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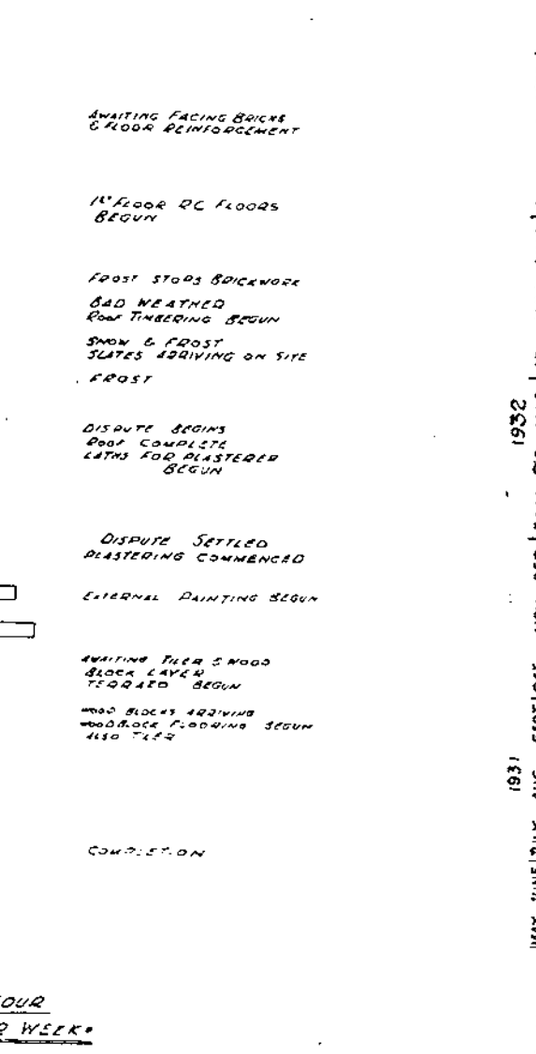

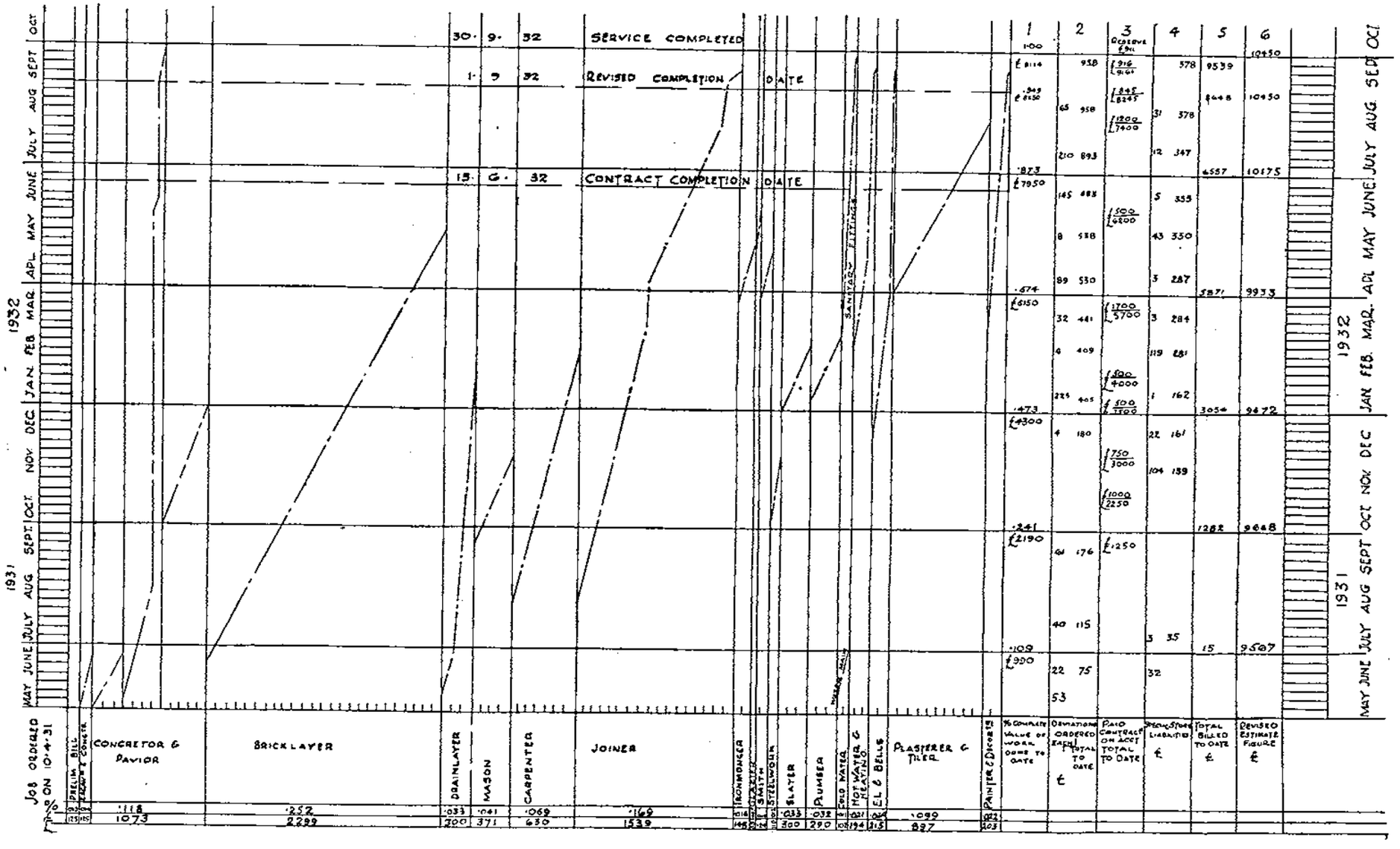

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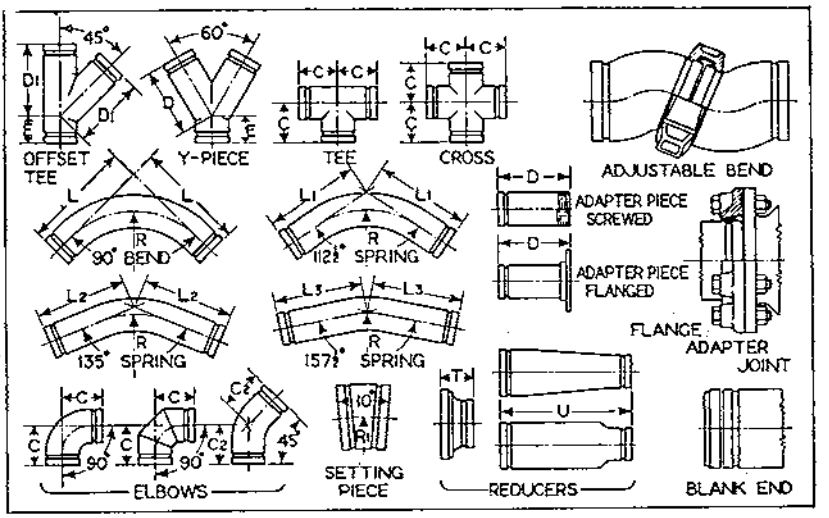

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¾	1 5/16	2	—	2½	5	1¾	4	3 5/16	3½	3⅜	2⅞	—	—	—
1	1 13/16	2	1¾	2⅞	5⅜	1⅞	4⅜	4¼	4⅛	4	3½	14	2½	9
1¼	1 15/16	2¼	2	3¼	5⅞	2	6	5½	5¼	5⅛	4¼	14¼	2½	9
1½	1 29/32	2½	2 3/16	3⅝	6¼	2¼	6¼	6	5¾	5⅝	5	14½	2½	9
2	2⅜	2¾	2 7/16	4½	7¼	2¼	8	7⅛	6¾	6⅝	6¼	14¾	2½	9
2½	3	3¼	2¾	5¼	8	2⅝	9⅜	8¼	8¼	8⅛	7¾	15⅜	3	9
3	3½	3⅝	3⅛	6	8¾	3	11½	10¼	9¾	9⅝	9⅛	16¼	3	12
4	4½	4⅝	4	7⅞	10	3⅝	15	13⅜	12⅝	12½	12⅜	18½	3	12
5	5½	5½	4¾	9	12	4½	18	16	15¼	14⅞	15	19	3	15
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DEMOLITIONS, FIFTH ARMY, 1918.

By MAJOR-GENERAL SIR REGINALD U. H. BUCKLAND, K.C.M.G., C.B., *Colonel Commandant R.E.*

(Continued.)

VI. 22ND MARCH.

General Situation.

Whilst the front south of the Oise was still intact, and Condren was held, the new line north of that river on the morning of the 22nd ran along the southern branch of the Crozat Canal from Tergnier through Jussy and St. Simon (where the greatest amount of ground had been lost) to the canal junction, whence it followed the northern branch in a north-easterly direction through Le Hamel to within half a mile of Fontaine les Clercs. Here it turned north and ran through Savy, east of Holnon wood, Bihecourt, Le Verguier and Epéhy, but west of Gouzeaucourt.

III. Corps.

It has already been described how the bridges on the canal from Fargnier to Menessis had been destroyed. In the confusion regarding responsibility, two railway bridges west of Jussy, and another over the canal a mile east of that place,* had not been dealt with. This was discovered by the C.R.E. 14th Division at 2 a.m. on the 22nd, and those west of Jussy were destroyed by 9 a.m., with the results already described.

Lieut. L. T. Moore, after some stiff fighting alongside his affiliated

* Nos. 1, 2 and 8 on the list on pp. 30-31, March 1933 *R.E. Journal.*

Brigade west of Benay, had been ordered to report to the C.R.E. at Jussy with No. 1 Section, 89th Field Coy. During the night 21st/22nd, he was sent to destroy a wooden trestle bridge of three spans over the railway deviation a mile north of Jussy. Crossing the railway bridge (No. 108*) over the canal, he spoke to the French officer in charge there, went on to his bridge, found that the French had prepared it for burning, and set fire to the trestles, thinking it desirable to get them burning well before the conflagration of the decking drew the enemy's attention to the spot.

On his return he attempted to destroy bridge No. 108, as the party of French Engineers had left without doing so. The reason for this was that their officer had been arrested as a spy, and was not released in time to do his job. The same officer was responsible for two road-over-rail bridges near Montescourt, which consequently were not destroyed. Bridge No. 108 carried a double line of railway, and consisted of a central lattice girder, 12 ft. in depth, with smaller girders on each side. It was originally a single span of about 70 ft. The girders had been cut in the centre during the German retreat in 1917, but had been raised into their former position by an English firm from Darlington, and now rested on two bents, each of ten stout piles. Lieut. Moore had seen this work going on during the previous fortnight, and, not knowing that the patching up of the girders had been completed, he fired the French charges on the piles and brought them down all right, but the girders remained intact as a single span. He had only one box of guncotton and with this he cut the lower boom of the central girder, but no more could be done as further supplies of explosives were not available,† and the bridge was left passable for infantry.

There had been some uncertainty as to whether bridge No. 11, over the lock, half a mile east of No. 108, was within the divisional boundary, but after daybreak, Capt. Lyon, 89th Field Coy., was sent from Jussy with a party of volunteers to blow it up, which he did successfully as already narrated. (See 21st March.)

The dump at Montescourt had been prepared for firing, and the R.S.M. (Serjt.-Major Bayes) stood by until 4 a.m., on the 22nd, to set it alight, but the O.C. of the Cavalry rearguard gave orders that it should not be burnt lest the flare should show the enemy that we were crossing the canal.

At 3 p.m. the C.E. sent his staff officer to Major F. G. Bywater, acting C.R.E. 58th Division,‡ to arrange that the Division should take over responsibility for the bridges west of Chauny, the 135th A.T. Coy. being placed at their disposal for work farther back. This Company therefore marched to Abbécourt, took over the bridges from

* Railway bridges were distinguished by 100 having been added to their original numbers.

† The tool cart had just been destroyed by a shell.

‡ Lt.-Col. Savage returned from leave on the 26th.

the 2nd Field Squadron, and drew explosives from the ammunition dump there.

At 5.45 p.m., Lieut. Fraser, 284th A.T. Coy., was instructed to destroy two observatories near Guivry on receiving the order from Major-General Greenly, commanding at the moment the 14th Division in addition to his own 2nd Cavalry Division. One of these was successfully dealt with on the 24th, but, on account of faulty liaison between the Company and General Greenly, the second was captured intact.

XVIII. Corps.

The right of the XVIII. Corps having been withdrawn west of the northern branch of the Crozat canal by 4.15 a.m., it is to be noticed that the bridges on that canal and on the Somme beside it, used hitherto as means of lateral communication only, were now in the front line and liable to attack from the south-east. At 1.5 p.m., on the 22nd, the Corps delegated further responsibility for the demolition of their bridges as under :—

36th Division.	St. Simon to Sommette Eaucourt, inclusive.
30th Division.	Sommette Eaucourt to Offoy, both exclusive.
61st Division.	Offoy to Buny, both inclusive.

At the same time they arranged to hand over to the XIX. Corps the bridges from Béthencourt to Falvy, both inclusive.* The message to that Corps went on to say that demolition parties were in position and had been warned by D.R.

In the 36th Division the Artemps group of four bridges (one of 84-ft. span) was destroyed between 4 and 4.30 a.m., by Lieut. W. M. W. Brunyate, with one section of the 150th Field Coy.; the Tugny group (10 road and 2 footbridges) at 9.30 a.m., by Lieut. C. L. Knox and 1½ sections of the same Company. At one of Lieut. Knox's bridges a fuze junction failed. He lit the instantaneous fuze with a match, successfully demolished the bridge and escaped unhurt !†

Lieut. Stapylton Smith, with another section, scuttled the boats of a pontoon bridge near St. Simon at 8 a.m., and destroyed the remainder of the St. Simon group (4 road and 7 footbridges)‡ at 10 a.m. All these bridges were destroyed at the latest possible moment, and in one case the enemy were actually on the bridge.

During the afternoon, 2nd-Lieut. R. E. Walsh, with No. 3 Section, 121st Field Coy., took over from the 172nd T. Coy. their bridges on the Somme and the Somme canal between Ollezy and Ham. These comprised three bridges on the Dury–Ollezy road, six at Sommette

* The northern boundary of the XVIII. Corps ran just south of Béthencourt.

† Lieut. C. L. Knox was awarded the M.C. for this self-sacrificing act of courage.

‡ The number of the bridges had increased since the demolition scheme had been prepared. The same will be noticed in other cases.

Eaucourt (4 wooden trestle road bridges and 2 for light railways), a steel standard-gauge railway bridge at Pithon, a wooden bridge on the Ham–Sommette Eaucourt road, and a pair of steel girder bridges on the Ham–Noyon road, a total of 13 bridges. The Dury–Ollezy bridges were blown up at about 1.30 p.m., and the road bridges at Sommette-Eaucourt at about midnight 22nd/23rd. The two light railway bridges were set on fire; this rendered them useless as light railway bridges but left them still passable for infantry. At the time there was some doubt as to the fate of the bridge at Pithon. This being a railway bridge, it was for the French to blow it up. Seeing that no steps had been taken to demolish it, 2nd-Lieut. Walsh put 2nd-Corpl. Wheeler and two sappers to do as much damage as they could to the wooden piles of the abutments. 2nd-Lieut. Walsh and this N.C.O. were afterwards missing, so there is no record as to what was accomplished.

From a *précis* in English of the *History of the 3rd Foot Guards, 5th Guards Division* prepared by Lt.-Col. Maxwell Hyslop at Audit House, it appears that a battalion of the regiment captured Pithon early on the 23rd, but was unable to cross the river owing to the railway bridge being swept by m.g. fire, which, on account of the fog, they were unable to subdue. Later the 11th Coy. got across, followed at 11.30 a.m. by the remainder of the Fusilier Bn. At 2 p.m. the 3rd Guard Grenadier Regt. crossed "the partially constructed railway bridge," but had difficulty in getting over their first-line transport and their accompanying batteries. From this it would seem that very little damage had been done to this bridge on the 22nd.

Capt. Cooper, 172nd T. Coy., blew up the bridge over the Somme canal just west of its junction with the northern branch of the Crozat canal at 9.55 a.m. The bridge over a small stream between Ollezy and the canal was blown up by this Company at 10.10 a.m.

The following notes from the narrative of the C.R.E. 36th Division are of interest:—

For steel lattice and plate girder bridges, and for wooden trestle and pile bridges, guncotton was used; for pile bridges for infantry in file ammonal tubes were employed. The charges had been calculated and stored near the sites in special boxes. These boxes were to be fitted into boxes or on to shelves permanently fastened to the members to be destroyed. Owing to the newness of the wood employed it was found necessary to use a loose fit, and provide a number of small wooden wedges for the purpose of tightening up. Every charge was numbered and lettered to correspond with its bridge and member. Alternative methods of firing were provided. On the steel girder bridges the charges were applied in the usual way to cut the flanges and the lattices at an intersection. No charges were laid to destroy abutments.

On the wooden pile bridges the charges were applied in two ways on each bridge :—

(*a*) A long charge on a horizontal shelf just under the road-bearers, designed to destroy both piles and superstructure.

(*b*) A long charge on a sloping shelf attached to the piles, designed to cut the piles at different heights.

The foot-bridges were demolished by means of zinc tubes 2½ in. in diameter and two metres long filled with ammonal, and fired by safety and instantaneous fuze.

At 11.30 a.m. the C.R.E. 30th Division was given by the C.R.E. Corps Troops an order from the Corps to the effect that the Division became responsible for the issue of orders for firing the charges on the bridges already prepared, between Sommette Eaucourt exclusive and Ham inclusive, excluding the railway bridge at Pithon. The bridges at Ham had been prepared by the 1st Siege Coy., so Lieut.-Colonel Denison interviewed the officers who had made the preparations, and sent one of his Field Company officers to take charge of the bridges north of the town, and two others to take the orders of the G.O.C. 89th Infantry Brigade regarding the bridges south of it.

In the 61st Division, the C.E. XVIII. Corps was asked to supply explosives for Offoy and Buny bridges, those for the former to be sent to the 1st Siege Coy. The C.E. complied, but pointed out that the Division was responsible for the bridges at both places. At 5 p.m. the 479th Field Coy. went to Voyennes, where it held Buny as a bridgehead, whilst the 476th formed a bridgehead at Offoy and the 478th Coy. remained in support west of the river.

Lieut. H. M. C. Hosegood, 479th Field Coy., took over at 4.30 p.m. four bridges on the Buny-Voyennes road, which had been prepared by the C.R.E. Corps Troops. Sentries were placed, leads fitted and firing arrangements tested. The 61st Division retired during the night, and when all the infantry had crossed the bridges were handed over to demolition parties of the 20th Division,* who blew them up. Two of the bridges at Offoy were on a deviation and would have been difficult to destroy in a hurry, so at 11 p.m. their immediate destruction was ordered. Lieut. Powell, 476th Field Coy., carried out the work. The remaining bridges were handed over to the 20th Division at 1 a.m. on the 23rd and destroyed by them. (See below, 23rd March.)

Lieut. Sharpe, Corps Water Supply Officer, reported that 37 pumping stations were lost east of the canal, but all were destroyed except one spare installation which was not in use at the time. The Sappers in charge brought away the magnetos and carburettors from the engines, and handed them in to the 353rd E. and M. Coy. Those to

* This Division had joined the XVIII. Corps and covered the retirement of the 30th and 61st Divisions during the night 22nd/23rd.

whom heavy hammers had been issued completed their jobs by breaking the water jackets of the engines.

XIX. Corps.

In the 24th Division, Lieut. Fairbourn, 103rd Field Coy., destroyed three bridges at Vermand. There seems to have been some special anxiety about these bridges, and the Army Commander's approval of their being considered as being in the battle zone had been obtained. On the 13th March the Corps had written to the 24th Division as follows :—

(1) The four bridges* at Vermand are included in the battle zone for purposes of demolition.

(2) They have been prepared for demolition but will NOT be destroyed without reference to Corps H.Q. except under the following circumstances : should the enemy drive back our troops on both sides of the R. Omignon, and Vermand be isolated, and the advance of the enemy over the bridges make it impossible for Vermand to hold out, the demolition of these bridges may be ordered by the B.G.C. the Infantry Brigade, whose Headquarters are at Vermand, on his own authority, in the absence of orders from his Divisional Headquarters.

(3) The officer entrusted with the demolition is not to carry out the destruction without the authority of either (*a*) a telegram or letter from Divisional Headquarters based on orders from Corps Headquarters, or (*b*) a written order from the B.G.C. Infantry Brigade whose Headquarters are at Vermand.

The records do not show on what order Lieut. Fairbourn acted.

Capt. A. Thorburn, 258th T. Coy., finding at 4 p.m. the enemy advancing on the south side of the Omignon, prepared to set off the two bridges at Caulaincourt. At the wooden trestle bridge the leads were cut and the charges could not be detonated, but the structure had been previously treated with a barrel of tar and six gallons of petrol, so that it was set on fire and completely burnt out. The second bridge, a small one, was blown up, but as only one charge went off the result was not altogether a success.

At St. Martin les Prés, Lieut. J. M. Ross, of the same Company, had the bridge ready at 10.30 a.m. The roadway, 15 ft. wide, was carried on 15 R.S.J.s (7 in. by 4 in.) over a span of 15 ft. He arranged to cut the joists at 3 ft. from an abutment with a charge of 56 lb. guncotton, to be set off by fuze. Traffic ceased at 3 p.m. and the bridge was destroyed at 6.30 p.m. At Tertry, he had two bridges to deal with. East of the village a road, 18 ft. wide, crossed the Omignon by a semi-circular arch springing from the water's edge. Driving a gallery, 3 ft. by 2 ft., into one of the haunches, at a point half way up the sloping bank of the river, he used a charge of 200 lb. of guncotton, and setting it off with fuze brought down the arch and the whole of

* There were only three bridges, one of 12 ft. 6 in. and two of 9 ft. 6 in. span.

one abutment. The second was a double bridge of unusual construction, south-west of the village, and this was destroyed at 7 p.m. (See Appendix p. 215.)

The light railway bridges at Tertry and Bernes were not destroyed by R.C.E.4, as he received no orders to prepare them.

The O.C. 288th A.T. Coy. started from his camp at St. Cren at 7.30 a.m., to look for Corps H.Q. and get orders about the bridges for which he was responsible, but could not find H.Q. At the same time, Lieut. Fogg proceeded to Monchy Lagache with two G.S. wagons, carrying explosives and a party of men, and started to lay charges on the bridges intending to work westwards. The O.C., however, returned, and leaving Lieut. Fogg at Monchy, took off the wagons and most of the men, and distributed them to the bridges at Devise, Fourques and Athies. He then returned eastwards from bridge to bridge, and rejoined Lieut. Fogg. Serjt. Price was in charge of the preparation of the bridges at St. Christ.*

The 281st A.T. Coy. at Doingt received orders to stand by their bridges on the Cologne at Buire, Cartigny, Doingt and Flamicourt, and Capt. Kentish personally inspected all the charges. One of the bridges at Buire (wooden trestle, 360 ft. long) was hit at 5.40 p.m. by a shell, which blew a 30-ft. gap in it. The C.E. therefore ordered its destruction to be completed at once, and three more gaps of 20 ft. each were made in it at 11.10 p.m. Lieut. Mackenzie went to Cartigny and stood by the bridges there all night.

