affect most intimately the lives of the people that the demand to be taken into the confidence of the authorities must be taken seriously. The key to the problem is the degree of confidence which can be established between the critical public and the military authorities.

Armée de metier et nation armée by, Major P. de Vallière. Attention is called to an article on the Royal Military College, Sandhurst, which appeared in the Revue Militaire Suisse of October, 1945, in which the author made the statement that if England had no professional Army, she had at least cadres of officers for the rapid training of new troops. Major de Vallière points out that in 1939, England was the only power in Europe with a professional Army, by which he means a voluntary Army. Only twice in her history has England resorted to conscription. A professional Army can only be obtained by voluntary engagements. Conscription, affecting every class, must produce an armed nation, and an armed nation is not a professional Army. But an Army of volunteers is insufficient for total war. All the nations of Europe, except England, have therefore, invested in obligatory service. At present, England is trying to combine the two systems as a temporary measure.

The Swiss militia system has recently been criticized in Switzerland as producing an Army quite insufficient to avert the fate of Denmark, Holland or Norway. Yet the fact remains that Switzerland emerged intact from both Great Wars. Major de Vallière challenges the pacifist view in the following month.

Le Prestige extérieur et le Personnalité du Chef, by Major P. De Vallière. The Russian Army, having revolted against discipline, officer-control, saluting, and all the impositions of the old regime, has found it necessary to return to the old measures for establishing and maintaining discipline, authority, prestige and ceremony. Moscow now loves its huge ceremonial parades. Medals and decorations are prized once more. Staff officers are ornamented with lace. Even the regiments of the Imperial Guard have been resuscitated with their gorgeous uniforms. The Russian jackets are even more be-decorated than the British or American.

It was so after the French Revolution, it will be so again. At the moment, freedom of speech, freedom of manner, indifference to regulation forms of dress, slackness in saluting and easy familiarity are having a run for their money. They did no harm to the war effort, and certainly did not lower the fighting qualities of the troops. But can an Army exist in peace-time on the same easy-going basis ?

March, 1946.—*Une offensive pacifiste contre la défense nationale*, by

Major P. de Vallière. An answer to a recent pacifist attack on the Swiss system of national Defence. An anonymous pamphlet, "Should Switzerland be militarized," is the main theme; this puts forward four pleas: that the Swiss Army is incapable of warding off the fate of Denmark, Holland and Norway in 1940; that the militia system is directly anti-democratic; that Switzerland's perpetual neutrality should be abandoned for collective security, that the military leaders are deifying war.

It would be difficult to select a more peaceably-minded nation than the Swiss; or one which is more determined to preserve her integrity.

Even democracies must admit the obligation to safeguard themselves. An attack on the very measures which have proved successful in preserving integrity is nothing but attempted sabotage.

Major de Vallière refers to the measures taken by Britain and France in 1916-17 for the rapid movement of divisions to help Switzerland in the event of a German violation.

La réorganisaton de l'Armèe Francaise by Edmond Delaye. However uncertain the French may be as to the form of Government they wish to re-establish, all Frenchmen are united in a desire to reorganize their Army and rehabilitate their military strength. But the economists ask, what is the good of spending more billions of money on national defence now that Germany has been laid low, at least for many years? The urgency of the present time is for a truce to armament and for the development of all industrial and commercial resources.

The military authorities, with General de Gaulle, claim that France cannot, at a stroke, suddenly fall into a neutral and second-rate Power. She is still a great world-community. Who will defend her if she is unarmed?

April, 1946.—*Quelques notes sur les points essentials de notre défense nationale*, by Colonel M. Montfort. The newly appointed commander of the 2nd Division is a constant advocate of the supreme importance of preparation for war. His ideal is the patriot who neither hates war not likes war, but holds himself ready to make war, if need be.