The C.E. had ascertained during the day that the A.D.L.R. would prepare and destroy the light railway bridges at Brie, but at 10.30 p.m. he was informed that the A.D.L.R. had neither the men nor the explosives to carry out this work. He sent an urgent order to the 239th A.T. Coy. to take on these bridges in addition to the road bridges which were now ready, and a message reporting the completion of the preparations was received five hours later.

VII. Corps.

Corps H.Q. moved to Cléry, and preparations were continued for the demolition of the bridges over the Tortille (178th T. Coy.) and over the Cologne, near Péronne (180th T. Coy.).

Capt. Shaw, Corps Water Supply Officer, reported that all pumping stations, pipe lines and water points were maintained in good order up to the 22nd, when pumping plants were either completely destroyed or put out of action by the removal of important parts of engines and pumps.

In the 21st Division one N.C.O. and one Sapper of the 126th Field Coy. had been left at Pezière (the north end of Epéhy) to blow up the

* The preparation of the seven original bridges here had been begun by the Cavalry Corps, but since their departure some had been replaced, so that the work had to be done again.

main road bridge and a half-finished railway bridge just north of that place. The N.C.O. was wounded, but the Sapper stuck to his post, constantly repairing the leads throughout the 21st and the night 21st/22nd. When Pezière was evacuated on the 22nd, he blew up both bridges, and retired with the last of the infantry. The machinery at the divisional dump at Liéramont was destroyed, and as much material as possible burnt.

A.H.Q.

The A.H.Q. moved to Villers Bretonneux, and during the night the C.E. was directed by the Army Commander to visit the H.Q. of the XIX. and VII. Corps to ensure that responsible officers should be at the various bridges over the Somme with authority to blow the charges at the moment German infantry could be seen advancing and the bridges were actually under fire from them. His diary says :—

> It was obvious that unless some such arrangement was made there would be a risk of premature firing, or firing not taking place at all. I saw the G.S. and C.E. VII. Corps at about 12.30 a.m. on the night 22nd/23rd March. . . . I was informed that everything was ready, and parties standing by at each bridge. I asked that officers should be at each bridge empowered to fire the charges without having to wait for messages which might never reach them. I was told that this was arranged. I then proceeded to H.Q. XIX. Corps at Villers Carbonnel, and saw the Corps Commander and the B.G.G.S., and pressed for similar arrangements if not already made. The B.G.G.S. at once took this up. The C.E., Brig.-Gen. A. G. Bremner, had been wounded earlier in the night by a bomb. I saw Capt. Edleston, S.O.R.E., and explained to him why I had come. All R.E. arrangements for bridge demolition appeared to be in order.

At about 9 p.m. an order was sent to Corps authorizing them to delegate to divisions the responsibility for the destruction of bridges.

VII. 23RD MARCH.

General Situation.

On the morning of the 23rd the III. Corps held its original front line south of the Oise, and Condren. It had lost the Crozat canal from the St. Quentin canal up to near Liez, but from that point still held it up to the Corps boundary east of St. Simon.

XVIII. Corps. The 36th Division, pivoting on its right, had swung back from the Crozat canal to behind the Somme ; the 30th and 61st Divisions had retired, covered by the 20th, to the west bank of the Somme, which was held as far as Béthencourt, with a bridgehead at Ham. On the left of the Corps there was a gap.

XIX. Corps. The 24th and 50th Divisions, with their right at Guizancourt, held a line running from there east of Monchy Lagache,

through Vraignes and Beaumetz to the Cologne opposite Buire. The 66th Division had retired during the night through Doingt and Péronne, and was now in support on the west bank of the Somme from Eterpigny to Biaches.

The VII. Corps, with its right on the Cologne in front of Tincourt, had its left near Equancourt, in doubtful touch with the 47th Division (the right division of the Third Army), which formed a defensive flank facing south-east along the boundary between the two armies, the 63rd and 17th Divisions, north of it, being in a salient.

III. Corps.

In the 58th Division, Lieut. Davidson and No. 2 Section, 511th Field Coy., went to Bac d'Arblincourt, and took over from the 135th A.T. Coy. three bridges over the Oise canal and three over the Ailette south of that place.

The 135th A.T. Coy. was ordered to Manicamp to complete the preparations there begun by the 2nd Field Squadron. They left demolition parties at Abbécourt on the bridges at the junction of the two canals.

At 6.25 p.m. the III. Corps was placed under the orders of the French 3rd Army.

XVIII. Corps.

On the right of the XVIII. Corps, the R.E. of the 36th Division had blown up the bridges east of Ham on the 22nd, as already described. With a view to further retirement, Major Otway, with H.Q. and the mounted sections of the three Field Coys., was ordered to march to Frétoy and prepare two trestle bridges over the Canal du Nord, west of that place, and another at Campagne.

The 30th Division was responsible for the destruction of the bridges in Ham prepared by the 1st Siege Coy. The four bridges over the Somme, which here flows in a bend round the north side of the town, were blown up by men of the 1st Siege Coy., under the orders of a field company officer of the Division, no relief of their demolition parties having taken place. The first attempt at 4 a.m. at the bridge west of the Ham–Toulle road was not satisfactory, but fresh charges completely destroyed it at 5 a.m. South of Ham, the 12-ft. bridge over the canal, a few yards north of the Sommette–Eaucourt road,* close to a lock, was blown up by Lieut. Lannon, 200th Field Coy., at 6 a.m. The bridge on the Noyon road crossed a lock, which the French were repairing, and was only 6 ft. above the level of the top of the lock walls. It was a double-lattice girder bridge of 84-ft. span, erected by the French in the place of the plate girder bridge with jack arches, from which Lieut. Boulnois withdrew his charges on the 28th

* The bridge on this road had not been rebuilt, but a deviation north of it had been made.

August, 1914 (see March, 1932, number of *The R.E. Journal*, page 34). The Germans had destroyed the original bridge in 1917. To facilitate work the French had drained the portion of the canal between these two locks. The retreat through Ham was closely followed up by the enemy, and when, at 8 a.m., the last of our infantry had got across the bridge, 2nd-Lieut. Petschler, 201st Field Coy., blew it up just as the enemy were gaining a footing on it. The explosion cut the girders in the centre, but their shore ends stayed on their abutments, and the hanging ends were supported by the lock walls so that the gap was small. A German prisoner reported that infantry could still cross. It was not possible to lay further charges though explosives were on the spot.

At 3.15 p.m. the C.R.E. 30th Division at Ercheu ordered the 202nd Field Coy. to prepare three bridges over the Canal du Nord on the Ercheu–Libermont road, and two on the Ercheu–Esmery Hallon road for demolition. These had already been prepared by the 96th Field Coy. (20th Division) and were taken over by Lieut. Burford that evening.

The retirement of the 30th and 61st Divisions during the night 22nd/23rd was covered by two brigades of the 20th Division. When these had to retire the Division directed its 60th Brigade to use the bridges at Ham and Offoy, the 59th those at Voyennes and Béthencourt. The route through Toulle and Offoy was reserved to the 60th Brigade. The C.R.E. was ordered to arrange for blowing up these " and any other existing bridges." The authority for the destruction of " three specified bridges " (it is impossible to say which) was to be a C.O. specially detailed by the B.G.C.s. The bridges on the Germaine at Douilly and Toulle were blown up by the 1st Siege Coy. at 1.45 and 5.45 a.m., whilst the retirement was taking place.

S.W. of Offoy the 20th Division destroyed a dam across the canal and six bridges, two of which required a second set of charges. They also blew up a temporary wooden bridge over the canal N.E. of Rouy (le Grand), and two (over the river and canal) on the Voyennes–Buny road. These had all been taken over from the 61st Division during the night and were blown up some time before 7.30 a.m.

The C.E. XVIII. Corps had wired to the XIX. Corps at 12.30 p.m. on the 22nd that Capt. Howe, R.E., was responsible for the demolition* of the bridges Béthencourt to Falvy inclusive. The XIX. Corps apparently had no R.E. available to send to take over from Capt. Howe, and the C.E. XVIII. Corps, becoming aware that his men were not being relieved, wired to the XIX. Corps at 12.30 p.m. on the 23rd that his Corps would be responsible for them. The

* He must have meant that Capt. Howe (1st Siege Coy., R.A.R.E.) was responsible for the preparation of these bridges, and was the officer from whom they should take over, responsibility for their destruction having been definitely handed over to the XIX. Corps on the previous day.

XIX. Corps, however, were evidently a bit nervous about the bridges at Béthencourt which were three miles in rear of their exposed right flank, as at 12.15 p.m. on the 23rd they sent an officer to inspect them, but he reported on his return that they had been dealt with by the XVIII. Corps.

There were at Béthencourt five bridges, Nos. 56 and 57 side by side across the canal and Nos. 58–60 across branches of the river. The C.E. XVIII. Corps' list shows Nos. 59 and 60 completely destroyed by the 1st Siege Coy. at 12.30 a.m. on the night 22nd/23rd, and the remainder destroyed by the 20th Division during the morning of the 23rd, "girders cut, centre of bridge dropped into the water."

When, however, the 1st Cavalry Division took over the defence of the crossings from Béthencourt to Pargny (as described below) a report was received that the efforts to destroy the bridges at Béthencourt had not been entirely successful, and at about 2.30 p.m. Capt. B. C. Davey, 1st Field Squadron, was sent with a mounted party of his men and explosives carried on packs to complete their destruction. It was impossible to approach the river in this vicinity by daylight, but after waiting until dusk he reconnoitred the bridges over the canal on foot, and found that whereas No. 57 had been rendered useless for wheeled traffic, No. 56 was intact. This bridge consisted of a timber decking carried on four heavy R.S.J.s. A charge was placed on each R.S.J. close to the abutment, and the bridge was successfully destroyed.

XIX. Corps.

During the morning the XIX. Corps wired: "All concerned. All bridges may be destroyed at discretion of divisional commanders 50th, 24th, 1st Cav., according to circumstances and as soon as all troops have crossed. All such demolitions to be reported to Corps."

The bridges at Béthencourt, having been dealt with as described above, the most southern crossing of the Somme in the Corps area was between Falvy and Pargny. Here there were five bridges on a single road, numbered 61–65.

No. 61 was over the canal and the others in numerical order over branches of the river, No. 65 being close to Pargny.

Responsibility for ordering the destruction of these bridges had not been fixed on any individual commander.

On the morning of the 23rd the 24th Division was east of the river and about to retire across it. The 8th Division was arriving from Belgium and coming up to take over the defence of the west bank; their 1st Worcesters was on the march to Pargny, and two of their companies were to move east of the river to cover the retirement of the 72nd Infantry Brigade, which formed the rearguard of the 24th Division.

At noon the 1st Cavalry Division was made responsible for holding

the river from Béthencourt to Pargny, and its 9th Cavalry Brigade was detailed to hold the crossing at Pargny, pending the arrival of the 8th Division. The 19th Hussars were sent mounted across the river, reinforced later by the 8th Hussars, but before the arrival of the cavalry the two companies of the Worcesters were in position, and the crossing might have been considered safe.

The five bridges had been prepared for demolition by the 1st Siege Coy., R.A.R.E. (XVIII. Corps), whose demolition parties were still standing by to destroy them. The report of the C.E. XVIII. Corps states that the order* to blow up No. 65 came too late; that Nos. 64 and 63 were blown up at 2.30 p.m.; that the party at 62 were in danger of being cut off, and were ordered by Lieut.-Colonel Wyatt to leave that bridge and make sure of the destruction of the more important bridge over the canal (No. 61.)

The enemy reached the river south of Falvy, and the infantry had a bad time getting through the village. The acting G.O.C. 72nd Infantry Brigade had no authority to order the destruction of any of these bridges. He asked Serjt. Crossley, 1st Siege Coy., who was in charge of the demolition party on the canal bridge, what orders he had, and the reply was that he had none, so an orderly was sent to H.Q. 24th Division for instructions.

When the cavalry retired they found two of the bridges (Nos. 64 and 63)† destroyed: some of them rode north and crossed at Epenancourt, but those who persisted in attempting to cross by means of the wreckage at Falvy were forced to abandon their horses and scramble over as best they could. An attempt was made to swim the horses across, but they got bogged in the marshy ground on the east bank.

Serjt. Crossley had already been obliged to repair his leads, cut by the enemy's fire, and at 4.30 p.m., judging by the turmoil around him, and unable to get any orders, he blew up the canal bridge. For some reason, possibly because the charges had been loosened by the previous explosions, the demolition was not successful.

The 9th Cavalry Brigade had made Lieut. G. F. Baylay, 1st Field Squadron, responsible for the destruction of the bridge—apparently they were not aware that there had been five when they arrived. Lieut. Baylay, seeing that the canal bridge had been only partially destroyed, sent for more explosives, and with Corpl. S. Regester and six of his sappers laid fresh charges under heavy m.g. fire and set them off. Accompanied by his corporal, he went forward to see the result, which was satisfactory, but on his way back he was unfortunately killed by a m.g. bullet.

* It is impossible to say who dispatched this order: it was not Lt.-Col. Wyatt, acting G.O.C. 72nd Inf. Brig.

† According to Lieut. Paton, Adjt. 8th Hussars, and the diary of the 1st Field Squadron, the destruction of one of these bridges was due to a shell.

At 4.15 a.m., the O.C. 288th A.T. Coy. received orders from the C.R.E. XIX. Corps Troops to blow up all his bridges on the Omignon on the authority of Divisional Commanders. At 7 a.m. he left Serjt. Price in charge of the bridges at St. Christ, and went to relieve Lieut. Fogg at Monchy Lagache, where he found the situation very uncertain. At 10 a.m., as the infantry were retiring, he blew up the 60-ft. bridge, the girders being cut through. Going back to Devise, he was told by the C.O. of the infantry battalion there that the pile trestle road bridge, east of Devise, could be destroyed, and this was accomplished at 10.40 a.m. As the infantry were now falling back to the line Mons–Devise, charges were fixed on the bridge over the Omignon between these two places. They were ready by 11 a.m. when, as no infantry could be seen east of Devise, they were fired. The road bearers were cut and the trestles damaged, but the roadway was hardly affected, so that infantry could have walked over it in file. It was, however, set on fire with petrol and tar.

The bridges on the Athies–Fourques road were next tackled. The old wooden bridge was completely destroyed, but the class A girder bridge beside it, recently erected by the U.S. Engineers, was only shaken. At the first attempt the exploder failed to work, due, it was thought, to the pin of the ratchet wheel stripping. The charges were then set off with fuze, but the explosion on the timber bridge must have shaken them loose, as their effect was very slight. Lack of explosives prevented any further attempt being made to destroy this bridge. At 12.30 p.m., as it was not possible to get in touch with any H.Q., and all transport and guns had passed, the double bridge on the Athies–Ennemains road was successfully blown up.

The O.C. then went to St. Christ. North of the road across the River Somme and the canal there was a straggling chain of bridges about 100 yards long, evidently built to form a deviation when those on the main road were found destroyed in 1917. They were timber pile and trestle bridges for horse transport, and had for some time been in disuse. They were destroyed at 11 a.m. with gunpowder, tar and petrol. At 2 p.m. the bridges over the Omignon north of St. Christ (one wooden, one steel girders for tanks) were destroyed. A man could have clambered over the gaps made, but horses and wheeled transport could not have crossed.

At 3.45 p.m. the G.O.C. 149th Infantry Brigade (50th Division) gave orders for the bridges at St. Christ to be destroyed at once. The main road there crossed the canal and two branches of the river on steel girder bridges to carry tanks, which had just been completed by the U.S. Engineers. Those over the river were small and were demolished without trouble, but the debris of the girders and roadway practically filled up the gaps. A few minutes after their destruction a troop of riderless horses dashed down the road, and the three leaders were impaled on the broken steelwork of the first bridge they met.

Capt. Borns clambered across the debris lying in the two gaps, and dispatched them with his revolver.

The amount of explosives available did not suffice to make a complete job of the girder bridge over the canal, and it is recorded in the G.S. diary of the XIX. Corps that, at 10.19 a.m. on the 24th, the 8th Division reported that parties of the enemy had crossed the canal where the " concrete bridge " was intact. These parties had been driven back, but as the enemy were within 20 yards of the bridge it was impossible to fix further charges, and they proposed to bring up two 6-in. Newton mortars with a view to demolishing the bridge on the following morning, but during the day of the 25th the line of the river was lost. This " concrete bridge " must have been the remains of the partially destroyed girder bridge over the canal.*

On the Cologne the O.C. 281st A.T. Coy. visited Lieut. Mackenzie at Cartigny Mill, at 6 a.m. Here there were twin trestle bridges of 12-ft. span, and at 8 a.m., when the infantry were retiring from Buire (where the bridge had been demolished the previous night), an attempt was made to blow them up. Both the electrical and safety arrangements failed to ignite the charges, probably because these had become damp in the heavy ground mist of the previous evening. The attempt was made after the infantry had crossed, and the enemy's fire prevented any close examination being made as to the cause of failure. Capt. Kentish then withdrew his party to Flamicourt, blowing up on his way the bridge at Doingt at 11.15 a.m., when there was no traffic in sight, the last tank having passed at 10.50 a.m.

At Flamicourt there were two pairs of twin bridges on the causeway leading from the station to Péronne. Capt. Kentish blew up the pair nearer to Flamicourt at 3.45 p.m., the R.S.J. being cut and the abutments blown in. (For the other pair of bridges see VII. Corps.)

R.C.E.4 received no orders to prepare the railway bridge north-east of Roisel, which consequently was left intact, but he demolished one east of Tincourt.

The magnitude of the task of destroying the bridges at Brie will be realized from the diagram, but it is hard to understand why all of them had been kept available for use up to the last moment. The French had been anxious to reopen the Somme canal for barge traffic, and this accounts for the lifting bridge No. 13, the dismantling of No. 14, and the temporary nature of No. 15. For the purposes of demolition the bridges over each waterway were considered as a group, and were to go up simultaneously.

In the scheme of demolition it had been decided to avoid damaging the abutments of the bridges, so that, if a stand were made on the Somme, they could be more easily repaired for an advance. Also it

* The Directeur des Ponts et Chaussées, Amiens, assures me that there was never any concrete bridge at St. Christ.

had been intended that the first explosions should be effected as soon as the last of the guns and wheeled transport had crossed, as it was considered that the infantry of the rearguard would have little difficulty in scrambling over the debris. Capt. Fox* was sent to give the executive order for the destruction of the first (easternmost) group of bridges. There was a certain amount of shelling, but many of the shells fell on marshy ground and failed to explode.

Between 2 and 3 p.m. the enemy's gunners appear to have increased their range, and all was comparatively quiet when five tanks appeared in succession on the eastern bank intending to cross. The larger bridges consisted of 60-ft. " A " class lattice girders used as " through spans " and could carry tanks, but to cross a through span tanks had to take in their sponsons,† the dimensions being :—

Tank. Track, 8 ft. 3½ in.; width, including sponsons, 12 ft. 9 in.; without sponsons, same as track.
Bridge. Width: between curbs, 10 ft.; between girders, 11 ft. 9¾ in.

There was not time to do this, so the tanks had to be set on fire and abandoned.

After this there was a lull for some time, and the leads and charges were again inspected and found intact. At last, when all wheeled transport had long since gone by, Capt. Fox, through his field-glasses, observed Germans creeping upstream towards the bridges on the right bank of the river, and gave the order to fire the charges. At this moment an enemy aeroplane came along and traversed the bridges backwards and forwards, but apparently without much effect. Lieut. G. Begg, 239th A.T. Coy., who, with his men, had made all the preparations for the demolition of these bridges, promptly pressed the exploder hard down to send up the first group—but nothing happened. A second attempt was made with the same result. There was nothing to do but to try the exploder again, and this time the charges fired. At the remaining groups none of the charges failed to go off and the demolitions were completed by 4.30 p.m. The results are shown in tabular form on the diagram.‡ The C.R.E. 50th Division had sent Lieut. Reay and two sections, 447th Field Coy., to stand by in case assistance was required, but they were not wanted. The last two companies of the 4th Yorks under Lieut. Ginger, who had formed the rearguard, scrambled across the debris of the bridges.

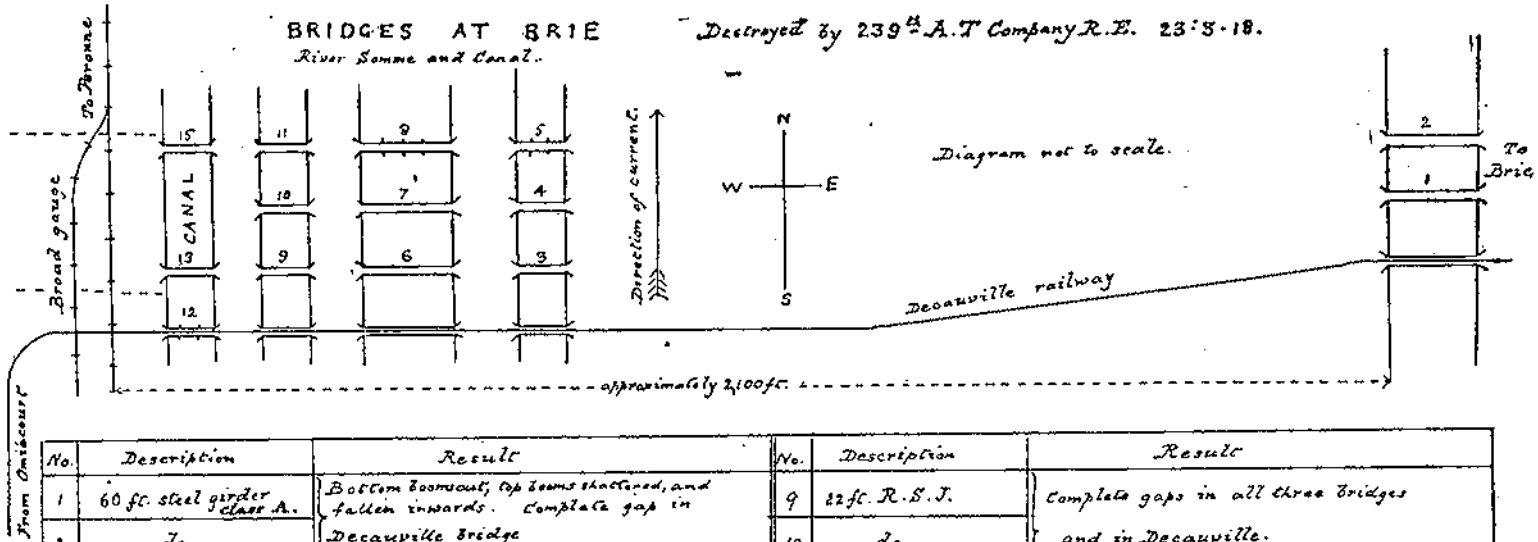
* Capt. Fox appears to have belonged to some divisional or brigade staff.

† In a " deck span " the girders are entirely beneath the roadway.

‡ A short time ago Capt. Adam met in Essen an officer of the German Pioneers, who informed him that he had been employed on the job of making a temporary crossing at Brie. He said that although the bridges had all been successfully demolished the distance for them to drop was so small that a temporary crossing was easily and rapidly made.

BRIDGES AT BRIE

Destroyed by 239th A.T. Company R.E. 23·5·18.



No.	Description	Result
1	60 ft. steel girder class A.	Bottom booms cut, top booms shattered, and fallen inwards. Complete gap in Decauville Bridge
2	do.	
3	22 ft R.S.J.	Complete gap in all three bridges and Decauville Bridge.
4	do.	
5	Timber trestle H.T.	
6	60 ft. steel girder class A.	Top and bottom booms completely cut, decking destroyed. Complete gap in Decauville.
7	do.	
8	Timber trestle H.T.	Complete gap.
9	22 ft. R.S.J.	Complete gaps in all three bridges and in Decauville.
10	do.	
11	do.	
12	Pile bridge.	Decauville. Complete gap.
13	Lifting Bridge. 22 ft R.S.J. on 12" x 12" piles.	Completely destroyed.
14	Dismantled.	
15	Temporary. 22 ft R.S.J. on crib piers	One girder completely shattered, one shattered and left hanging.

VII. Corps.

The position maps for this day show the boundary between the XIX. and VII. Corps as running from Tincourt, north of Péronne, to Biaches, whereas it had previously followed the line of the Cologne, but the VII. Corps seems to have kept the responsibility for the road bridges in Péronne.

On the 12th March, A.H.Q. wired VII. Corps, " Please arrange to prepare for demolition the road bridge Péronne–Flamicourt under the same conditions as those laid down for other road bridges in the battle zone." It will be noticed that only one bridge is referred to, whereas two pairs of bridges existed.

At 3 p.m., when all troops of the 16th and 39th Divisions* had passed through Péronne and crossed the river, and the enemy was only a few hundred yards away, the 180th T. Coy. started to destroy the bridges, working methodically from north to south. The town was being shelled and parts of it were in flames, but it was reported that in all cases complete destruction was achieved. In five cases the steel girders were cut and the abutments blown in : the remaining bridge and a culvert were completely destroyed and large craters formed.† The Bristol bridges at the south end of the Faubourg de Paris were blown up at 6 p.m., leaving a gap of 150 ft. The O.C. and his demolition parties got away along the south side of the canal and made for Suzanne. A small wooden bridge, which had been overlooked, was destroyed by Lieut. Hovey, 432nd Field Coy. (66th Division), the same evening.

Of the two pairs of bridges on the Péronne–Flamicourt causeway, the pair nearer to Péronne was blown up, the girders being cut and the abutments destroyed.‡

At about 8 a.m. the Corps Commander ordered the bridges over the Somme between Péronne and Cléry to be dealt with by the 39th Division. Orders were accordingly sent, through the C.R.E. 39th Division, to the 177th T. Coy., which was on the march from Bussu to Cléry and arrived there at 10 a.m., directing the O.C. to prepare the bridges across the Somme at Halle and Cléry for demolition. He was given schemes prepared a month earlier by officers of the 227th Field Coy. (39th Division), and told not to destroy the bridges unless (*a*) the enemy was seen approaching, or (*b*) the C.R.E. 39th Division issued written orders. Having obtained explosives from the 21st and 39th Divisions, he detailed Capt. Kennard to the three bridges (one canal, two river) at Halle, Capt. Dalgas to the four (one canal, three

* These divisions came from near Bussu. The 39th moved to the south bank of the canal between Biaches and Buscourt, and the 16th went into reserve south of Eclusier.

† There must be some mistake here. The list of C.E. VII. Corps gives, " Péronne moat. Bridge and abutments completely destroyed, and crater formed," but the report of the Fourth Army Bridging Officer states, " A reconnaissance of the Péronne crossings was made on 2.9.18, and it was found that the 60-ft. class A bridge across the moat (erected by the British in 1917) was still intact."

‡ The other pair was blown up by the 281st A.T. Coy. XIX. Corps.

river) on the Cléry–Omiécourt road, and Capt. Wright to the long trestle bridge over the river and marshes west of Cléry. Work started at 1 p.m.

At 6.30 p.m. the 17th Entrenching Battalion (VII. Corps) retired to the south bank of the river across the bridges at Halle, saying that they were in touch with the enemy, and at 7 p.m. a small party of Germans was observed south of Halle, so the charge on the canal bridge was fired. An enemy patrol looked on but did not interfere with the work. The girders were cut in the centre and the foundations of the trestle piers destroyed. Infantry might have been able to pass over the wreckage, but the crossing was commanded by a high bank on which a strong post was being prepared.

An anti-aircraft lorry had partially fallen through the centre of the large trestle bridge over the river, and this, having been fired, set the bridge alight. Two or three spans on the far side and one halfway across were demolished. The small wooden bridge over the river was also destroyed.

Meanwhile, parties of infantry moving south were crossing the Omiécourt–Cléry bridges under heavy m.g. fire. Charges had by now been placed, and at 9 p.m. the heavy plate-girder bridge over the canal, after two unsuccessful attempts, was cut close to the north pier and dropped into the water, and three small bridges were destroyed. One pair of the lock gates was rendered useless ; infantry could have crossed by the other pair, but they would have been under direct fire. The long trestle bridge west of Cléry was set on fire at 8.30 p.m.

It is, however, noted in the diary of the C.R.E. 39th Division for the 24th that three of the bridges over the Somme blown up by the 177th T. Coy. were not completely destroyed, so a party of the 225th Field Coy., under 2nd-Lieut. McLachlan, was sent out at dusk to improve matters.

The 221st A.T. Coy. marched from near Péronne to Cléry, where it arrived at 1.15 p.m., and Lieut. Johnstone was at once sent to Feuillerès with a detachment to blow up the two *ponts-levis* there over the canal. This he accomplished at 9.30 p.m. Lieut. Briscomb was sent with another party to Frise, where he was at work on the bridges for the next two days.

The 238th A.T. Coy. (at Maricourt) was ordered to prepare the bridges at Eclusier and Cappy. Farther to the north the 178th A.T. Coy. was responsible for the destruction of the bridges over the Tortille river, from Moislains inclusive down to the junction of the Tortille with the Somme. Their preparations for demolition had been completed before the 21st March, and all the necessary materials were on the site.

At No. 1 bridge in Moislains, on the road to Nurlu, 100 lb. of ammonal was buried in the roadway at each end, and fired at 11 a.m.,

completely destroying the bridge and blowing large craters in either bank.

At No. 2 bridge, in the centre of Moislains, 100 lb. of ammonal was similarly buried at one end, and 100 lb. guncotton at the other. The charges were fired at 11 a.m. and the bridge was lifted bodily from its foundations, two craters being formed in the road, each about 15 ft. in diameter.

No. 3 bridge, being close to No. 2, was blown up at 9.30 a.m., as soon as the last tank had got safely across. Here, in addition to 100 lb. of ammonal buried at each end, four charges, each of 25 lb. of guncotton, were placed under the main roadbearers. The bridge was totally destroyed and two craters of 15-ft. diameter formed.

The three bridges mentioned above were of timber and built during the war, with a roadway only a few feet above the water. In their case it was impossible to bury the charges deep enough to produce large craters, as water was met with a foot or two below ground level. Boxes five or six feet long, made of 9 in. x 3 in. planks nailed together, were buried at each end of the bridges some time previously to take the large charges, and when the order to demolish was received, the roadway was scraped away from the top of the boxes, the charges inserted and tamped with sandbags.

No. 4 bridge, by which the road to Bouchavesnes crossed the Tortille, had to be kept open to the last moment, and it was decided, therefore, instead of working with four charger boxes, to put in one single charge of 300 lb. of ammonal and 100 lb. of guncotton at one end of the bridge, thereby avoiding the danger of long leads across the bridge being cut by shells. This charge was set off at noon, one side of the bridge being lifted bodily from its foundations, the girders twisted and torn, and a large crater formed in the road.

No. 5 bridge, between Allaines and Haut Allaines, was a brick arch. A tunnel, 2 ft. x 2 ft., was driven behind the abutment at one end and charged with 200 lb. of ammonal, and two boxes each containing 50 lb. of ammonal were securely clamped into the brickwork at the centre of the arch. The charges were fired at noon and the arch was broken and the bridge rendered absolutely impassable, although the craters formed were smaller than had been anticipated.

No. 6 bridge, carrying the Allaines–Péronne road over the Tortille, was built of small steel girders resting on brick abutments. The charge in this case consisted of eight slabs of guncotton secured to each girder one foot from the abutment. It was fired at noon when the girders were completely cut through and the bridge fell into the river.

No. 7 bridge at Feuillaucourt, described as a bow bridge, crossed a bend of the Tortille south of the village on the Péronne road. A tunnel was driven behind one of the abutments and charged with 400 lb. of ammonal. This was touched off at 3 p.m. and the bridge

completely disappeared, leaving a large crater 60 ft. in diameter and 20 ft. deep. As the road was embanked at this spot the gap made in it was highly satisfactory.

At the demolition of this bridge safety fuze was used as all the exploders were in use elsewhere, and when it was thought that all traffic was over a fuze calculated to burn for five minutes was lighted. When the five minutes had almost expired a limber was seen approaching the bridge at full gallop. All attempts to stop the driver failed, which was just as well, as he managed to cross safely about fifteen seconds before the charges went off.

In addition to the preparation and demolition of the above-mentioned bridges, the 178th T. Coy. left the necessary explosives cached beside the lock gates at Buscourt and by the bridge over the canal north-west of Biaches, also petrol for setting alight the long trestle bridge west of Cléry. These stores proved useful to the 177th T. Coy. in their work described above.

It was impossible to prepare the small bridge on the Péronne–Cléry road north of Halle owing to continuous traffic passing over it.

The preparation and demolition of the railway bridges at Péronne and Marchélepot can best be told here in one story, though the latter place was in the XIX. Corps area.

Capt. R. Maclean, commanding the 260th Railway Construction Coy., in camp at Doingt (later at La Chapellette), had been warned by R.C.E.4 that, in the event of a retirement, he would be responsible for the demolition of bridges on his section of the railway, which extended from Chaulnes to Péronne–Flamicourt junction inclusive. He surveyed the bridges, all of which were our replacements of those destroyed by the Germans during their retreat in 1917, and indented on R.C.E.4 for explosives.

The line having first been put through as a single track and subsequently doubled, there were two separate bridges over each gap. Those over Flamicourt Water, west of the station, were single spans of pitch pine, resting at one end on an original abutment and at the other on a sleeper crib pier. Over the River Somme there were timber trestle bridges, one of four, the other of five, bents of piles, and over the canal, close to La Chapellette station, two similar bridges each of 18 bents. The span between bents was usually 16 ft., and each of the two stringers consisted of two pieces of 20 in. x 10 in. pitch pine on edge, bolted together. The civilian railway engineers of the Chemin de Fer du Nord had for some time past been working on the permanent reconstruction of these bridges, and a new steel lattice girder bridge of French manufacture, single track and over 100 metres in length, was lying close to the bank of the canal ready to be launched across it.

Arrangements were made to cut the stringers and piles, and, where

abutments existed, shafts were sunk between and outside the two tracks, and a gallery driven close behind the abutment. The charges were calculated, with 100 per cent. for contingencies, and kept in dug-outs made for the purpose close to each bridge. As the company had no men trained in demolition work, those employed in making the preparations were given a very brief course of instruction in the handling of explosives, using wooden models. The timber of the bridges was saturated with petrol, so that in last resource they might be burnt. The charges on the bridges over Flamicourt Water were to be exploded by means of safety fuze, the remainder electrically.

Capt. Maclean was told that the charges were not to be laid until he received an order direct from the VII. Corps,* after which the order to fire them would be sent by the Corps to the officer in charge of the demolitions at the prearranged rendezvous at Péronne-Flamicourt station.

The preparations up to the point of charging, were ready by the evening of the 21st March. At 1 p.m., on the 22nd, Lieut. Butler, one of R.C.E.4's officers, called at the camp and said that he had been to VII. Corps H.Q. to see whether the arrangements were thoroughly understood, but had been told there that these railway bridges were outside Corps jurisdiction, and that the Army would give the necessary orders. On calling up R.C.E.4 on the telephone, Capt. Maclean was advised that orders would come through the Army, but that the bridges were of such importance that they would not be destroyed until the last moment.

The amount of traffic passing west along the roads, and the information gleaned by Capt. Maclean from stragglers, caused him considerable alarm, but it was not until 8 p.m. that orders came from R.C.E.4's adjutant that the charges were to be laid, and a party of 2 N.C.O's and 10 men, under 2nd-Lieut. Spilsbury, was sent off from La Chapellette at 9 p.m. to place them in position. Before 6 a.m. next morning (23rd March) Capt. Maclean inspected the preparations, and then left to organize the move of his company to Omiécourt (Chaulnes), leaving 2nd-Lieut. Spilsbury on the bridges.

The charges were in position early in the forenoon. At 2 p.m., the enemy, who had been shelling the station intermittently since dawn, were seen advancing over the ridge N.E. and E. of Péronne, and machine-gun bullets were falling in the yard and on the track, so 2nd-Lieut. Spilsbury decided that, in default of orders,† he had better get busy with his demolitions. Whilst he destroyed the water tank

* The original boundary between XIX. and VII. Corps followed the course of the Cologne through Peronne.

† The wire sent by VII. Corps to R.C.E.4 and O.C. 119th Railway Construction Coy. at 8.30 a.m. on the 23rd does not appear to have reached 2nd-Lieut. Spilsbury. It ran, "Please arrange that an officer is detailed to be at each of the railway bridges prepared for demolition ready to demolish it at a few minutes notice at his own discretion on the close approach of the enemy." Possibly Lieut. Butler had left Corps H.Q. before 8.30 a.m.

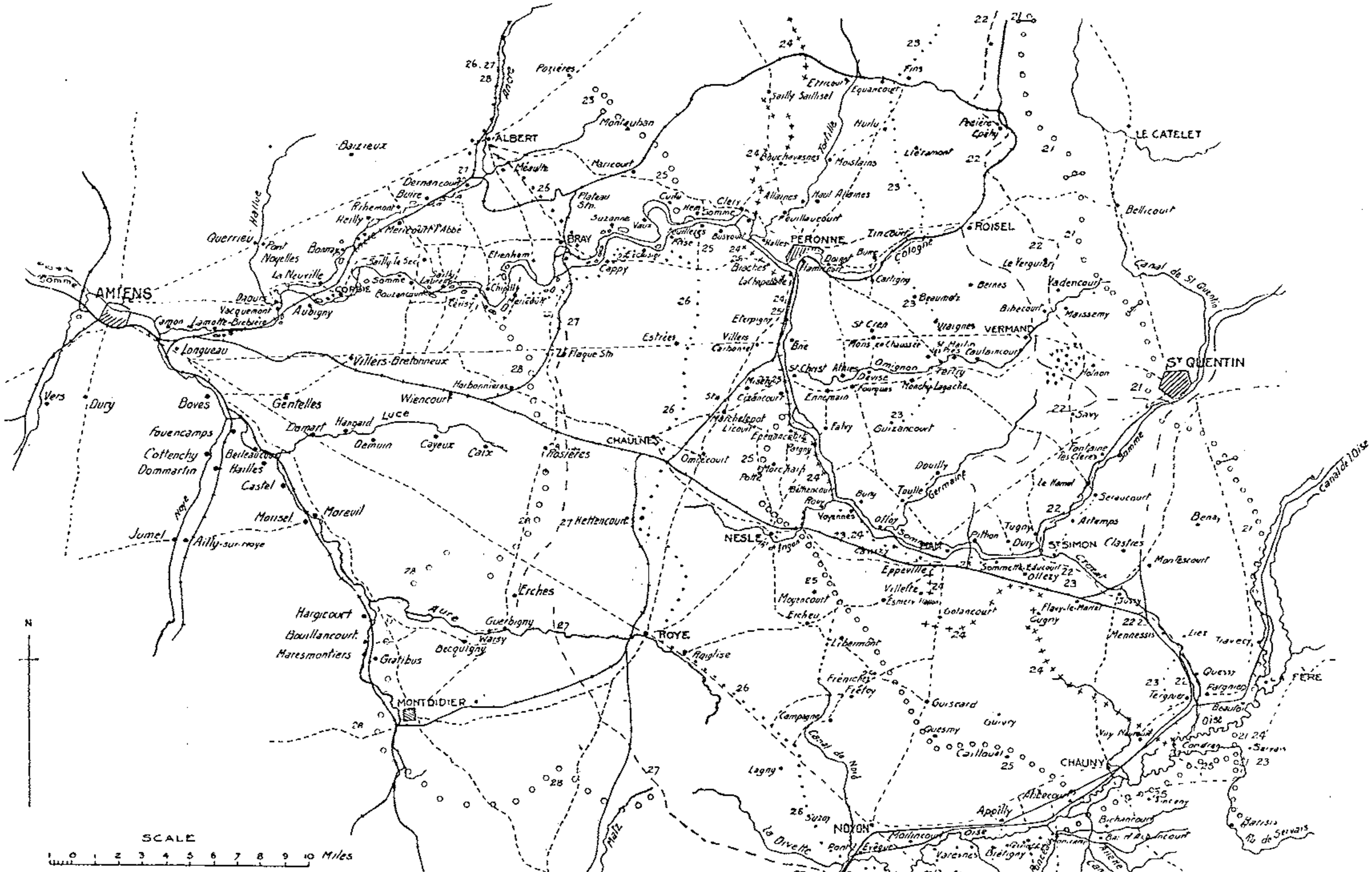
in the station yard, Serjt. Goddard and the rest of the party completed the final arrangements on the bridges. First the bridges over Flamicourt Water were dealt with, the stringers and the old abutment being successfully blown up and the wreckage set on fire. The charges on the bridges over the river were next exploded, but they were more effective on one track than on the other. To repair these river bridges new piles would have been necessary. The new French bridge was then rendered useless, the upper and lower chords and the diagonal bracing being cut. Finally, when the enemy was getting close, the canal bridges were blown up. The piles under the up road were completely destroyed and the bridge left burning. On the down line the demolition party was driven off by m.g. fire before all the charges were connected up, so the result was not so successful. This bridge was rendered useless for traffic and set on fire, but did not burn satisfactorily.

It was now impossible to get along the track to Eterpigny, so an unimportant culvert there was left intact. The destruction of the brick arch bridge, one mile south-east of Villers Carbonnel, known as the Misery Bridge, was not attempted for lack of time and men. This bridge had been left standing by the Germans in 1917. 2nd-Lieut. Spilsbury and his party made their way across country through Estrées to rejoin their company.

Later in the day, when the 431st Field Coy. (66th Division) was at Barleux, Lieut. Hovey was sent to inspect the destroyed road and railway bridges in Péronne, and reported that they had been adequately destroyed, but evidently it was considered that more might be done on one of the canal railway bridges, which was not burning well. During the night 23rd/24th, Lieut. Derbyshire, with No. 1 Section of the same company, was dispatched with explosives to increase the destruction, but as he passed through the infantry outpost covering the bridge, an enemy bomb fell and destroyed all his detonators. He succeeded, however, in sawing through the main timbers which still remained sound, and "sprayed oil to keep the bridge alight."

At 4 p.m. on the 23rd, the O.C. 260th Coy., now at Omiécourt, got orders from R.C.E.4 to blow up the railway bridges north and south of Marchélepot station. Having no more explosives he drew a supply from No. 6 R.E. Park at Omiécourt, and sent Capt. L. G. Allison, with Serjt. Field and 9 Sappers, to carry out the demolitions. Capt. Allison, on arrival at Marchélepot, found the station yard in use as two C.C.S. were being evacuated by train, so that the bridge south of the station could not well be destroyed at the moment. The traffic, guns and transport, under the bridge north of the station, was so congested that to destroy it would be fatal. He reported this to his C.O. at Omiécourt, and the information was repeated to R.C.E.4 at La Flaque. The reply, given by the adjutant, was that the

DEMOLITIONS, FIFTH ARMY, 1918.



Numbers 21, 22 etc give the positions at dawn on these dates
Corps Boundaries

demolition of the bridges was to be delayed. Capt. Allison broke up the track north of the station in 19 different places over a distance of 2½ kilos, and went back at Omiécourt. Orders then came from R.C.E.4 that he and his detachment were to remain there with 2nd-Lieut. Barclay and a party of the 119th Railway Construction Coy. to clear the yards, and to destroy the bridges at Marchélepot as soon as all traffic had passed.

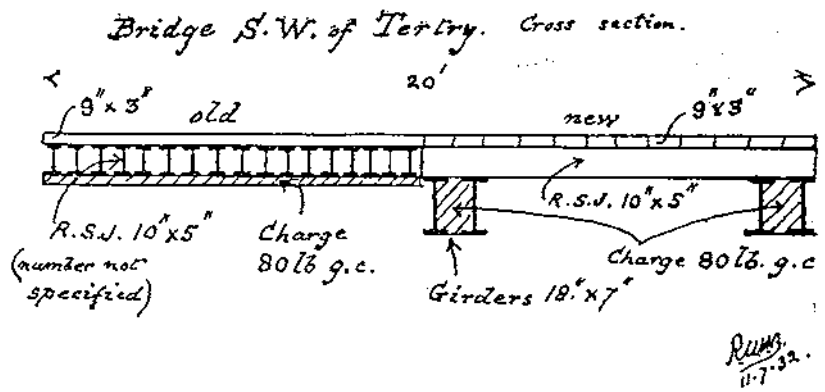
The two bridges north and south of the station were steel plate girders erected after the German retreat in 1917. Charges well in excess of requirements were laid, and Capt. Allison stood by with his men all night, being relieved by 2nd-Lieut. Barclay and his party at 7.15 a.m. on the 24th. It was very difficult for Capt. Allison to get any information regarding the situation. At No. 6 R.E. Park he found a demolition party standing by to destroy it, which they did at 11.20 a.m. At 12.30 p.m. he visited the H.Q. of a group of heavies in action in rear of Chaulnes village, and learnt that, in reply to an S.O.S., they were firing on Licourt (only two miles S.E. of Marchélepot), which the enemy had entered.* He immediately sent a runner to 2nd-Lieut. Barclay to tell him to blow up the bridges at once, and they were successfully destroyed at 1.45 and 2.15 p.m.

(To be continued.)

APPENDIX.

Bridge South-West of Tertry.

The new portion of this bridge had just been completed and was designed to carry heavy guns (one account says tanks). The charges were to be fired electrically and separately—the reason for this is not obvious. At 3 p.m. some guns crossed in a south-easterly direction and came into action : at 5 p.m. all traffic ceased. At 7 p.m. the R.A. sent word that they had orders to retire south so would not require the bridge, and the demolition was successfully carried out.