Constrained to make a little go a very long way, the Swiss must ensure that they concentrate on essentials. All superfluities and specialities must be set aside. The author indicates aviation and mechanization as the main objectives. Refusing to be deterred by the atomic bomb's possibilities, he finds full reason for Switzerland to continue to pursue her policy of making the best possible preparations for her defence that her resources allow. All honour to the smaller countries whose people resolve to defend themselves, among whom Switzerland has set so steadfast an example.

Le Problèmes du Haut Commandment, by Colonel Anderegg. Deals with some difficulties which arise from an anomalous composition of the Commission of National Defence, of seven members, four of whom are the Commanders of the four Army Corps; the other three are the Chiefs respectively of the Military Department, the General Staff, and the Training Department. Nominally, the four Corps Commanders are directly subordinate to the Chief of the Military Department, who is President of the Commission, but in peace-time, they receive directions from the other two members. On the Commission the four Corps Commanders can outvote the other three. The difficulty seems to lie in the uncertainty whether Administration or Command should have the upper hand. At present, the functioning of the High Command depends entirely on the good understanding existing between the seven members of the Commission. The passage from a war to peace footing accentuates the difficulties.

W.H.K.

INFANTRY JOURNAL

(Published by the U.S. Infantry Association)

February, 1946.—*Why Normandy?* by Brig.-Gen. P. W. Thompson gives the reasons why Normandy was selected for the invasion of France. These reasons are now known to most military readers, but the pros and cons for the decision are very clearly stated. What would have happened if we had taken the shorter route to Germany, via the Pas-de-Calais, may be much argued, but even when all historical records are available it is unlikely that any definite answer to this question will be found.

The Battle is Still the Pay-Off, by Maj.-Gen. O. Ward, stresses the importance of teaching the soldier actual battle conditions during his training. This is recognized by all, but Maj.-Gen. Ward does not tell us how it is to be done. There is the primary difficulty of taking away war experienced Officers and N.C.O.s from fighting units to make them instructors. In the early and most important stages of a war you require the greatest number of instructors and have the fewest to pick from. Having got your instructors, real war conditions can only be produced in training if you are prepared to have casualties, not only among the soldiers training, but also probably among civilians unless you can find uninhabited countries for training.

For Unification contains extracts from President Truman's speech to Congress on 19th December, 1945, and gives nine points for a single defence ministry with a civilian head and one chief of staff. The Army, Navy and Air Force to each have its own Commander. The Chief of Staff and the three Commanders to form an advisory body to advise the Defence Minister. With modern conditions of world-wide commitments under the United Nations, unified control seems to be essential both for planning and operation.

March, 1946.—*Replacement Rifleman*, by Lt.-Col. A. Goodfriend, gives a picture of his experiences in passing through the various transit camps to eventually join a Unit during the operations in North-West Europe. In order to obtain a true picture of conditions, Col. Goodfriend assumed the role of a private soldier and so got first hand information of the conditions.

Seeing is Believing, by Lt.-Col. Fred Walker, Jr., stresses the importance of trying to overcome men's fears in battle by suitable training and explains how this can be done.

Transportation and Supply on Anzio, by Lt.-Col. W. V. Owen, gives particulars of peculiar supply conditions during this operation which were unique in certain respects, in that it was the longest time that any force has been supplied entirely by amphibious means and was the first time that pre-loaded trucks were shuttled by L.S.T. in great quantities for the daily supply.

There is an interesting review of *We Planned the Second Front*, by Maj. Dalgleish, R.A.S.C., which deals mainly with the supply portion of the planning and shows some of the immensity of the task and the difficulties and disappointments of the planners.

April, 1946.—*Strategy Must Change*, gives some views of the Japanese General Yamashita while awaiting trial by the Americans. He considers that the atomic bomb and the super long-range bomber will change all future strategy. He states that it was lack of air-power and material resources that defeated Japan and not the atomic bomb.

Ethics of Surrender, by Capt. W. C. Rowe, gives an interesting discussion on the right of any man or unit to surrender and says that men are told what to do if they have to surrender, but the conditions which warrant the right to surrender are not usually discussed. The difficulties of laying down any conditions of this nature are clearly shown in the article.

C.C.P.