* The order to fire on Licourt must have been given in error, as the map for dawn on the 24th shows the line of the Somme as being held on the whole of the Corps front from Biaches to Béthencourt.

THE ST. LAWRENCE DEEP WATERWAY.

A Lecture delivered at the S.M.E., on 3rd November, 1932, *by* SIR ALEXANDER GIBB, G.B.E., C.B., M.INST.C.E., F.R.S.E.

WHEN, some months ago, I was honoured by an invitation to address you, I was at first rather at a loss to know what subject to select. I decided eventually to take the great scheme known as the St. Lawrence Deep Waterway Project, because in this country, it is, I think, but imperfectly realized what is really comprised in that scheme, whether from the engineering, economic, traffic or political points of view. In Canada and the United States it has generated a great amount of controversy and heat—not unjustifiably, seeing the great issues that are involved. But here, though by no means unaffected, we scarcely pay it the tribute of even academic interest.

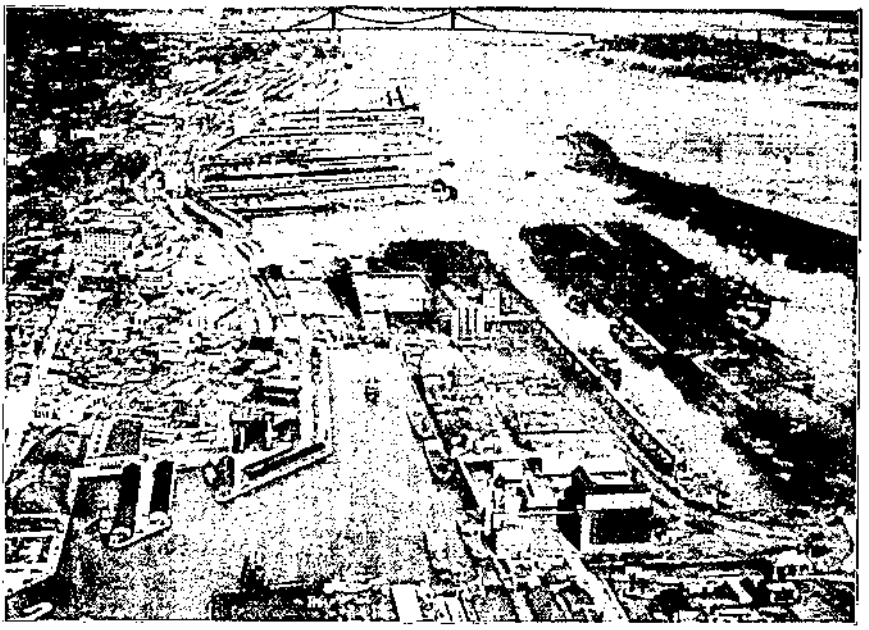
So far as I, myself, am concerned, I have for years followed the development of the project, and having during the last eighteen months had the duty of advising the Dominion Government on its national ports, I became closely concerned in certain aspects of it.

There are some preliminary points in regard to questions of transport in Canada to which I would draw your attention. There may be little new in them to you and, in fact, they are obvious enough if you study the matter ; but they are often overlooked in considering traffic problems in Canada, even by many Canadians. In the first place, then, if one excludes the northern coasts, where in the whole length there is only one port, Port Churchill, Canada has an exceedingly limited coastline compared with its area. It is about 5,500 miles for about 2,250,000 square miles of definitely usable area, as compared with 5,300 miles for Great Britain with an area about one-eighteenth that of Canada.

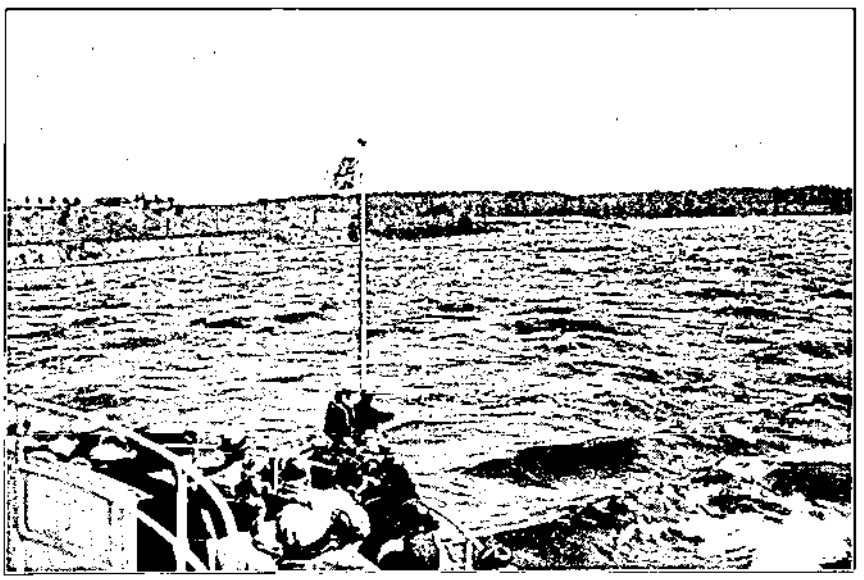
Moreover, the average distance that the exports and imports of Canada have to travel on their way to and from the seaboard is something like 500 miles, as compared with about 50 miles in Great Britain. The centres of population and industry in Canada are not sited at or near the seaboard, as is very largely so even in the United States, but many hundreds of miles inland. The origin of the principal exports of Canada, on which her economic structure will be mainly based for many years—that is, farm produce, and particularly wheat—is situated in the very centre of the continent from 1,000 to 2,000 miles from the open sea.

Further, I want you to realize how Canada stretches round nearly

THE ST. LAWRENCE DEEP WATERWAY.



1.—Port of Montreal—looking over the river.



2.—St. Lawrence Rapids

3.—Montreal. Ice conditions, showing ice shove in the springtime.
Photograph by S. J. Hayward, Montreal.

4.—Ice conditions in the St. Lawrence—near Quebec.

The St Lawrence deep waterway 3-4.

one-quarter of the globe. In these high latitudes the effect of the earth's shape is more marked. The ordinary map is misleading in this respect, even to those fully aware of the facts. The latitude of London is about the latitude of the entrance to Belle Isle Strait, but the shortest route between the two places lies some hundreds of miles north of the line of latitude — and this is the steamship route by what is called Great Circle navigation. This fact affects all questions of traffic routing in Canada, as on the Atlantic. It is this that economically puts Montreal on the map in competition with the United States Atlantic ports.

And here there is another fact of which I would remind you, and that is from Lake Ontario to the sea, the St. Lawrence—contrary to the general vague impression—runs far more northerly than eastwards and the coast of the United States almost exactly parallels it; so that for the more populous parts of Canada, for those areas of Canada where industry is mostly located, for the great fruit-growing country of the Niagara Peninsula, the nearest route to the sea is not to any Canadian port, but to one or other of the ports of Maine, New Hampshire, and the other New England States.

Before the opening of the Panama Canal, and before Canada's discovery of the markets of China and Japan in the East, Canada, so far as its overseas traffic was concerned, looked eastward to Europe, and the only traffic route she knew was by the Atlantic. Since the opening of the Canal, Vancouver, with which I include the Fraser River port of New Westminster, has come rapidly into the picture. It is already one of the greatest grain-shipping ports of the world, as New Westminster is one of the greatest timber-exporting places. At the present time, assisted by abnormally low freight rates, it is possible, in spite of Panama Canal dues and the much greater length of voyage, for Vancouver to operate effectively and economically as the logical grain-shipping port to Europe for about one-third of the whole grain-producing area of Canada. The line of division varies; but roughly one may say that somewhere about Swift Current or Moose Jaw, *i.e.*, somewhat west of the centre of Saskatchewan, is the watershed, or perhaps I should call it the "grainshed," westward of which the grain flows to Vancouver, and eastward of which it still finds its way to the Atlantic.

In such a rapidly developing country as Canada it is not to be imagined that anything like finality has yet been reached in regard to traffic routes. They are always experimenting. The incessant urge to cheapen the cost of transport, owing primarily to the hard facts that agricultural products cannot bear high transport costs, and that Canadian grain is produced so much farther from the sea than in rival grain-growing countries, has stimulated the search for still cheaper routes than those in present use. As a rival to Vancouver, the port of Prince Rupert, nearly 500 miles farther north,

was built at considerable expense as the ocean terminus of the costly and unfortunate extension of the Grand Trunk to the Pacific. It is a fact, though you would not think it from the map, that from Prince Rupert to, say, Yokohama or Shanghai, is some 480 miles shorter, a day and a half's steaming, than from Vancouver; and if distance were the only consideration Prince Rupert would seriously threaten Vancouver. Again, after a generation of agitation and propaganda, a port—Port Churchill—has been established on Hudson Bay, served by a railway, the last 100 miles of which is virtually built on ice, by which the combined rail and water route from Saskatoon to Liverpool is over 650 miles shorter than *via* Montreal.

A great deal has been said, and will still be said, about these experiments. I have not the time to discuss them in detail to-night, and anyhow they are controversial matters. I instance them as showing the effective influences that can be brought to bear by such powers in the land as the farming and grain interests of Canada. With this demand, incidentally, for cheap transport at all cost, there exists an equally strong demand in other directions that Canadian imports and exports should follow Canadian traffic routes only, and so benefit Canadian and not foreign carriers. Obviously the two policies are often conflicting, but I will not pursue the matter.

I have indicated some of the factors that, coupled with climatic conditions, make so difficult the problems of transport and traffic routing in Canada; and it is only with these facts in one's mind that one can get the Canadian point of view in regard to such a project as the St. Lawrence Deep Waterway.

The growth of the St. Lawrence as a route for ocean vessels has been a striking sign, as it has been one of the principal means, of the great expansion of Canada. Quebec has been a seaport for about 250 or more years, but 100 years ago the voyage between Quebec and Montreal was a perilous one. Downstream it involved the negotiation of various rapids and shallows, with a limiting depth of a few feet. With the aid of a river flowing often at three or four knots, the journey might be compassed, provided one survived the various hazards, in two or three days. But upstream the general method of progression was by being towed, and the voyage, even with lightened boats, might take a fortnight.

Now, Montreal is one of the principal ports in the world. It stands at the head of a waterway navigable by ocean steamers for 1,000 miles from the sea. It stands, too, on the other side, as the ocean gateway of an inland water system extending over 1,000 miles farther into the heart of the continent. It is a great place of transfer between ocean and inland water vessels, a city of a million inhabitants and many industries, the largest grain-shipping ocean port in the world and one of the greatest traffic centres (Photo 1).

All this has been secured only by much expenditure of thought

and money, and by the vision and courage of those who mapped out and have carried through the great programme of dredging and improvement which has now been in progress in the St. Lawrence for nearly ninety years, and which is still going on. Some heavy work has been required below Quebec, but the great bulk of the dredging and improvement has been above Quebec, making the ocean route to Montreal. The whole length thus artificially deepened or improved is known as the "St. Lawrence Ship Channel." It is nearly 200 miles long, and will, when completed next year or thereabouts, have a minimum width of 1,000 feet. It is buoyed and lighted by the most complete and ingenious system of aids to navigation that I have seen anywhere; and though, of course, navigating officers always prefer the open sea to sailing in confined land-locked waters, yet the St. Lawrence Ship Channel has a remarkably clean history in spite of the severity of the natural conditions that sometimes are experienced.

Above Montreal are the 180 miles of the Upper St. Lawrence, and then the Great Lakes. One is inclined to take the Great Lakes for granted without realizing how remarkable this wonderful inland sea really is. The combined shore length of the five Great Lakes is about 5,400 miles and they have an area of nearly 100,000 square miles. On their coasts are a whole series of ports, each of which deals with a tonnage of shipping and traffic equal to the figures of all but a very few of the well-known ports in the world. On the lakes plies an immense fleet of vessels; in fact, no less than 4½% of the total world tonnage is on a water area not half that of the Black Sea. The United States' lake tonnage is one-fifth of the total United States' tonnage.

In providing the cheapest means of transport for the grain of the prairies and the Middle-West States, for the ore of the mines at Missabe, etc., for the coal of Pennsylvania, etc., for the manufactured articles and products of Detroit, Chicago, Milwaukee, Cleveland, Hamilton, Toronto, and serving directly or indirectly a population of nearly 50,000,000, the Great Lakes are a dominating factor in the economic structure of both Canada and the United States, and the system of traffic on them is one of the most remarkable developments in the world.

This result has not been secured without considerable engineering works. The elevations of the five Great Lakes vary considerably. The normal elevation above sea-level of Lake Superior is 602·29; Lakes Michigan and Huron are 581·13; Lake Erie is 572·52; and Lake Ontario, below Niagara, 246·17. Obviously, without artificial works, there could be no through navigation. Between Lake Superior and Lake Huron is the narrow connecting link, some 60 miles long, known as the St. Mary's River, with the twin cities of Sault Ste. Marie, Ontario, and Sault Ste. Marie, Michigan, on either

side. Colloquially the passage is referred to as the "Soo." Very considerable deepening has been necessary throughout its length and it has been necessary to deal with the rapids, known as St. Mary's Falls, where the level drops about 20 feet in 1½ miles. Extensive works have been carried out here, the earliest being done by Canada, and later a more direct artificial route being provided by the United States. There are now three parallel waterways here and the annual traffic in the seven or eight months of season has amounted to a record tonnage of 92,000,000 tons.

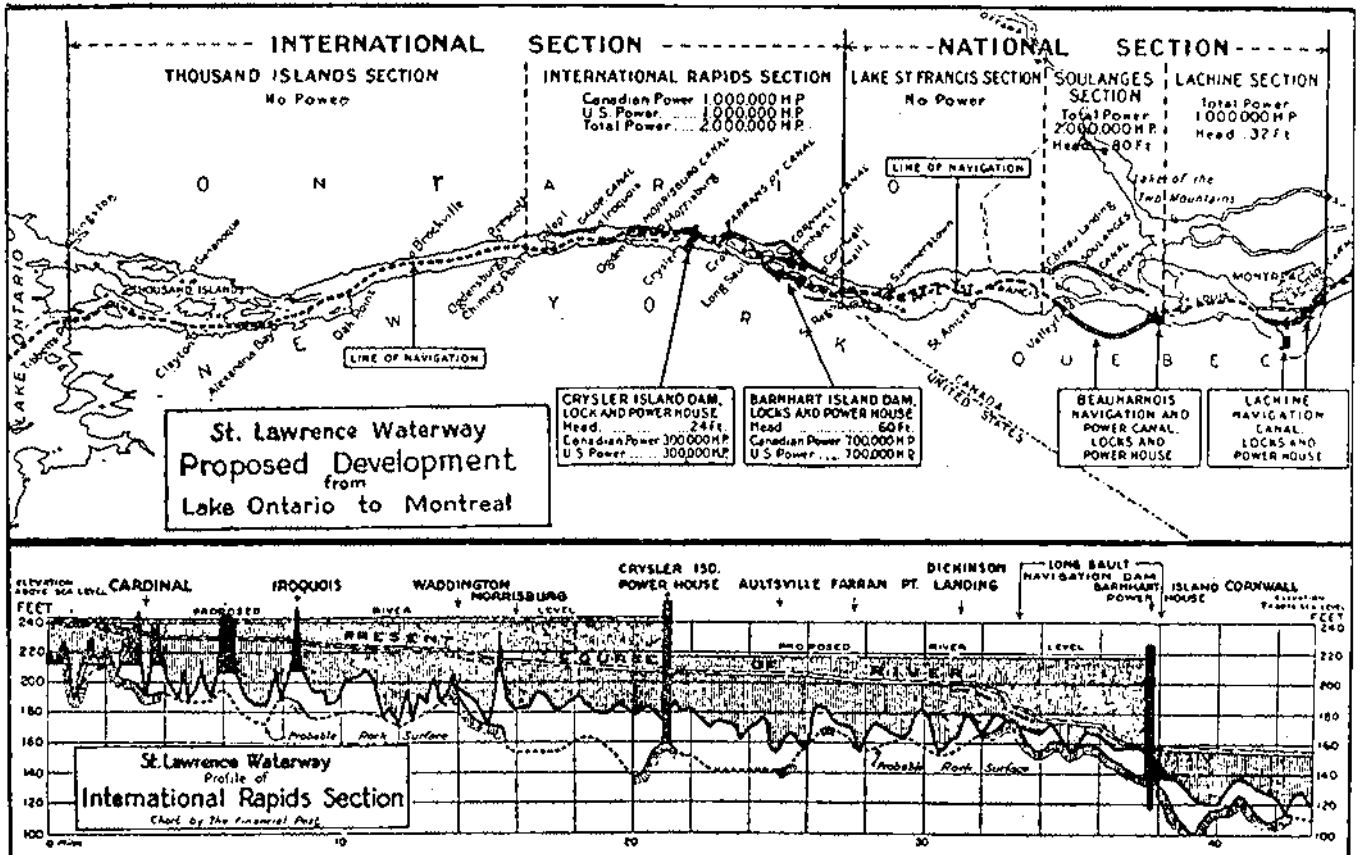
Between Lake Huron and Lake Erie is the section comprising the River St. Clair, with the Huron Rapids, Lake St. Clair, and the Detroit River, throughout which length a great amount of deepening and regulation has been necessary.

Between Lake Erie and Lake Ontario are the Niagara Falls, to circumvent which was constructed many years ago the old Welland Canal and now has just been completed the great Welland Ship Canal, the two together having cost some £32,000,000.

The engineering works carried out on the lakes have partly been carried out by the United States and partly by Canada. At the "Soo," as I have already mentioned, both Canada and the United States have been concerned in the expenditure of some £6,500,000 to date, the heavier work being at the expense of the United States. The Welland Canals are wholly Canadian, the St. Clair works American. By agreement, however, between the two countries, all canals and locks are free; no charge is made on vessels using the Great Lakes, nor is there any discrimination as between the vessel of one country or the other, except that, under the Coastal Carrying Acts of the two countries, it is not permitted for a vessel of one country to carry goods between any two ports of the other country.

The maximum size of lake vessel possible under present conditions is governed by the state of affairs at the "Soo" and St. Clair. Except in an abnormally low level of the water, a draught of 19 feet, a length of about 650 feet and a breadth of 70 feet is now available. The general improvements now being carried out, irrespective of the Deep Waterway scheme as a whole, will give 24 feet at the "Soo," and, I understand, also at St. Clair. The capacity of the Welland Canal is considerably in excess of this, already permitting navigation by vessels with a draught of 25 feet, a length of 820 feet and a beam of 80 feet. The locks have, moreover, been designed for eventual deepening, another 5 feet. The Welland Ship Canal was formally opened in 1932, and Lake Ontario was thus thrown open to the largest type of lake vessel, which before that had had to tranship at one or other of the Canadian or United States ports above Niagara, of which Buffalo is the greatest. The Welland Ship Canal has only eight locks compared with twenty-seven in the old Welland.

The Great Lakes are thus now of approximately equal carrying



St. Lawrence Waterway. Profile of International Rapids Section. Proposed development from Lake Ontario to Montreal.

capacity, but the large lake boats still cannot reach Montreal. From the foot of Lake Ontario, where the St. Lawrence issues, to Montreal there is a drop in level of approximately 226 feet, an average gradient, if it were equally spread over the whole length, of only 1 in 4,200, but actually concentrated into three series of rapids. At the present time the very considerable traffic over this length is carried by a smaller type of canal vessel of average dimensions of 14 feet draught, 250 feet length and 43 feet breadth, the rapids being by-passed by means of a number of canals, the Lachine, just above Montreal, the Soulanges, and the group of small canals between Lake St. Francis and Prescott, making in all some twenty locks.

The objective of the St. Lawrence Deep Waterway is to open the entire length of the system of inland water navigation from Montreal to the head of the Lakes to navigation of a standard such as that provided by the new Welland Ship Canal.

By treaty which has been signed by the United States and Canada, but which still remains to be ratified by the legislatures of each country, the Deep Waterway has to be carried out jointly, but the cost of the work yet to be done has been apportioned after each side has been given credit for the expenditure it has already incurred. With the heavy cost of the Welland to its credit, Canada has much the smaller share of the future burden.

The principal new engineering works involved are the construction of the three full-sized canals on the St. Lawrence, and the deepening of the St. Clair and "Soo" sections. The total estimated cost of these new navigation works is approximately £35,000,000 which, added to the £43,000,000 which has already been spent, makes a total of nearly £80,000,000 for the 27 feet depth and for the 30 feet depth of about £100,000,000.

Since traffic pays no tolls on the lakes or canals, the justification for the expenditure of such large sums on the construction of artificial waterways is to be looked for in the general benefit to the country in the reduction in transport costs. So far as the Canadian wheat-growing districts are concerned, the enthusiasm for these canal and water developments has perhaps been to some extent lessened by the establishment of Manitoba's Hudson Bay Port, and the growth of Vancouver. On the other hand, the American Middle-West farmer is still very vociferous in his demands for cheaper water transport, and it is perhaps not unconnected with this reason that Mr. Hoover has shown such a particular interest in the St. Lawrence project. The manufacturing cities on the Great Lakes have also strong views as to the advantages that they expect to accrue to them when the Lakes are thrown open to ocean ships. Some enthusiasts in Toronto already see their city a great ocean port, as soon as ever the Deep Waterway is completed; and a good deal is heard, off and on, of the benefits that might accrue to Chicago when her enormous output

of canned goods and such products can be dispatched direct to overseas markets without any re-handling.

I will return later to the examination of the effect on traffic routing that the Deep Waterway may be expected to have, and will turn now for a few minutes to consideration of what is at bottom, I suspect, the basis and reason for the project; and that is the immense power resources that exist yet undeveloped in the length of the St. Lawrence. One is often inclined, in thinking of hydro-electric developments, to visualize sites such as the Niagara Falls, the Victoria Falls on the Zambesi, or the Kaietur Falls in British Guiana. But while all hydro-electric development depends on the head of water available that is by no means the principal question. The Victoria Falls Power Company has still found it more profitable to produce some of the cheapest electricity in the world from coal close beside its principal market in the Transvaal, instead of developing the Falls, however spectacular. What one particularly requires in a hydro-electric scheme is volume and permanence of supply. The St. Lawrence has a watershed of 503,000 square miles. It draws on the whole volume of the Great Lakes. Its mean discharge over 66 years has been found to be 246,000 cusecs; the maximum average in any one month being 318,000 and the minimum 174,000. This is an extraordinarily small variation, and only equalled in hydro-electric works where extensive artificial regulation is involved. With such a volume available, no spectacular fall of water is required. There are, in fact, no falls on the St. Lawrence; only rapids, and these of such a nature that they are quite easily navigable downstream.

Photo No. 2 was taken from the well-known pleasure-steamer that during the summer daily runs the whole length of this part of the St. Lawrence. It traverses the rapids without either danger or difficulty.

You may then be surprised to learn that the three series of rapids on the St. Lawrence, none of which is different from the portion shown in the photo, contain potential power estimated at about 5,000,000 h.p. It is the development of this unexploited source of power that is the chief reason for the intense United States interest in the project and for which another £110,000,000 is to be put up, very largely by the United States. On the right bank of the St. Lawrence are the populous manufacturing New England States, and they are ill-supplied with cheap power—a fact which they feel to be a serious handicap. They are many of them not seized with the traffic point of view—but they must have cheap power.

Page 221 shows diagrammatically the sections of the St. Lawrence, in which the developments of power will be:—

The top section, known as the "International Section," where the boundary between Canada and the United States lies in the river-bed, will provide 2,000,000 h.p. Its development requires the

co-operation of the two countries. Below that the river runs wholly in Canada, and, incidentally, in the Province of Quebec; and while navigation under existing treaties on the St. Lawrence is open to U.S. vessels without let or bar, the development of the power is a domestic matter for Canada. Actually what will, in fact, be the first section of the development of the St. Lawrence has already been carried out, in the Beauharnois Hydro-electric Scheme, which has just started operation at the second series of rapids, namely, the Soulanges Section, where the ultimate capacity is also 2,000,000 h.p. This project was set on foot by a private company but has recently been taken over by the Dominion Government. The new canal will eventually take the entire flow of the St. Lawrence and provide facilities for navigation equal to the designed capacity of the Welland.

The last section, just above Montreal, is also in Quebec Province, and will produce about 1,000,000 h.p.

The development of 5,000,000 h.p., at a cost of about £21 per h.p., is sound business, but the value of the power is not sufficient in itself to cover the whole cost of the St. Lawrence Deep Waterway, as was at one time often stated. It can afford, however, to contribute indirectly, if not directly, to the excessive burden of the navigation works, and this has been the conclusive factor in the long-drawn-out arguments which have been so hotly debated in Canada during this generation.

Incidentally, it is, perhaps, this question of power that may provide the principal difficulty so far as Canada is concerned. For the Province of Quebec has peculiar and exceptional rights and privileges in Canada, dating back to the old French "Crown and seignorial" rights. Quebec claims the power rights in the St. Lawrence within its boundaries, and is not willing to waive its right. Still less is Quebec agreeable to the export of power, that is to say, the selling of hydro-electric power developed in Canada to consumers in the United States—which is the principal object of the U.S. advocates; for power once exported becomes, by the creation of vested interests, a permanent alienation of the country's resources. Since Quebec has immense stores of power itself, and is neither in want of, nor capable of, immediately utilizing the St. Lawrence power, Quebec has perhaps less interest in the St. Lawrence development than the other parties affected; and the cautious mind of Quebec is alarmed at the possible effect on the country's finances of the heavy financial commitments that the project involves. The threats to the port of Montreal and the railways have probably considerable influence, too, on the Quebec outlook. However, this is a matter which the Canadian people will settle between themselves with their usual good sense.

The real interest in the St. Lawrence Deep Waterway lies, to my mind, not in the question of power, nor in the possible political reper-

cussions, but in the effect that it may have on Canadian transport and traffic problems. I have hinted at some of the aspirations of the Great Lake cities. The hopes of some of these advocates are as exaggerated as the fears on the other side are often groundless. The Deep Waterway means, to some, a future of immense expansion for such cities as Chicago and Toronto. Some hold that it spells disaster and ruin to the port of Montreal; others, again, that it is that port's only salvation. Many Americans say that the results will be to place in the hands of Canada the carriage of the whole output of the Middle West. On the other side, it is equally vehemently stated that the all-Canadian St. Lawrence route will be killed, and its traffic permanently diverted through the United States.

Let us consider some of the possibilities.

First note once more on the map the position of Montreal and the Atlantic Coast. Observe the much greater distance from the sources of traffic of the Canadian winter ports of Halifax, Saint John and Sydney, than the United States all-year ports from Baltimore to Portland; and how, even to get to Saint John, the most favourably situated of the Canadian winter ports, the shortest route of travel is *via* Maine.

The plates show the real St. Lawrence Deep Waterway area. Now what is the project going to secure and effect? In the first place it is suggested, as I have said, that the ordinary ocean-going cargo vessel will no longer stop at Montreal, but will go right through into Lake Ontario, Lake Erie, Lake Michigan and Chicago and right up to Duluth-Superior and Fort William. British coal and anthracite will be delivered at Fort William or Superior and direct return cargoes of grain taken on board for Europe on an extensive scale, and to the demoralization of the existing grain routes. The canned goods of Chicago, Canadian cheddars, Niagara apples, are to go by ocean-steamer, without the transfer at Montreal; similarly the exports of Windsor and Detroit. The enthusiasts see the addition of 5,400 miles to the Atlantic seaboard; Fort William an Atlantic port; they reckon by simple mathematics great savings in the cost of carriage of wheat, coal, ore, manufactured articles, and every import and export, to the obvious and immense benefit of the whole continent.

All this is not very palatable for Montreal, which is the heart of Canada. But there is an even worse bogey that has been created for uneasy Montrealers, viz., that the Erie Canal route will be developed and the new port of Albany on the Hudson River will supplant Montreal with a new and shorter route to the sea, favoured with a longer open season and running from Oswego at the foot of Lake Ontario entirely through U.S. territory. Hand in hand with the extinction of the port of Montreal and the eclipse of the St. Lawrence route will go, according to these Jeremiahs, the final ruin of the

Canadian railways owing to the unfair competition of the subsidized waterways.

In such cases there is sure to be considerable exaggeration on both sides. It is so here. When I was in Canada last year for the Dominion Government, I had to give much thought to the question of the effect that the St. Lawrence Deep Waterway might have on the port of Montreal; and I came to the conclusion that on both sides material factors had been overlooked, over valued or under-valued.

It is most necessary before dogmatizing on the future of the new inland waterway to realize the very peculiar and specialized nature of the traffic on the Great Lakes. In the first place, navigation is in generally sheltered conditions wholly different from ocean navigation Shipbuilders, relieved from the necessity of designing to meet the Atlantic waves, or any serious sea conditions, have evolved for the Lakes a unique type of boat. It is, in fact, nothing but a long box, like an immense coffin, and one of the most apparently unwieldy types of vessel imaginable. The largest lake boat is the *Lemoyne*, 633 feet long, 70 feet in beam, and with a draught of only 20 feet.

It is some years since the *Lemoyne* was built, and actually in the years of depression through which we have been passing it has not altogether fulfilled its hopes, chiefly because of the difficulty of getting full cargoes. But there are numerous lake boats of between 500 and 600 feet long, of exactly similar design. It is not possible to say that, as conditions change, larger vessels may not be put on the Lakes. The *Lemoyne* has a carrying capacity of over 17,000 tons, with a draught of only 20 feet. If it were ever considered economically feasible to build a lake freighter up to the full capacity of the largest lock on the Welland Ship Canal, it would have a carrying capacity of 35,000 tons of freight!

Consider what the carrying capacity of an ocean-going vessel is. A vessel of the same draught as the *Lemoyne* would not carry more than 4,000 tons, and the largest ocean-going freighter in the world barely exceeds the *Lemoyne's* capacity, and requires a depth of water of something like five feet more than even the ultimate designed capacity of the Welland Ship Canal. No more need be said to show the serious disadvantage the ocean-going boat would be under, the moment it started to compete with the lake freighter.

But there are other and scarcely less important considerations. Rapidity of cargo handling is one of the necessities of traffic on the Great Lakes. The season is a comparatively short one—from May to November—and the number of trips that can be made is limited. Rapidity and bulk loading and unloading have consequently been brought almost to an incredible perfection.

For instance, the Canadian Pacific Railway's elevator at Port McNicholl on Georgian Bay in Lake Huron has a capacity of over

6,000,000 bushels, say 750,000 quarters of wheat, and the grain boats are brought under the elevator. The lake boat is simply a series of hatches, and the elevator is provided with a large number of grain spouts. Loading can take place simultaneously into any number of the hatches, and the record that has been achieved is to load a vessel with 8,098 long tons of wheat in 120 minutes. The record grain loading into an ocean vessel that I have figures of is 300,000 bushels, say 8,036 long tons, in six hours.

Even more wonderful results have been obtained in the loading of coal and ore than in handling grain. The palm in every respect, I think, goes to the record at Two Harbours, Minn., where 12,508 tons of ore were loaded into a lake vessel in 16½ minutes. At Swansea the ordinary coal tramp is considered to do notably well if it loads 4,000 tons in the day; and it would be exceptionally rapid loading of ore into an ocean vessel to attain about 350 to 400 tons an hour.

Again, in comparing ocean and lake freighters, one must remember that on the lake freighter the crew is reduced to a minimum. If cargoes are not available the vessel is tied up and a crew of about two remain in charge; while during the winter the boats are regularly used for storage.

Operating conditions are such on the Lakes that schedules can in many cases be worked out to allow a minimum of time for the round voyage. The schedule of an ocean vessel, particularly one that crosses the Atlantic, has to have an allowance of probably 15% or 20% in order to be able to keep to its timetable in all conditions. The lake freighter requires no margin.

I have not the time to go into these aspects further, but I have shown you that there is more than the mere creation of a waterway. If I may sum up my own views, I would say that I think there is no doubt that an expansion of coastal traffic as between, particularly, Canada's Atlantic coast, and Newfoundland, and the Great Lakes, will follow the construction of the St. Lawrence Deep Waterway. In certain directions, too, new services will be created; British Columbia timber will be delivered direct into the Lakes and a certain class of small European tramp vessel will be found on the Lakes when business is brisk. British coal tramps, too, will undoubtedly make their way into the Lakes. But, generally, I am satisfied that the ocean vessel can never compete with the lake freighter, and I believe that, provided the right policy prevails at Montreal, that port may become even more important in the future by developing into a great transhipping port, and *entrepôt*.

Some effect on the railways the new scheme must inevitably have, because it is a form of subsidized competition. I cannot say that I have fully studied this aspect. Possibly the effects may not be as serious as is sometimes feared. There may be something in the arguments of the protagonists of the Deep Waterway scheme that

the general increase in prosperity and development that will follow must lead to an increase in the demand for rapid transit, where the railways will always have the advantage over the water-borne traffic. This is the view of the Royal Commission that has just reported on the Canadian railways—and there we may leave it.

How many and how immensely interesting are the many problems involved! One might spend many hours considering them and discussing them. From the engineering point of view, the most noteworthy of all is, perhaps, the magnitude of the conception. There are hundreds of problems that require attention and study, as do all engineering matters, but few essentially novel questions involved, excepting one of the maintenance of water levels in the St. Lawrence, which has not yet received the attention that its importance demands. The level in the St. Lawrence has been dropping for 50 years, and neither the cause nor the cure has yet been fully worked out. It is vital to the port of Montreal to solve it.

One other almost incidental engineering matter I would like to mention before I stop—not that it directly affects the scheme, but because it may have important indirect results, and in any case is a matter that has always particularly interested me—namely, the effect that the construction of these new St. Lawrence canals might have on the production of ice in the St. Lawrence.

The St. Lawrence is now closed to navigation approximately from 5th December to 17th April. The freezing up takes place in the following way. The ice begins to form first along the shore in the beginning of winter, extending little by little out towards the centre of the river. In the tidal area—that is, at Quebec, and for some 20 or 30 miles above—the masses of shore ice get broken off by the rise and fall of the tide, and they float down with the falling tide. When the tide turns, the ice is held up and at the narrower parts of the river, particularly at the gorge, where the Quebec Bridge spans the St. Lawrence, is packed together. It then very soon forms a bridge across the full width of the river.

Above the tidal influence the formation of the ice bridge is much slower, because it is only the portions of shore ice that are broken off by the action of the current, or by rises and falls in the level of the river, or by sudden thaws, that float down to collect together at narrow places and eventually link up to form a bridge. As soon, however, as a bridge is formed, by whatever means, the growth of the ice continues very rapidly upstream, every floating piece being caught and added to the mass.

If this were the only form that the freezing of the St. Lawrence took, the use of ice-breakers would very easily keep the way clear; and, in fact, for many years past, in almost every year the ice jam at Quebec Bridge has been prevented from forming. The real difficulty is provided by what is known as the "frazil" ice, which

in the form of tiny spikes and crystals of ice is formed by the rapids on the St. Lawrence to the extent of millions of tons. In clear water, too, and in clear weather, every boulder and stone in the river-bed by radiating off its heat more rapidly than the water, freezes the water in its immediate vicinity. This—often known as " anchor " ice—forms round the stones and goes on increasing until eventually it floats up to the surface like a small haycock, often carrying the boulders or stones with it, and goes to join the accumulating ice jam.

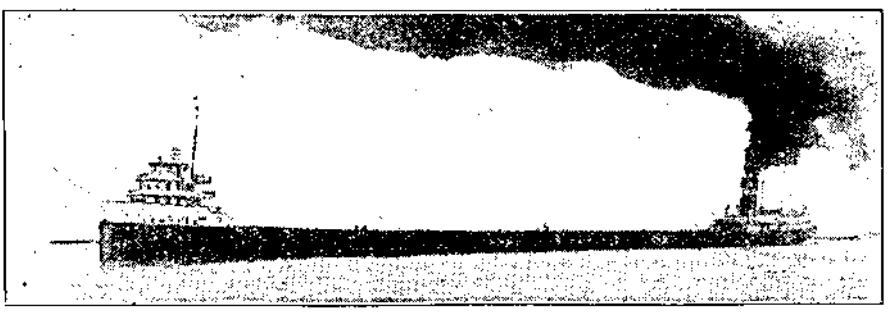
By these two means immense quantities of a slushy, spongy ice are being continuously poured down the St. Lawrence. It floats down until it meets the surface ice. These masses are then drawn by the current under the ice, beneath which they attach themselves, slowly closing the cross-section of the river-bed, until the river is eventually running, as it were, in an ice tunnel, the size of which is fixed only by the velocity of flow, that is, just sufficient to prevent more " frazil " ice attaching itself.

The cross-section of the St. Lawrence is so restricted in this way that immense floods are sometimes caused, and in the past the height of water has been raised at Montreal by more than 20 feet, flooding the whole of the lower portions of the city. I saw a report of ice breaking the second-story windows in the place. Until quite recently all the sheds and the wharves at Montreal were made of a temporary nature, taken down at the beginning of each winter and re-erected after the spring floods. The floods occur, too, at other parts of the winter and are a serious problem. The depth of ice produced in the river often amounts to 30 feet, and I am informed that depths of well over 100 feet have been measured. Being of a semi-spongy nature, even when subject to pressure, neither ice-breakers nor explosives have effect on it.

Now the elimination of the rapids must considerably reduce the formation of " frazil " ice, and to this extent will reduce the danger of flooding, which is a serious matter. Possibly, too, to some extent it might extend the period during which the navigation of the St. Lawrence is possible. If it did so to any degree, it would have a great effect on traffic routing in Canada. There are, indeed, some who believe that it might be possible to keep the St. Lawrence route open for a far greater length of season than it now has—even through the whole year; and that regular winter navigation on the St. Lawrence, to Quebec if not right up to Montreal, is practicable. For myself, I feel that this is, at least economically, quite impracticable. My last two photographs show you what ice can mean on the St. Lawrence. Photo 3 is an ice-jam in Montreal Harbour in the spring, before the final break-up; and Photo 4 shows you Quebec Harbour in December, 1926. Added to this, you may have sudden blinding snowstorms and blizzards lasting perhaps 24 hours on end.

Winter navigation scarcely seems practical, but the matter is too important to dismiss without full consideration; and such criticisms —and stronger—have in the past been poured on schemes and projects that are long since in operation, and indeed accepted as commonplaces of civilization. In any case, even if the whole be not attained, the effects of the Deep Waterway may be profound in the reduction of the floods by reducing the "frazil" ice manufacture and, perhaps, in the lengthening to some extent of the open season.

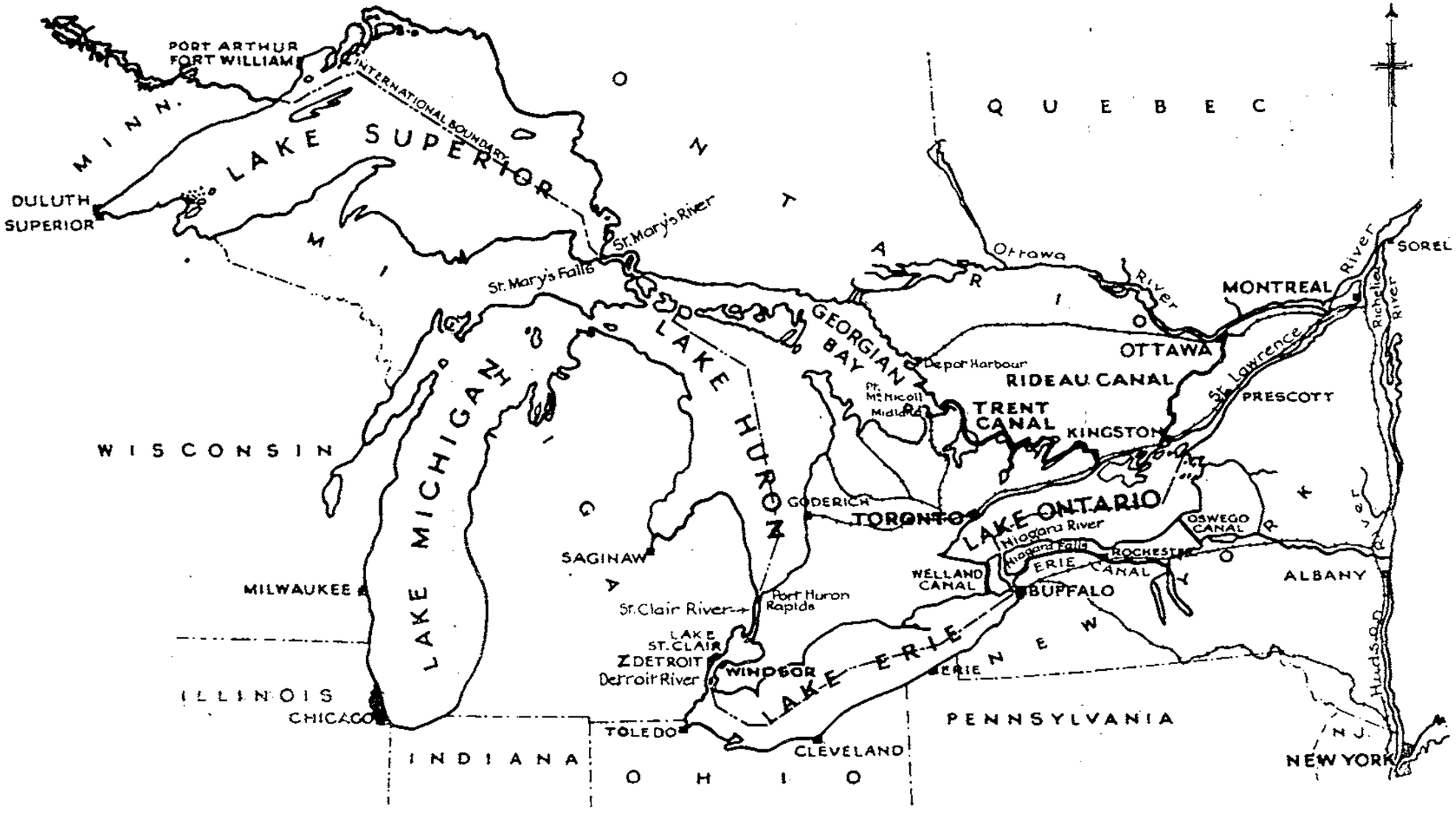
That concludes such remarks as I have to make on the subject of the St. Lawrence Deep Waterway. I fear they have been disjointed, and that many of the points that deserve deep thought have been rather cursorily treated. But I hope I may have given you some conception of this great scheme—one of the greatest, if not the greatest, engineering scheme that is now in active promotion—costing, from first to last, some £200,000,000, as compared with £29,725,000 the cost of the Suez Canal and £75,000,000 the cost of the Panama Canal; dealing at one stage or another with a cargo tonnage of something like 150,000,000 tons as compared with about 31,000,000 tons, the largest yet recorded in the Panama; and being from open sea to head of navigation 2,000 miles in length, the breadth of the Atlantic from these Isles to the nearest point of Canada.



S.S. "Lemoyne."

PLATE I.

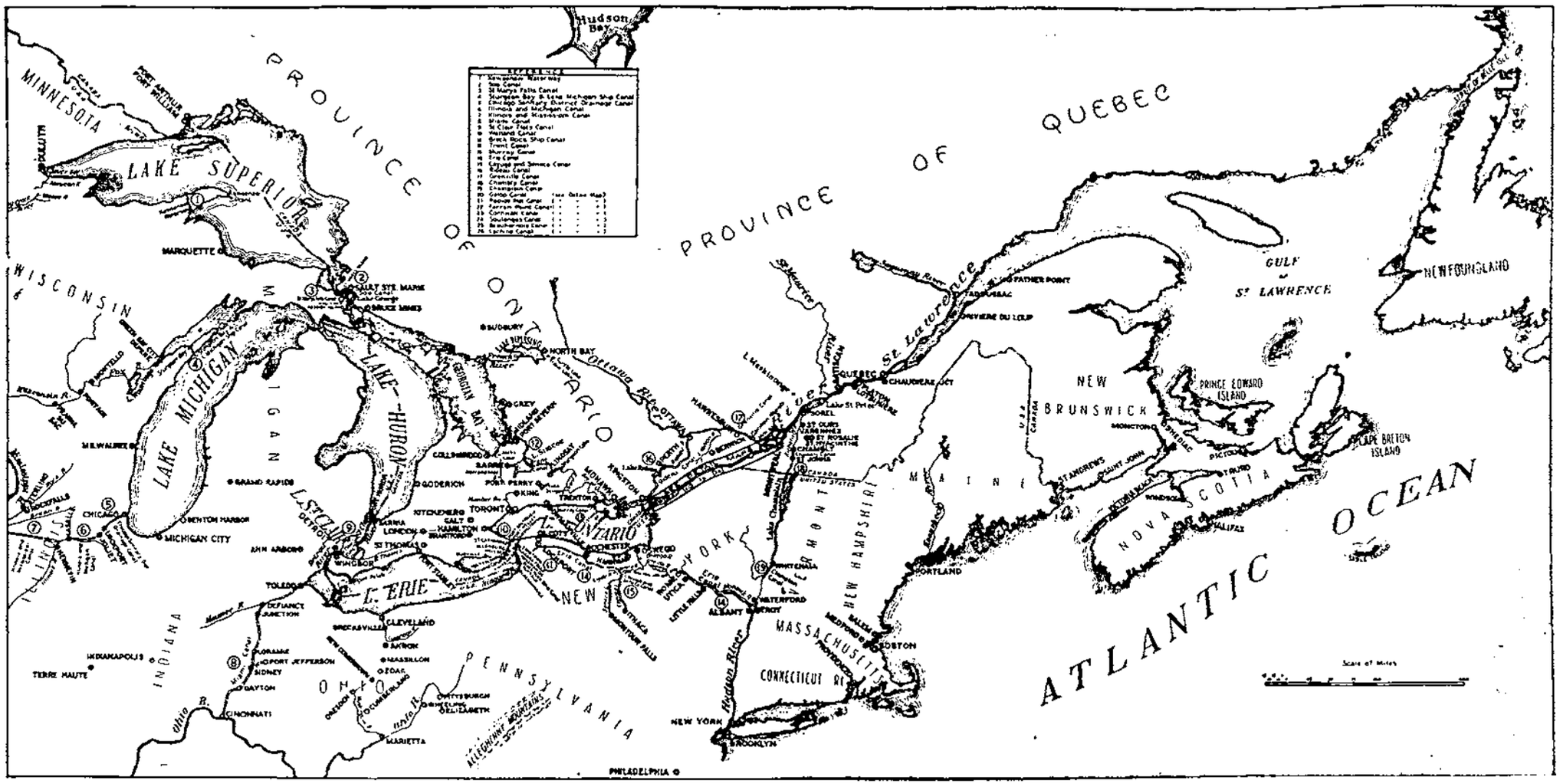
GREAT LAKES. LAKE SUPERIOR TO MONTREAL.



SCALE OF MILES

Mls. 25 0 50 100 150 200 250 300 Mls.

GREAT LAKES TO ATLANTIC OCEAN.



FROM "ST. LAWRENCE WATERWAY PROJECT," BY G. W. STEPHENS.

MOVEMENTS OF THE GROUND LEVEL IN BENGAL.

By COLONEL SIR SIDNEY BURRARD, K.C.S.I., F.R.S., *formerly Surveyor General of India.*

(With a Map of Bengal.)

To a casual observer the plains of Bengal appear flat, but that they are not flat is shown by the courses of their rivers. Their gentle slopes are objects of great importance to engineers and surveyors, and they have been carefully measured. In the report on levelling published by the Survey of India in 1931 the conclusion was reached that the plains of Bengal and Bihar have been rising at an average rate of half an inch a year for the last 70 years, and it is even stated that " these changes of ground level must be accepted as proved." I was surprised when I first saw these changes of level suggested as possible, but when I read that they must be accepted as proved, my surprise increased to amazement.

(1) THE GROUND LEVEL OF BENGAL AS OBSERVED FROM 1862 TO 1932.

In 1858 the Survey of India began to observe lines of levelling over India, and throughout the last 75 years the work has progressed. Modern lines have crossed the older lines, and a complete network has been created; the Survey have checked the accuracy of their levels against the mean level of the sea at many tidal observatories on the coasts. The levelling marks which the Survey have cut upon rocks and the stone pillars which they have erected upon the alluvial plains constitute permanent monuments of height; they are known to the villagers as survey marks or height marks, but in reports they are called bench-marks.

In the *Geodetic Report of the Survey*, 1931, Vol. VI, pp. 104-106, it was shown that three modern lines of level, 1920-1930, had all given greater values of height to bench-marks in North Bengal and Bihar, than had been obtained for the same marks during the last century. Dr. De Graaff Hunter has done a most useful service in discussing this problem in the report.

The changes in height which are believed to have been discovered may be summarized as follows :—

1. The mark at Pirpainti near Raj Mahal has been found in 1930 to be 3·178 feet higher than it was in 1863.
2. The mark at Benares has been found in 1917 to be 2·170 feet higher than it was in 1863.
3. The mark at Dinajpur has been found to be 0·963 foot higher in 1926 than it was in 1900.

Upon these results the theory has been built that the bench-marks of Northern Bengal and Bihar have been rising half an inch a year for 70 years. The Survey report shows that Patna and Benares are rising at a rate of 5½ feet a century ; the gravity of these changes is my apology as a retired surveyor for my presumption in criticizing the new theory. This theory will require heights of marks to be treated in future as variables ; hitherto the simple statement has been made that the height of Patna is 164 feet ; but according to the new theory it will be necessary in future to record heights as follows :—

Height of Patna in 1900	162·5 feet.
Height of Patna in 1930	164 feet.
Height in 1960	165·5 feet.

Although this theory of "rise" of ground level may receive support from technical levelling results, it cannot be accepted on these grounds alone, and its full significance and meaning will not be appreciated, unless it is considered in its relation to geographical history.

(2) THE GEOGRAPHICAL HISTORY OF THE PLAINS.

West of the River Tista the alluvial plains of the Ganges are bordered by mountain ranges, on the north by the Himalaya, on the south by the Hazaribagh ; the Hazaribagh range comes to an end in the Raj Mahal hills and here the Ganges has found its way to the sea.* Farther east the Brahmaputra follows a similar course but opposite in direction. In Upper Assam it flows along the trough between the Himalaya and the Garo hills, and when the latter terminate the Brahmaputra sweeps round them, just as the Ganges does at Raj Mahal. Between the Raj Mahal and the Garo hills there is a gateway, 130 miles wide, and through it the two rivers escape. In recent times they have formed a junction, and they now enter the Bay of Bengal together.

A century ago James Ferguson, the famous archæologist, studied

* On the sketch map the Hazaribagh range is shown as the Vindhya ; Vindhya is a scientific name, but Hazaribagh is the local name.

the sites of the ancient capital cities. He found that the most ancient cities of the Ganges had been built upon the upper reaches of the river, and that 3,000 years ago there was no Gangetic city as far down the river as Allahabad. The great cities were founded in succession, each being lower down the river than its predecessor; Benares after Allahabad, and Patna after Benares; the cities on the lower reaches such as Murshidabad belong to a later period. Ferguson arrived at the conclusion that "5,000 years ago the sea "extended up to Raj Mahal, and that Bengal was a vast lagoon or "shallow sea."*

The coastline of the Delta is in our time 200 miles south of the Raj Mahal-Garo gateway, and thus the plains of Bengal have been expanding seawards for 5,000 years. The present height of the plains in Rajshahi near the centre of the gateway is 50 feet above the sea; and if the sea approached here 5,000 years ago, as Ferguson believed, the level of the plains must have risen 50 feet in 5,000 years. Their average rise in height due to riverain deposits of silt and sand has thus been about 1·0 foot in 100 years. There are no ancient cities buried under the plains of the Ganges, and there are thus no archæological excavations from which we might have learnt the rate of growth of the silt, and have obtained a check upon the estimate of 1·0 foot in a century. But in recent years the relics of a very ancient civilization have been discovered by the Archæological Survey near the Indus in Sind, and these excavations have thrown considerable light upon the question of the growth of silt. In his book on *Mohenjo-Daro and the Indian Civilization*, Sir John Marshall writes:—"If "there is one fact that stands out clear and unmistakable amid these "ruins, it is that the people must have lived in ever-present dread "of the river. That this is so is shown by the pains which the "builders of Mohenjo-Daro have taken to provide their edifices with "prætornaturally solid basements and to raise them aloft on artificial terraces, which time and again were heightened in order to "place them out of reach of the floods. Even so, however, it must "frequently have happened that the river came down in abnormal "flood, bursting its banks and carrying ruin far and wide.

"The bed itself of the Indus, as the centuries passed, was steadily "being raised by the vast volumes of silt that the river brings down, "and the level of the adjacent plains was being raised with it."

Sir John Marshall goes on to say that "the then level of the plains "appears to have been some 25 to 30 feet below their present level. "The subsoil water is now 10 to 15 feet above the ground level of "5,000 years ago."

From Marshall's account it would appear that the plains of the Indus have risen 30 feet in 5,000 years; their average rate of growth

* "Recent Changes in the Delta of the Ganges," by James Ferguson, F.R.S., *Quarterly Geological Journal*, XIX, p. 321.

has been 0·6 foot in a century. This rate is not very different from the rate of 1·0 foot per century which was obtained above for the growth of the Bengal plains in Rajshahi.

Geologists agree with archæologists in thinking that the level of the plains of Bengal has been steadily rising for 5,000 years and more, but this rise, which I will call the "historic rise," as it is based upon history, has been due to the additional silt and sand which is always being brought down by rivers and scattered over the surface of the plains by winds.

The "geodetic rise" of the bench-marks, described in the Survey report, and based upon geodetic levelling, is something quite different, for this latter rise can only be due to an uplift from below of the rock-foundations upon which the silt of the plains is resting. The "historic rise" has been due to the horizontal movements of sand over the surface of the earth, and its effect upon bench-marks is to bury them under the sand, and certainly not to raise them. The "geodetic rise" is said to be raising bench-marks, and it must, therefore, be raising cities also, and helping to save them from burial.

The "historic rise" of surface-silt amounts, as estimated above, to about 1·0 foot in a century; the "geodetic rise" is shown in Chart XXII of the Survey Report as 5·5 feet a century at Patna and Benares. In considering the "geodetic rise" we are thus dealing with a phenomenon essentially different from the "historic rise" that has been forcing the sea to recede from Raj Mahal; the seaward growth of the delta is still continuing, but it is being brought about, not by any vertical uplift, but by the horizontal transference of loads of silt.

(3) THE DELTA OF THE GANGES.

No feature of the earth's surface has been held in such sacred regard as the Ganges; it may therefore appear a sacrilege to bring the sacred river into modern controversy. But it is not a sacrilege, for scientists require inspiration no less than poets, and in a dispute over the levels of Bengal where can a higher source of inspiration be found than in the Ganges? This wonderful river knows more about the slopes of the plains than any engineer or surveyor; it has created the plains, it has chosen its own course, it has made its own bed. In crossing Bengal it has given to itself a slope of 3 inches in the mile, and if the plains on its north have been rising 4 feet in a century (40 feet in 1,000 years), as has been recorded in the Survey report, the Ganges would have become aware of the fact long before the dull mind of humanity had discovered it. Let us then study the history of the Ganges, and learn what her actions have been.

In our age the Ganges is flowing into the Brahmaputra, the greater river into the lesser. The delta which the two have created has

been mainly the work of the Ganges. The western border of the delta is the River Hugli, and though it is famous as the river of Calcutta, it is geographically only a small river. Its waters visible at Calcutta are mainly derived from the tides of the ocean. The eastern border of the delta is the Brahmaputra, and there is no important river-mouth between the Hugli and the Brahmaputra.

The seaward advance of the delta appears to have been more rapid on its western side (Hugli) than on its eastern (Brahmaputra), and this difference in rate of growth is an indication of the superiority of the Ganges to the Brahmaputra as a creative force. We have been able to estimate the average rate of growth of the plains in height at 1·0 foot in a 100 years, a growth which has been due to the distribution of fresh sand over their surface, but we cannot estimate the average rate of the horizontal growth of the delta as it advances out to sea; according to Ferguson the coastline of the delta was 200 miles in rear of its present position 5,000 years ago, but it would be misleading to deduce from these figures any average rate of growth. In the earlier centuries Bengal was a shallow lagoon, and the delta was only 130 miles wide; in our time the delta has reached deep water and is now 300 miles wide. The silt which the Ganges and Brahmaputra are now bringing down and which forms the building material for the delta is probably not very different in amount now, when its coast is long and deep, from that which the rivers were carrying when the coast at Raj Mahal was short and shallow. It will, therefore, be realized that the Gangetic delta is growing out to sea at a rate very much slower now than it was 5,000 years ago.

The map of the world made in A.D. 1569 by the Dutch navigator Mercator shows the delta to have been bordered by a large river-mouth on the west, and by another on the east, without any important intermediate mouth. His map shows that the mouths of the Ganges have not undergone any great changes since 1569.

If we compare Major Rennell's map of A.D. 1785 with the latest maps, we learn that the recent growth of the delta has been imperceptible near the mouth of the Hugli, but that there have been increases in the numbers and sizes of the sandbanks at the mouth of the Brahmaputra; some of the changes are sufficient to show that the delta is not *terra firma*, and that it belongs neither to the land nor to the sea. Since 1785 the Brahmaputra has altered its course by 30 miles between Dacca and Comilla, although it still enters the Bay on the east of the delta, as it did in 1569 and 1785. The Ganges itself has also altered its course across the delta; in 1785 it flowed into the sea independently of the Brahmaputra; since that date it has swung no less than 14 miles to the east, and it now joins the Brahmaputra 90 miles above the mouth, where their joint stream enters the Bay. The easterly swing which the Ganges made 100 years ago was brought about by the relatively slow growth

of the eastern side of the delta, and the Ganges therefore joined the Brahmaputra in order to help bring the eastern delta into line with the central and western.

If, therefore, we are justified in building the history of the delta upon the archæology of Ferguson and the geography of Rennell, we may conclude that a few thousand years ago, when the delta began first to protrude through the Raj Mahal-Garo gateway, the Hugli was a primary mouth of the Ganges—perhaps even its principal mouth; in the succeeding centuries the Ganges was slowly swinging like a pendulum to the east and was widening its delta from the Hugli to the Brahmaputra.

If the plains of Bengal had been continually rising to greater heights above Calcutta, as has been suggested by the Survey report, the influence of this "geodetic rise" would have tended always to deflect the Ganges southwards towards Calcutta; but historical geography seems to teach that the Ganges has for centuries been swinging away from Calcutta. A constant increase in the slope of the Bengal plains from north to south would have had an influence upon the drainage, but no such influence is traceable in history.

(4) THE STABILITY OF THE GROUND AT CALCUTTA.

The theory that Upper Bengal is rising in height has been based upon three lines of level which emanate from Calcutta. In the Survey report Dr. Hunter has been led to consider whether these apparent rises could not be explained, if Calcutta itself had been sinking. It is not possible to prove that the ground at Calcutta has remained at the same level for 50 years, but the rises in Bengal amount to 2 and 3 feet, and Dr. Hunter has been able to show that such a subsidence as 2 feet at Calcutta is unthinkable. It is possible that Calcutta has sunk 0·20 foot in the last 50 years, but it cannot have sunk 2 feet.

Owing to the importance of Calcutta the Survey have erected several bench-marks in the city and district, and in co-operation with the port authorities they have maintained a permanent tidal observatory on the Hugli. When in 1884 Colonel Baird fixed the bench-marks in Calcutta, he planned two methods by which the marks could be always tested in times of doubt: (1) He expected that the observatory on the Hugli would provide a permanent mean sea level against which bench-marks could be tested. (2) He erected a bench-mark at False Point near the tidal observatory on the Orissa coast, and he intended this distant mark to be the independent point of reference outside the Calcutta area.

Both Baird's plans have failed through no fault of his. He had found by careful measurements that the mean level of the Hugli for

four years was 3·170 feet higher than the mean level of the sea in the Bay. From his experiences in other inland tidal waters he believed that this difference of 3·170 feet would prove permanent. But owing to dredging operations the Hugli level has been continually falling for 30 years. As a permanent test for bench-marks it is useless, although it did furnish valuable information in the earthquake crisis.

As to the reference mark at False Point which was to have been the independent test in times of crisis, it proved of no use in the earthquake, as False Point was shaken then like Calcutta. Moreover, False Point is on the delta of the Mahanadi, and now that objections have been raised to a ground level of alluvium, it is of little use to test one alluvial site by a mark on another alluvial site.

When Sir Thomas Holland was the Director of the Geological Survey, he gave two reasons for questioning the stability of Calcutta as a site for a standard bench-mark. His first reason was that Calcutta is liable to earthquakes, and the second was that any ground level which is resting upon deep deposits of silt is liable to sink from subsoil compression.

(5) The Bengal Earthquakes.

Although the Ganges delta has never yet been the scene of maximum disaster in any earthquake, yet it has been shown by Oldham to have been shaken by seven major earthquakes since 1800 A.D. On the 12th June, 1897, Calcutta was shaken severely by the earthquake that levelled Shillong. Oldham made a close study of this earthquake, and his memoir is a seismological classic.* The Survey officers who were in Calcutta during the shock did for the time being lose their confidence in the bench-marks, but their loss of faith was momentary, and they became gradually reassured. The tidal record of the Hugli showed that the river's surface rose and fell by 3 inches (relatively to the land), many times in rapid succession during the 3 minutes that the earthquake lasted, but that after the disturbance was over the river assumed a level that was identical with the level before the earthquake.

Oldham's Memoir was published in 1899, and it showed that our bench-marks must have been exposed to three forms of violent vibration—horizontal, vertical, and rotatory. These bench-marks are standing upon alluvium, and one fact mentioned by Oldham threw a light upon the behaviour of alluvium when under strain ; the fact was this, that the iron rails of the Eastern Bengal State Railway,

* "The Great Earthquake of 12th June, 1897," by R. D. Oldham, F.R.S., *Memoirs, Geological Survey of India.*

which had been resting upon alluvial plains, had been twisted and bent. The lessons of the earthquake were not, however, such as could be learnt at once; opinions differed; the Garrison Engineer of Fort William contended that the fort was stable. And the Survey still believed in 1897 that they had a permanent standard level in the mean surface of the Hugli. It was in 1910, after a consultation with the executive engineer of the Nadia Canals, that the Survey abandoned their hope of obtaining a constant mean level from the Hugli.* In 1915 they placed several bench-marks upon the ancient rock of Hazaribagh, and they connected these marks with Calcutta.

(6) THE COMPRESSIBILITY OF ALLUVIAL DEPOSITS.

When we investigate the formation of alluvial plains, we concentrate attention upon the new loads of silt that are always tending to raise the level of the plains. But there is another process in operation which is less visible, and that is the slow downward shrinkage of the silt after it has been deposited. This underground shrinkage is due to the weight of the silt that is always being thrown over the surface. If we measure the density of silt, we find that its density increases with compression. Mr. C. S. Middlemiss, F.R.S., referring to bench-marks, has written, "Slow earth-movements are to be "expected, and when considering changes of level in Bengal I should "prefer to reckon from a bench-mark on ancient rock rather than "from one at Calcutta." Sir Thomas Holland, F.R.S., has written, "The Gangetic alluvium is about as useful for a standard bench-mark "as the lightship at the mouth of the Hugli."

The following extract is from Colonel Hill's report, 1894, "The "opinion of engineers in Karachi is that after the year 1887, when "the Karachi waterworks were opened several buildings settled; "before the completion of the waterworks the bench-mark near the "church showed no signs of sinking: in 1892 it was found to have "sunk half an inch; in 1894 its settlement increased to three-"fourths of an inch."

In the Survey Report for 1928 it was stated that the standard bench-mark at Agra had sunk 0·10 foot, and that the standard bench-mark at Allahabad had sunk 0·15 foot. In the Survey report for 1930 it was stated that "it must be considered as proved that "the country round Ambala has sunk one or two inches since 1915, "in continuation of the sinkage of seven inches previously discovered. "The Director Geological Survey has expressed the opinion that the "Ambala sinkage was probably due to de-watering by wells."

* *G.T. Survey of India*, Vol. XIX.

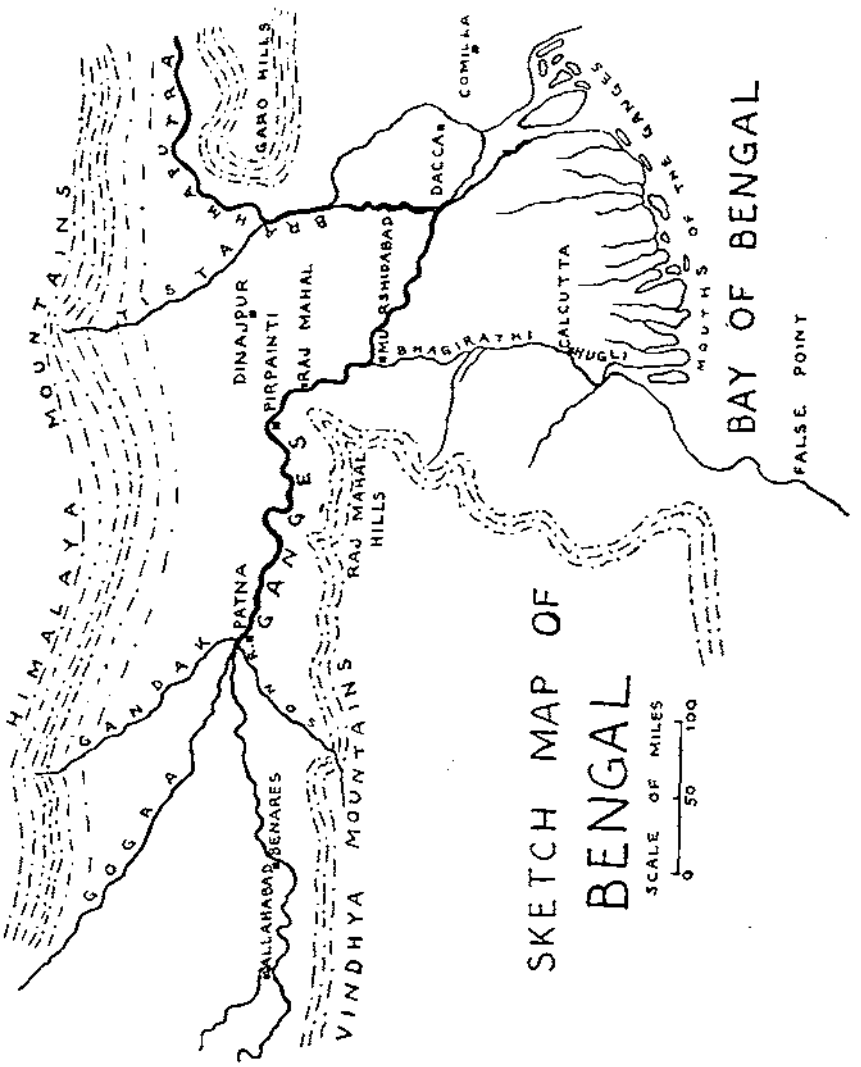
(7) Conclusions.

I venture to submit that the probable explanation of the levelling discrepancies in Bengal and Bihar is the occasional inferiority of the levelling of 1862. Dr. Hunter has introduced so many improvements into the methods and instruments of levelling, that he ought not to regard the old levelling as equal in merit to that of his own time. If we take the several lines of level that surround Bengal and Bihar, the closing error of this 1,000-mile circuit is only 0·606 foot; the levelling composing this circuit belongs to different dates from 1862 to 1930; its small closing error is evidence that this levelling deserves the confidence of engineers; it also furnishes evidence that the bench-marks are not rising. But when we introduce the line of levels from Howrah to Pirpainti across the middle of the Bengal circuit, we get a large error on each side of this line. Although this old line emanated from the Calcutta area, it was observed in 1863 before the standard bench-mark at Calcutta had been established; its starting-point was a mark on Howrah railway station, and a site that is always being shaken by trains is not fitted for the detection of movements of the earth's crust.

According to the Survey theory (Chart XXII) Benares has risen in height by 4 feet since 1863; Allahabad has, however, been found by actual levelling to have sunk 0·15 foot. Allahabad is only 75 miles from Benares, and if a new line of levels were now to be run from one to the other, it would show if the supposed rise of the Benares bench-mark is real or not. (See sketch).

The levelling operations in Bengal have met with difficulties not experienced elsewhere in India. The growth of Calcutta upon a ground level of alluvium has given rise to special problems. The city is only 16 feet above the sea, and on all sides it is surrounded by alluvial plains and sandbanks for 100 miles; the ocean is too far distant to provide the datum for levels that it does at Bombay; the Hugli has proved to be no substitute for the ocean, and Calcutta is liable to earthquakes. Hitherto the requirements of the great city have outweighed the demands of scientists, and the standard bench-mark has remained in Calcutta. As the ground level had been found sufficiently stable for the many fine buildings, it came to be trusted for the bench-mark also. But experience has been slowly accumulating, and when in 1915 the line of levels was carried from Calcutta to the ancient rock of Hazaribagh, it was a sign that the confidence of the Survey in the ground level of the capital was being shaken.

Since 1915 discoveries have been made that bench-marks on the alluvium at Agra and Allahabad and Ambala are sinking, and I would respectfully suggest that the time has come for recognizing, that whilst the engineering progress of Calcutta requires a standard


SKETCH MAP OF
BENGAL
SCALE OF MILES
0 50 100
HIMALAYA MOUNTAINS
VINDHYA MOUNTAINS
GANGES
BRAHMAPUTRA
GARO HILLS
RAJ MAHAL HILLS
DINAJPUR
PIRPAINTI
RAJ MAHAL
MURSHIDABAD
DACCA
COMILLA
BHAGIRATHI
HUGLI
CALCUTTA
MOUTHS OF THE GANGES
BAY OF BENGAL
FALSE POINT
PATNA
GANDAK
GOGRA
BENARES
ALLAHABAD

bench-mark in the city, the progress of science requires a standard bench-mark on the ancient rock.

A solution of the difficulty will be found, if one standard bench-mark be maintained at Calcutta for the use of the city, and if another be established on rock near Parasnath as the reference mark for the whole province. The rock mark could be used as an emergency test if Calcutta is shaken by an earthquake or cyclone.* It will, moreover, be of interest to compare the heights of the Calcutta mark and the rock-cut mark every ten years, even if there has been no earthquake in the interval. How instructive it would be now, if we possessed a series of decennial comparisons made between marks upon rock and alluvium since 1860.

The mark chosen to be the baseline for all heights in Bengal should be independent of masonry, and should be engraved upon the ancient rock. As this rock is in contact with Raj Mahal rock, the site should be approved by the Geological Survey; the site should be easily accessible to rapid levelling tests from the Calcutta standard bench-mark in Wood Street; it should therefore not be high up, and it should be protected from falls of gravel.

The cities of Bombay and Madras and Karachi have the open ocean at their doors, and this provides them with a scientific datum of level. If the mark of reference for Bengal be engraved upon the ancient rock, it will provide Calcutta with a scientific datum 150 miles distant; but this distance will be no serious drawback, if an easy line for levelling can be found.

The new theory in the Survey Report, that the plains of Purnea, and Patna and Benares are now rising in height, will require to be tested by actual levelling in future decades. If these future tests are based upon the rock bench-mark of Bengal, they will carry greater scientific weight than if they are dependent upon the mark at Calcutta.

* In 1884 a cyclone swept the tidal observatory at False Point into the sea and moved the stone bench-mark 100 yards. (*G.T. Survey*, Vol. XIX.) The effect of the cyclone was to lift the bench-mark, the effect of earthquakes is to depress.

ROAD SURFACING BY THE MIX-IN-PLACE METHOD IN INDIA.

By BRIGADIER C. H. HASWELL, C.I.E.

IN India, the lack of money due to financial stringency, the increasing length of mileage and the rapid growth of fast motor transport has made the maintenance of roads a very serious problem. Engineers, both military and civil, for some years have been studying this problem in an endeavour to make the funds available to cover the maintenance of an increased mileage and also to produce a cheaper form of road surface which will stand up to modern motor traffic.

The sealing of the surfaces of water-bound macadam roads with road tar or bitumen has now become a recognized practice and the life of the roads has been more than doubled. This means capital expenditure but when once the roads have been surfaced the maintenance can be very considerably reduced.

If a metalled road is neglected and not given the necessary repairs, it deteriorates very rapidly and it may be necessary to completely reconstruct the road if it is ever required at a later date.

In Baluchistan the distances are very great, and the road mileage considerable. When money was plentiful, roads were metalled; but when maintenance grants were reduced, it was beyond the means of the Local Authorities to repair them and it is sad to see the deterioration.

For the last four years the spreading of shingle on metalled, soled and earth surfaces has been the common practice. On the earth roads where the shingle can bind with the soil, it forms a hard surface which can be used as an emergency road for light and occasional motor traffic. On old metalled and soled surfaces, unless some binding material is used with the shingle and rolled by rollers, with a certain amount of water, the shingle always remains loose. Fast motor traffic forms it into windrows, one on each side of the road and one down the centre, leaving two narrow tracks. Therefore the whole of the traffic is taken on less than one-sixth of the width of the road, and the wear on this small width is very considerable. Gangs have to be employed continually to scrape back the shingle on to the tracks and new coats of shingle have to be provided up to as many as five in the year, according to the amount of motor traffic.

The result is a loose rolling surface which corrugates rapidly. It is dusty and dangerous to traffic as has been shown by the number of

serious accidents due to skidding, particularly on corners. The cost in P.O.L. is increased by from 30% to 40%, due to the loss in traction on the rolling surface. Tyres do less than half their guaranteed mileage due to the erosive action of the shingle and the damage to the interior fabric of the tyre by bruising. As a car drives along there is a continuous bombardment of the underneath part of the car by the larger stones flicked up by the wheels. Cases have occurred of a petrol tank being punctured and a battery casing being cracked. Mudguards get badly dented and the paintwork destroyed.

Where the shingle will work into and bind with the surface of the road, a shingle road is cheap and suitable as an emergency road for light traffic, but where it remains loose it corrugates and the loose surface is a danger to traffic and exhausts marching troops. It was thought that the corrugations were due to the wearing of the hard surface under the shingle. This is not the cause. The surface under the shingle remains smooth, but a proportion of the shingle is ground into dust and this packs into ridges at short or long intervals, according to the speed of the traffic. The ridges can be smoothed off with a shovel but this means heavy expense in maintenance gangs. A planer towed by a caterpillar tractor has been found a remedy for a corrugated road. It can do at least four miles a day, leaving a smooth surface and evenly spreading the shingle behind it. The corrugations return after a few weeks, but a planer will keep a road in good condition at a very small cost, and is the solution to the trouble.

The cost of maintaining shingle roads was becoming so great, in some cases more than three times that of a metalled and surfaced road, and so much money was being wasted with no progress, that it was imperative to try and find some method of road construction within the means available which would save the excessive cost of maintenance and do away with the disadvantages and faults of the present system.

Throughout Baluchistan, shingle of all sizes and grades is obtainable either from river-beds or from *karezes* (underground water channels), and this appeared to be the ideal material for a mix-in-place method of stabilizing the surface of roads and providing a dustless, waterproof, wearing surface at a minimum cost. This form of construction has been used extensively in America, proving satisfactory and economical and with the help of the Burma Shell Coy. experts it was decided to try this out in Baluchistan. No one had any experience, the plant used was makeshift, and unskilled coolies were employed. It was very soon found out that there was a great future for this method of construction, and a number of varied experiments have been carried out which have provided sufficient data to enable work to be undertaken on a very much larger scale.

Very satisfactory results have been obtained as regards wearing

surface, economy and speed, and it is undoubtedly proved that work is being carried out on the right lines.

To obtain economy, sufficient machinery and plant is essential, and with larger works being undertaken this is justified.

The various experiments which have been carried out will now be described. It is not easy to lay down any hard and fast rule and each case has to be treated on its merits, but from the results obtained some general specification can be evolved. The problems before the engineers were to find a suitable and economical method of providing stable waterproof and dustless surfaces for the following types of tracks:—

(i) A road which had been soled with packed soling, surfaced with shingle, and consolidated by traffic.

(ii) An ordinary earth road into which shingle had been worked by traffic with a solid and hard sub-grade but no soling.

(iii) A road which had been soled and metalled with water-bound macadam, of which the surface had so broken up and deteriorated that it would require re-metalling.

(iv) A road which had been soled and metalled, of which the surface had become rough and bumpy but not broken up.

There are two processes which have been tried:—

(*a*) Hot mix, using a cut-back bitumen which is heated in boilers to a temperature of 150° and spread by means of a steam-heated pressure distributor or by hand-pouring.

(*b*) Cold mix, using a heavy road mix bitumen emulsion, a 50/50 mixture of bitumen and water, spread by means of a pressure distributor or by hand-pumps direct from containers.

Due to the fact that only a small quantity of the H.R.M.* emulsion was available in the country, sufficient experiments have not been carried out to give it a fair trial.

HOT MIX PROCESS.

Before describing the experiments, a note on the question of binder content may be of some help.

There are two methods of calculating this binder content:—

(i) By a formula.

(ii) By ascertaining the surface area of the particles and then finding the bitumen index from a graph.

Both these methods are fully described in the *Burma Shell Bulletin*, entitled "Mix-in-Place," Part 2.

With both these methods, samples of the shingle should be graded by means of sieves.

* Heavy Road Mix.

(*i*) *Formula Method.*

Owing to less than 50% of the shingle passing the $\frac{1}{4}$" screen, the formula will be as follows :—

$$P = 0{\cdot}02a + 0{\cdot}045b + 0{\cdot}20c.$$

Where P = percentage of binder required.
a = percentage of material retained on the 10 mesh.
b = percentage of material passing the 10 mesh and retained on the 200 mesh.
c = percentage of material passing 200 mesh.

Taking the grading of the Kuchlak shingle :—

$a = 79{\cdot}63$ $b = 16{\cdot}82$ $c = 3{\cdot}55$

Therefore $P = 0{\cdot}02 \times 79{\cdot}63 + 0{\cdot}045 \times 16{\cdot}82 + 0{\cdot}20 \times 3{\cdot}55$
$= 1{\cdot}5926 + 0{\cdot}7569 + 0{\cdot}710$
$= 3{\cdot}0595.$

The theoretical bitumen binder content by this method of calculation should be 3·06%. Let us apply this to the shingle used at Kuchlak. To provide a 3" consolidated mat, about 3 cu. ft. were spread per sq. yd. This corresponds to a loose layer of 4" thickness. A cu. ft. of loose shingle weighs 110 lb., and the weight per sq. yd. of 3" consolidated thickness will be approximately 330 lb. A binder content of 3·06% would mean that 10·1 lb. of bitumen would have to be applied per sq. yd. This is equivalent, with F.60 and F.70, to 1·01 gallons per sq. yd.

It is the practice in the United States to increase the percentage by 25% when a cut-back bitumen is used, and on this basis the binder content should be 1·25 gallons per sq. yd.

(*ii*) *Graphical Method.*

By taking the constants and graphs given in the *Burma Shell Bulletin*, and the actual grading of the Kuchlak shingle, the total surface area of the shingle worked out to 25·306 sq. ft.

From the graph, a surface area of 25·306 sq. ft. gives :—

Low bitumen index .. 0·001175
High „ „ .. 0·00175

Therefore lb. of binder required per lb. of shingle.. .. ..

Low Index.
$25{\cdot}3 \times 0{\cdot}001175$
$= 0{\cdot}0297$
—say 0·03 lb.

High Index.
$25{\cdot}3 \times 0{\cdot}00175$
$= 0{\cdot}0443$
—say 0·045.

Therefore the percentage of bitumen required should lie between 3% and 4·5%. For 330 lb. of shingle per sq. yd. the binder content should be from 0·99 to 1·485 gallons per sq. yd.

From this the correct rate of application should be about 1·25 gallons per sq. yd. This corresponds closely to the amount of binder used.

The following is a description of the experiments carried out using a hot mix, and gives the methods employed, the bitumen content used and the results.

Type (i), a road which has been soled with packed soling, surfaced with shingle and consolidated by traffic.

Kuchlak Road.

Half a mile was taken and divided into seven portions, each portion being treated with varying proportions of binding material. In each case the same methods of application and mixing were used. The thickness of shingle used was 4″ loose, consolidated to a 3″ mat. The shingle was unwashed and taken from a *karez* near the site. After being stacked in a windrow down the centre of the road, the shingle was spread to an even thickness by means of a tractor and maintainer. After being divided into sections, so as to give the correct content per square yard, the heated bitumen was poured from cans by hand. After pouring, the shingle was turned over and thoroughly mixed with the bitumen by a grader with the blade set at an angle. The whole mass of material was moved from side to side by the grader blade until all particles were coated and the colour became dark. The number of grader trips varied according to the amount of the bitumen content.

After complete mixing, the mass was spread again to an even thickness by the maintainer and the second application of binder was made. The procedure as regards mixing was the same in each case and the number of grader trips varied according to how the particles were becoming coated. After the final mixing had been completed, and the mass spread over the whole width of the road, a 5-ton steamroller was used to consolidate the surface lightly. Traffic was put on immediately and the rolling carried on while traffic was using the road. The marks caused by wheels while the surface was soft were taken out at once by the roller, and after four days the surface had hardened sufficiently to stand up to any traffic without any movement whatever. The surface was carefully watched and any bleeding was at once blinded with fine stone chippings rolled in.

The essential details of construction of the different sections laid can best be described as under :—

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
1	497 sq. yd.	0·5 gal. F.60	0·3 gal. F.60	No further applications, but a seal coat of 0·4 gal. of a 50/50 mixture of fuel oil and Spramex.	
		Total binder ...	0·8 gallons.		
		Seal coat ...	0·4 ,,		
			1·2 ,,		

Condition: Good. *Remarks:* Bled badly, which necessitated blinding with chips.

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
2	400 sq. yd.	0·25 gal. F.70	0·5 gal. F.70	0·25 gal. F.70	0·25 gal. F.70
Mixing trips		9	9	6	6
		Total binder ...	1·25 gallons.		

Condition: Very good and appears to be the best of all.

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
3	393 sq. yd.	0·25 gal. F.70	0·5 gal. F.60	0·25 gal. F.60	0·25 gal. F.70
Mixing trips ...		9	6	6	9
		Total binder ...	1·25 gallons.		

Condition: Very good. Runs a very close second to No. 2.

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
4	707 sq. yd.	0·25 gal. Fuel oil/ Spramex.	0·5 gal. F.70	0·5 gal. F.70	—
Mixing trips ...		10	9	9	
		Total binder ...	1·25 gallons.		

Condition: Good. *Remarks:* Bled badly and required blinding.

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
5	421 sq. yd.	0·5 gal. F.O./Spramex	0·5 gal. F.70	No further applications, but a seal coat of F.70 at 0·25 gallons was applied and blinded with chips.	
Mixing trips ...		10	9		
		Total binder ...	1·00 gallons.		
		Seal coat ...	0·25 ,,		
			1·25 ,,		
Condition: Good.		*Remarks:* Bled badly to start with and continued for some time.			

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
6	403 sq. yd.	0·25 gal. F.O./Spramex	0·5 gal. F.70	0·25 gal. F.70	*Nil.*
Mixing trips ...		10	9	10	
		Total binder ...	1·00 gallons.		
Condition: Good.		*Remarks:* Bled badly to start with in spite of less bitumen content.			

Section.	*Dimensions.*	*1st Application.*	*2nd Application.*	*3rd Application.*	*4th Application.*
7	491 sq. yd.	0·25 gal. F.O./Spramex	0·5 gal. F.70	0·25 gal. F.70	
Mixing trips ...		10	9	9	
		Total binder ...	1·00 gallons.		
Condition: Good.		*Remarks:* Similar to Section 6.			

General Remarks.

It is to be noted that bleeding only occurred in these sections where the fuel oil and spramex mixture was used either as an initial application or as a seal coat. The material that seeped to the surface contained more oil than asphalt and came up in small bubbles. Once the bleeding stopped, the whole surface set up very hard and after eight months' wear shows no sign of traffic marks.

Harnai Road.

The shingle used for this road was clean river-bed shingle from $1\frac{1}{4}''$ downwards, laid loose to a thickness of 4" consolidated to 3". According to the formula, by the grading of the shingle the theoretical bitumen content should be 0·65 gallons per sq. yd. Owing to cut-back bitumen F.60 and F.70 being used, which contains 35% solvent, 1·00 gallon per sq. yd. was used. The procedure adopted

was the same as the Kuchlak road experiment, and the essential details are as under :—

Day.	*Dimensions.*	*1st Application.*	*2nd Application.*
1	676 sq. yd.	0·5 gallons F.60 7 parts. F.70 3 parts.	0·5 gallons F.60 1 part. F.70 9 parts.
Mixing trips ...		12	11
2	784 sq. yd.	0·55 gallons F.60 9½ parts. F.70 2 parts.	0·55 gallons F.60 4½ parts. F.70 10 parts.
Mixing trips ...		18	14
3	808 sq. yd.	0·50 gallons F.60	0·50 gallons. F.70
Mixing trips ...		12	8
4	752 sq. yd.	0·50 gallons. F.60	0·50 gallons. F.70
Mixing trips ...		8	8

Condition : A portion of this has eventually set up quite hard, but is rough and does not appear to have a very even surface. A length of about 1,000 ft. has completely failed.

General Remarks.

This experiment has been almost a complete failure. Just before the experiment started there had been rain which soaked the ground. One length of road was under water for some hours. The experiment was stopped and the road allowed to dry out. No more work was done till the surface appeared to be perfectly dry.

After the mix-in-place had been completed the roller was put on to consolidate the surface, but the mat was found to be soft, the surface broke up, and in one patch the roller sank in and had to be dug out. A portion of the length eventually hardened and proved satisfactory, but a length of about 1,000 ft. completely ravelled and the shingle remained loose. Though every particle seemed well coated with bitumen, there was no binding property in it, and the section was marked down a failure.

A sample of the mat has been sent to the Burma Shell chemists for analysis. I attribute the failure to three causes :—

(*a*) The damp in the sub-grade rose and, combining with the oil solvent in the bitumen, emulsified the oil, definitely killing the binding properties of the bitumen.

(*b*) The binder content was in excess of what was really required.

(*c*) The shingle had been under water and had become coated with a very fine deposit of clay and the fines were not sufficient to allow the mix to set up quickly.

The finished surface of the portion which eventually hardened out is rough and has many voids in it, showing a lack of fines. It will require a seal coat and blinding with stone chippings to make a satisfactory smooth surface.

Type (ii), an ordinary earth road, into which shingle had been worked by traffic, with a solid and hard sub-grade but no soling.

Sperargha Road.

The road surface consists of well-consolidated shingle 10′ wide. The portion chosen for the experiment is level and has easy curves. The aggregate consisted of screened, unwashed river-bed shingle 1¼″ downwards.

Sufficient aggregate was collected to provide a loose mat 10′ wide, 3″ thick, which would be consolidated to 2″. The heated cut-back bitumen was poured by hand with two applications and the same procedure was adopted as with the other experiments.

The essential details are as under :—

Day.	*Dimensions.*	*1st Application.*	*2nd Application.*
1	490 sq. yd.	0·5 gallons F.60	0·5 gallons. F.70
Mixing trips ...		6	6
2	556 sq. yd.	0·59 gallons F.60	0·5 gallons. F.70
Mixing trips ...		6	6
3	612 sq. yd.	0·5 gallons F.60	0·5 gallons. F.70
Mixing trips ...		6	6
4	667 sq. yd.	0·5 gallons F.60	0·5 gallons F.70
Mixing trips ...		6	6
5	612 sq. yd.	0·5 gallons F.60	0·5 gallons. F.70
Mixing trips ...		6	6

Condition.

Rolling with a 6-ton roller was started the day after the first mix was laid, but had to be stopped owing to the softness of the mat. It took a long time to harden out and the surface showed a tendency to pick up under traffic. It required continual rolling to take out the marks of traffic and was apt to spread out beyond the 10′ width, in spite of a 4″ × 4″ trench dug on each side to prevent the spreading and the breaking away of the edges under traffic.

There has been no sign of bleeding and the surface, which at first was rather coarse, has now become finer. The eventual result has been satisfactory.

General Remarks.

The theoretical bitumen content for the shingle used amounted to 0·65 gallons per sq. yd., but 1 gallon was used.

The gravel contained a very small percentage of fines and this, together with the excess of bitumen content, caused the slow setting of the mat. The lack of fines caused a coarse surface and kept the mat soft under traffic, necessitating continuous rolling and causing some spreading. The width of 10′ is a definite disadvantage, as wheels are apt to track, leaving the centre untouched. Traffic is necessary to consolidate the mat and bring the fines to the surface to seal it. No priming of the sub-grade surface was carried out, yet the key of the mat seems satisfactory. There is undoubtedly an excess of solvent and this has helped to prevent the mat from setting hard.

Type (iii), a road which has been soled and metalled with water-bound macadam, of which the surface has so broken up and deteriorated that it would require re-metalling.

The Bazaar road, connecting the Cantonment of Loralai with the main bazaar, was taken for the first two experiments, being a metalled road, very badly worn, which carried a much heavier volume of traffic and had long been due for re-metalling.

1st Experiment.

Area covered	200′ × 14′.	
Aggregate used	Clean river-bed shingle ¾″ downwards, 2″ loose layer, consolidated to 1½″.	
Cut-back used	F.60 heated for 2 days to drive off some of the solvent.	
Quantity	For mixing ..	0·36 gal. sq. yd.
	For priming base	0·33 ,, ,, ,,
	For seal coat ..	0·22 ,, ,, ,,
		0·91 ,, ,, ,,

Procedure.

(*a*) The shingle was collected into a windrow in the centre of the road.

(*b*) Cut-back 0·36 gal. per sq. yd. applied and mixed with the grader. Windrow formed and moved to one side of the road.

(*c*) Base of half the road cleared and primed with 0·33 gal. per sq. yd.

(*d*) Windrow moved to the other side of the road and remainder of sub-grade primed.

(*e*) Mat levelled and spread with $\frac{3}{4}$" layer of sand. Sand brushed off after 3 days.
(*f*) Seal coat 0·22 gal. poured.
(*g*) Rolling started and road opened to traffic after 4 days.

Result.—The surface and texture of the mat is excellent but bleeding occurred for some time. It is not even as, owing to the thinness of the mat, it has taken the original roughness of the road.

2nd Experiment.

Area covered	.. ..	400′ × 14′.
Aggregate used	.. ..	Clean river-bed shingle mixed with sand in the proportion of 2 : 1, laid 2" loose to be consolidated to $1\frac{1}{2}$".
Cut-back used	.. ..	F.60 heated to 170°.
Quantity for mixing	..	0·66 gal. per sq. yd.
For priming base	..	0·25 ,, ,, ,, ,,
Total	..	0·91 ,, ,, ,, ,,

Procedure. After brushing road surface.

(*a*) First application of F.60 at 0·33 gal. sq. yd. and mixed in by grader fitted with a mixing blade.
(*b*) Windrow flattened out and second application of 0·33 gal. F.60.
(*c*) Base primed as before with 0·25 gal. per sq. yd.
(*d*) Windrow spread to even thickness and rolling started.
(*e*) Road opened to traffic 2 days after rolling started.

Result.—The surface and texture of the mat is excellent, as in the first experiment, but a good deal of bleeding occurred. The mat has moulded itself to the existing worn surface and has become uneven.

General Remarks.

In each of these experiments, the mat being thin has to a certain extent shaped itself to the original unevenness of the road surface, though the new surface is less uneven than the original road. Therefore, when laying a thin mat, any great faults in the original road surface should first be levelled by patching, using the same mix prepared by hand. The patches should be given time to set hard before the new mat is laid. The bleeding was, in my opinion, due to two causes :—

(*a*) Excess of bitumen content in the mix.
(*b*) Priming of the road surface and not allowing sufficient time for it to set up.

No lifting of the mat or sliding under traffic has been observed, either on curves or on the straight.

The object of the priming is to give a key to the mat, and if the old macadam surface is rough and has been brushed clean, there appears to be no necessity for the original priming. If the old surface is fine and loose, priming may be necessary. A cut-back bitumen with a high percentage of solvent should be used, applied at not more than 0·25 gallons per sq. yd., blinded with stone chippings, then rolled and left for at least four days to harden out. This should give a perfect key.

3rd Experiment.

For this experiment a mile of the Loralai–Harnai road was chosen. The existing road was an old water-bound macadam, which had worn considerably and in places the soling was sticking up. It had lost its shape to a great extent and though there were no potholes, traffic had worn longitudinal depressions. To scrape the surface and restore it with the grader blade was out of the question, as it would have removed the metal and so defeated the object of the experiment. Any soling heads which projected were broken off by hammers so as not to interfere with the grader blade during mixing.

Area covered, 474 sq. yd.

Aggregate used.—In view of the shape of the road it was decided to lay a mat of 2½″ loose, consolidated to 2″, since the final consolidated depth would vary considerably and on high spots would probably not exceed 1″. Since good shingle was not near the site and small boulders were available in great quantities, a granulator was used for crushing the gravel with the jaws set so as to produce nothing that would not pass the ¾″ mesh. No screening was done and the whole produce of the granulator was used.

Cut-back used.—Equal quantities of F.60 and Mexphalte 30/40. On the first day this mixture was heated to 170°F., but as the mixing was found to be rather difficult, it was heated to 230°F. on the second day, with better results.

Quantity.—The theoretical binder worked out to between 2·412% and 2·97%. To allow for the solvent, 3% was decided on equivalent to 0·55 gallons per sq. yd.

Actually, 0·6 gallons per sq. yd. was used applied in two applications of 0·3 gallons per sq. yd. It would have been better to have used 0·25 gallons for the second application instead of 0·3 gallons.

The average grading of the aggregate was found to be as follows :—

Retained in the 10 mesh	86·75%
Passing 10 mesh retained on the 200	12·65%
Passing the 200	0·60%
	100·00%

The weight of the aggregate was 95 lb. per loose cu. ft. and 178 lb. per sq. yd.

Procedure.

(*a*) The width of the road being 12′, the aggregate was spread in a flat form, 5′ wide and 6″ deep, down the centre of the road. This was marked off into 10′ lengths, and one bucket containing 4 gallons was poured over each length. This was the first application of 0·30 gallons per sq. yd.

(*b*) This was formed into a windrow and then mixed by a grader and mixing blade requiring 10 trips of the grader.

(*c*) The mass was then spread out and the second application of 0·3 gallons poured.

(*d*) Mixing was again carried out, requiring 12 trips of the grader.

(*e*) When completely mixed the mass was then spread out by the grader blade to the required thickness to cover the 12′ width of road and left for the day.

(*f*) Rolling was started and went on while traffic used the road till no marks were left by the traffic.

To prevent spreading beyond the 12′ width, a 4″ × 4″ notch was cut alongside the metal, and this was most successful, leaving a clean straight edge to the mat.

Result.—Only 450 feet length of road could be done, as the temperature at night dropped very considerably and it was decided to postpone the completion of the mile till warmer weather set in. The mix was excellent and the surface as good as it could be. It set up remarkably well, and the texture of the surface was close, requiring no seal coat.

General Remarks.

In my opinion, this is the best mix that has yet been turned out in Baluchistan by the mix-in-place methods, and the close texture of the surface clearly demonstrates the advantages of the inclusion of fines. The object of the experiment was successfully attained, for the finished road was true to shape and even the highest spots on the old road were covered with an adequate thickness of mat.

The cost worked out to approximately Rs. 5,000 per mile for the 12′ width, 2″ consolidated thickness. This cost should be reduced for a large area with trained gangs and the correct machinery.

MIX-IN-PLACE USING COLD BITUMEN EMULSION.

There was no slow-breaking emulsion in India, so arrangements were made with the Bitumuls Corporation of America to ship a small quantity of their H.R.M. emulsion (heavy road mix) to enable a mile of road to be surfaced. The mile chosen was on the main Quetta–Chaman road, near Kuchlak. The surface was an old water-bound

macadam, soled, which had been covered with a thick coat of shingle, and which had consolidated into a hard mat.

The following experiments were carried out :—

No. 1.—Shingle was spread to a depth of 1½″ loose, using sizes from 1½″ downwards with only 10% fines. The emulsion was applied at 0·75 gallons per sq. yd. to the dry shingle in 3 shots, by pouring from cans and by hand-pumps from the 40-gallon containers.

Between each application the shingle was coated with the emulsion by 4 trips of the grader.

After the last mixing operation the mass was spread by the grader and rolling attempted.

Result.—The mix remained loose, owing to the excess of emulsion, and seemed hopeless. However, it has since bound and set in a remarkable way, but owing to the large-sized shingle and lack of fines, a seal coat of 0·20 gallons of emulsion per sq. yd. was found necessary and applied. This was blinded with stone chippings and rolled. The result is now excellent.

No. 2.—The road was swept clean of all loose material and very carefully screened shingle, from which the fines had been extracted, was spread over the road to a depth of 1½″, using shingle from 1½″ downwards.

The emulsion was applied by hand-pumps at the rate of 0·50 gallons per sq. yd. in one application. The shingle was sprayed with water before the application of the emulsion and during mixing.

Mixing was done by a rake, consisting of a square wooden frame, fitted with a number of ½″ steel dowels. About 4 trips of the rake were made, and the surface then rolled.

Result.—The elimination of the fines was done to reduce the quantity of emulsion. It is proved from this that fines are necessary, as there was a lack of binding in the surface. The rake mixing had the effect of bringing all the heavy stuff to the surface, leaving the small stuff at the bottom. The surface set up excellently in the end and is very satisfactory. A seal coat of 0·20 gallons per sq. yd. was applied, blinded with stone chippings and rolled. The finished road after the seal coat is very good, except in a few patches.

No. 3.—The road was swept clean and shingle containing about 10% fines was spread to a depth of 1½″.

The emulsion was sprayed by hand at the rate of 0·50 gallons per sq. yd. The shingle was sprinkled with water before and during the mixing. Mixing was done by the grader, 4 trips being required.

After mixing, the mass was spread to an even thickness over the 16′ width and rolled.

Result.—This gave a good surface but, owing to the insufficiency of fines, a seal coat of 0·20 gallons per sq. yd. was necessary. The mat appeared thin in places, but this was due to faults in spreading, not in the materials.

Hand-spraying of the emulsion is not satisfactory, as the emulsion begins to break before it can be mixed with the shingle, unless done in very small lots. A 1½" loose coat of large shingle is not a satisfactory specification with an unskilled crew. The finished surface is very good.

No. 4.—The road was swept clean and the sub-grade primed at the rate of 0·20 gallons per sq. yd., consisting of 50% diesel oil, 25% furnace oil, 25% spramex.

Shingle containing about 10% fines, size 1½" downward, was spread loose to a depth of 2" to 2½". The shingle was lightly sprinkled with water before mixing and the emulsion was sprayed by a power distributor at the rate of 0·75 gallons per sq. yd. in one application.

The mixing was done by the grader in 6 trips. After mixing, the mat was spread to an even thickness and the surface rolled.

Result.—A power distributor had been made up and proved of very great value. Water was used in this case to delay the break-up of the emulsion. Due to insufficient fines, the surface is not quite dense enough and it may require a seal coat.

The surface obtained in this experiment is the best yet obtained.

The next two experiments were carried out to find a method of saving a water-bound metalled road which had not worn badly, but which was bumpy and showed signs of breaking up.

No. 1.—The road was brushed clean and watered lightly. 0·50 gallons of H.R.M. emulsion and 0·50 cu. ft. of stone chippings, ¾" downwards, were used. By means of the pressure distributor a track coat of 0·25 gallons per sq. yd. was sprayed on the sub-grade and blinded with 30 lb. of chippings per sq. yd. A second 0·25 gallons of emulsion was sprayed over the chippings and blinded with the remainder of the ½ cu. ft. of chippings. A drag broom was passed over the surface to level out the chippings and the surface rolled.

Result.—A very satisfactory method of providing a light wearing surface at a minimum cost. It remains to be seen whether the surface will take the inequalities of the original road.

The same results can be obtained both with the hot mix, using cut-back bitumen, and with the cold mix, using a bitumen emulsion, and from the experiments carried out, a comparison between the two processes will be made. The plant used was makeshift, no skilled men were available and only a small quantity of emulsion was obtainable. Therefore the emulsion has not yet had a fair test.

Cut-back Bitumen.

(*a*) No water is required. In fact, water is a danger and work cannot be done in wet weather or on a damp road.

(*b*) Heating in boilers is required and supervision to see that the solvent is not driven off by excess heat.

1.—Pouring the hot bitumen by hand.

2.—Forming the windrow after the first application by tractor and grader fitted with a mixing blade.

Road surfacing by the mix-in-place method in India 1-2

3 and 4.—Moving the windrow across the road to ensure all particles being coated with bitumen.

5.—Tractor and grader fitted with mixing blade carrying out the final mixing operations.

Road surfacing by the mix-in-place method in India 3-5

(*c*) The mix takes longer to set and gives more time for working. Rolling has to be carried on while traffic is using the road to remove wheel marks.
(*d*) More mixing trips of the grader are required to get all particles coated with bitumen.
(*e*) Any form of good shingle can be used.
(*f*) The minimum amount of bitumen is required as there is only a small percentage of solvent.
(*g*) Cut-back bitumen is cheaper than an emulsion at present.

Bitumen Emulsion.

(*a*) Water is required in certain cases, as it helps to coat the particles.
(*b*) No heating is required.
(*c*) The mix sets up quicker and is easier to work.
(*d*) Less mixing is required, and in thin mats no mixing at all, as the emulsion when shot into the aggregate by a pressure distributor will coat all particles.
(*e*) Care has to be taken in selecting the shingle and it should be clean.
(*f*) More emulsion is required than cut-back bitumen to give the same bitumen content.
(*g*) Emulsion is more expensive than cut-back bitumen at present.

When economy is of vital importance and time is no great object, then a cut-back bitumen should be used. When speed and ease of working are most important, then a slow-breaking bitumen emulsion is, without doubt, the best solution. When emulsion suitable for a road mix is made in India near a scene of operations and carried in bulk instead of containers, the price will be reduced and may be able to compete with cut-back bitumens, as regards cost. In my opinion, a bitumen emulsion gives just as good results as the cut-back and has the advantage of speed and ease of working, but is at a disadvantage as regards cost.

Machinery and Plant.

The plant used consisted of :—

1 caterpillar 30 tractor.
1 caterpillar 35 grader with ordinary and mixing blade.
1 caterpillar 20 planer.
1 bitumen boiler.
1 6-ton steam roller.

Pouring was done by hand with 4-gallon cans fitted with a baffle just in front of the spout. For the emulsion, hand-pumps, which

could be put into the containers as they arrived on site, were used. Work was slow in consequence, causing idle days for the plant and more labour was required than would be the case with better plant and better organization.

With the hot mix, the amount of work that could be done in a day was limited by the amount of bitumen that could be heated in one boiler. The limit was 600' of 12'-wide mat. With two boilers this could be increased to from 1,500' to 1,800' in a day, which is an economical task for mixing for a grader. Pouring by hand is a slow process and means more trips of the grader for mixing owing to the delay caused while the pouring is being carried out. The bitumen cools and does not coat the particles so readily. During the experiments with the emulsion mix, a pressure distributor was improvised from an old 350-gallon water tank on wheels. This was electrically welded to make it proof against a 40-lb. air pressure and moved on its bed to give room for a small compressor driven by a petrol engine. A spraying bar was attached, fitted with nozzles, and when this outfit was working properly, proved of inestimable value. For the hot mix this distributor is being fitted with a steam coil and fire-box and will be filled from the bitumen boiler. By spraying from a distributor, the mixing will be easier and less trips of the grader will be required. The economical length of road for mixing with a grader is about 1,500', as with shorter lengths so much time is wasted in turning and more mixing trips are required. The number of mixing trips can still further be reduced by using a double-disc harrow and a spring tooth harrow towed by a separate tractor directly behind the distributor. For a cold emulsion mix, if the double-disc harrow and spring-tooth harrow are used, mixing with the grader blade can be entirely eliminated.

For economy in cost and speed in execution, I recommend the following which I regard as a unit for mix-in-place work :—

1 caterpillar 30 tractor for grader.
1 caterpillar or wheeled 20 tractor for planer, double-disc harrow and spring-tooth harrow.
1 caterpillar 35 leaning wheel grader, fitted with a mixing blade in addition to the ordinary blade.
1 caterpillar 20 planer.
2 pressure distributors (not self-propelled), fitted with a steam coil, to be suitable for either hot or cold mix-in-place.
1 double-disc harrow.
1 spring-tooth harrow.
2 6-ton oil-driven rollers.
2 bitumen boilers fitted with pumps if hot mix process is used.

With the above plant, the best results will be obtained in every way and the capital cost will very soon be covered by the savings effected.

For the thin mats, the best results have been obtained from the heavier type of shingle crushed to $\frac{3}{4}$" in a granulator. The material binds much better than the round shingle and the fines, being stone dust, help to make a denser and smoother mat. A 12" granulator driven by a steam roller was tried out, but the delivery was only 3 tons or 70 cu. ft. per hour, which was found too small. A 20" granulator is now being fitted on a portable platform, driven by a 3L2 Gardner crude-oil engine, which will deliver $5\frac{1}{2}$ tons or 128 cu. ft. per hour. Two of these machines will be able to provide an economical day's work for one mix-in-place unit.

Cost.

Owing to want of experience, lack of knowledge of the best type of machinery to use and how best to use what we had, the cost of the experiments carried out is higher than would normally be the case with experienced and trained labour. A few of the costs per mile are given here merely as a guide :—

(i) 3" mix-in-place, using river shingle and cut-back bitumen F.60 and F.70, per mile, 10' wide ..	Rs. 5,148
(ii) 2" mix-in-place, using river shingle and bitumen emulsion, per mile, 16' wide, approx. ..	Rs. 8,000
(iii) $1\frac{1}{2}$" mix-in-place, using crushed boulders and shingle $3\frac{1}{4}$" downwards, per mile, 12' wide, approx. .. .. (Of this, approx. Rs. 450 is freight.)	Rs. 4,600
(iv) Light wearing coat, using stone chippings and bitumen emulsion, per mile, 16' wide, approx.	Rs. 4,000

Lessons Learned from the Experiments.

Owing to the low cost and speed with which work can be carried out, bitumen as a binder for a metalled road is a very practical proposition in India. Ordinary shingle taken straight from a river-bed can be used or crushed quarried stone or boulders. To obtain a dense smooth surface, from 15% to 20% of fines should be included according to the size of the shingle. The inclusion of fines will mean a larger bitumen content, but by rolling or under traffic, the fines come to the surface and effectively seal the surface, obviating a separate seal coat.

The mix-in-place is the cheapest method that can be adopted and, provided the correct plant is available, the correct amount of bitumen is used, and common practice is followed, there should be no failures and only good results should be obtained. In warm weather the F.60 and F.70 used in the experiments have undoubtedly too

much solvent, causing a slower set, and it will be found better to have a cut-back bitumen made with less solvent. The most suitable amount of solvent will have to be found by experiment for each locality.

It is absolutely essential that, before any work is done, samples of the aggregate to be used should be taken and carefully tested to find out the following percentages :—

(*a*) Percentage retained on the 10 mesh.
(*b*) Percentage passing 10 and retained on 200 mesh.
(*c*) Percentage passing 200 mesh.

From these percentages the theoretical bitumen content should be calculated and this should be tried out first. For a primer fuel oil should not be used, as this is apt to cause bleeding. If priming is required, this should be done with cut-back bitumen F.60 and given sufficient time to soak into the sub-grade and dry out.

For a road surface with a solid or hard sub-grade, such as soling or an old shingled road, a maximum consolidated thickness of $2\frac{1}{2}''$ of a mix-in-place should be sufficient to stand up to any traffic. Where the road to be surfaced has only to take ordinary traffic a 2" mat should be ample. For saving or surfacing old metal roads, a consolidated thickness of from 1" to $1\frac{1}{2}''$ should be sufficient according to the state of wear of the old surface. Any large pot-holes or heavy depressions should first be levelled off, allowed to set and rolled before the new surface is applied. The old surface should be swept clean and if it is found rough, no priming coat will be necessary. If the surface is loose, a priming coat should be given and allowed to soak in for 3 or 4 days.

From experience, not less than 12' width should ever be laid, as on a narrower width vehicles track and the centre portion of the road gets no consolidation from traffic. The minimum amount of camber should be given, *i.e.*, not more than 1 in 60.

A $4'' \times 4''$ notch should be dug on each edge of the old surface, to give a better key at the edges and to prevent spreading. This can best be done by using one tine of the scarifier fitted to the grader. A hot mix should not be used in wet weather or on a damp road surface, as the solvent is apt to emulsify and kill the binding properties of the bitumen. The mix-in-place method has been used in America for many years, and I am convinced that there is a great future for it in India. By using it, at least twice the length of road will be able to be surfaced for the same money and the costs of maintenance will be very greatly reduced. As regards the life of the mix-in-place in India, I can give no figures yet, but from the sections which have been laid for one year, the prospects as regards life look very promising indeed. As the life of an ordinary water-bound macadam road has been increased by sealing the surface with a thin coat of

tar or bitumen, so much more will the life be increased if the whole thickness is bound and sealed with bitumen.

As stated before, the results obtained with the hot mix and cold emulsion mix seem about equal, but at present the cost is against the cold mix.

The heavy road mix emulsion will very shortly be made in India, and if there is a demand for it, prices will be so fixed as to enable it to compete with other similar materials.

For rapid road surfacing on service there is no question that cold emulsion will solve a great many difficulties and training in this method should be carried out as soon as suitable materials are available in India. It should be possible with two sets of road machinery units to complete up to one mile a day. The advantage of a mix-in-place is that the surface can be opened to traffic within three days of laying and will improve as the traffic increases. A 6-ton roller will remove any marks caused by the traffic. Any form of aggregate can be used provided that it does not crush under a roller, but crushed stone certainly gives the best results.

The question of the necessity for a seal coat has been examined very carefully and the following conclusions arrived at from the experiments made.

In places where the mix-in-place has to be subjected to frost, a seal coat, blinded with chippings and rolled, is essential. This will definitely prevent any moisture penetrating the surface and causing it to ravel by the moisture freezing.

Where the fines used consist of grit and sand, and the weather is warm, the fines will work to the surface under rolling and traffic, and seal it, obviating a seal coat. Where only earth can be obtained as fines, it has been found better to eliminate fines altogether. This will much reduce the bitumen content. After the surface has been rolled, the balance of the bitumen can be used as a seal coat, at from 0·1 to 0·15 gallons per sq. yd., blinded with small chippings and rolled.

Where the H.R.M. cold Emulsion (bitumuls) is used, work will be done quicker and better if the fines are eliminated, and the finished surface given a seal coat, which should be blinded with chippings in which there is a percentage of small fines.

From the results obtained it has been decided to surface approximately 40 miles of old roads in Baluchistan during 1933–1934.

THE WORKING AND RECONNAISSANCE OF A RAILWAY DOCK.

By LIEUT. A. E. M. WALTER, R.E.

BEFORE making a reconnaissance of any description the methods of operating and the factors affecting these operations must be thoroughly grasped. No time will then be wasted gleaning useless information. Therefore before considering the reconnaissance of a dock we shall consider :—

A. The purely executive side of handling a cargo boat and its cargo.
B. The dock organization required to handle cargoes.
C. Some of the more important cargoes and the equipment for, and methods of, handling them and data.
D. Dock and railway layout.

The import dock will be visualized throughout, *i.e.*, the dock handling vessels bringing in cargoes for the various bases which will have to be established to maintain an E.F.

A. We shall follow the progress of a boat and its cargo from producer to consignee and see what persons are involved and how they function. To start with, assume the vessel loaded and at sea nearing its port of destination. Five important people are at work dealing with the boat and its cargo, viz., the consignor, the consignee, the ship's owners, the ship's agent at the port of destination, and the captain of the boat.

As soon as the boat is loaded and clears port, the consignor sends to the consignee a bill of lading, a most important document which gives all particulars of the cargo, its loading, tonnage, costs, etc. In each port the owners of a particular line of ships appoint a ship's agent. As the vessel nears its port of destination, the ship's agent is informed as to its probable time of arrival and on what tide the ship will expect to enter and dock. The ship's agent then :

a. Arranges for berthing accommodation with the dock authorities and the dock agent.
b. Arranges for pilotage of the ship to its berth.
c. Engages a stevedore to discharge the cargo.
d. Deals with customs authorities.

These are the main duties performed by the ship's agent to get the vessel to its berth and start discharging. Before the cargo can be discharged, the consignee has to present his bill of lading to the ship's agent, showing that he is the rightful owner of the cargo and that it has been paid for. Leaving out for a moment the actual discharging of the vessel, while the cargo is being discharged the captain arranges with the ship's agent for the supply of:

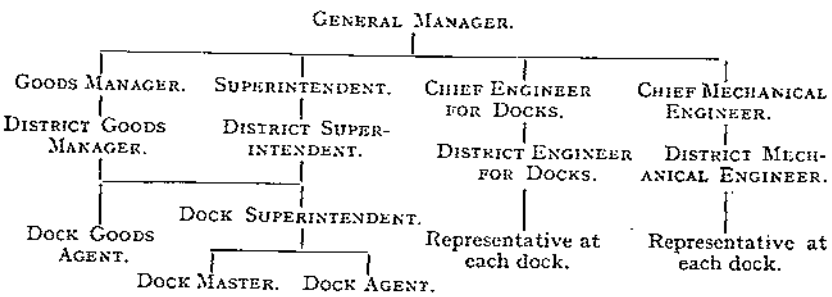
1. *Water.* The water flag is flown and the water boat supplies the water at a certain charge per 1,000 gallons.
2. *Ship's Stores.* The re-provisioning of the ship, if necessary, is done by contract with a chandler through the ship's agent.
3. *Coal* is supplied direct from colliery to ship, the supply being handled by the district train and traffic control.

The ship's agent also arranges for any repairs to the ship required by the captain. Finally before the ship leaves, he arranges for the payment of customs duties, harbour fees, and pilotage out of dock. Thus the ship's agent is a sort of fairy godmother to the ship and looks after it completely. Since he arranges for stevedoring, contracts for coal, stores, repairs, etc., his favour means business.

Consider now the discharge of the cargo itself. There are two stages of discharge. The first, performed by the stevedore and his gang—lifting the cargo from the hold to the deck. Except with timber, the stevedore's responsibility for moving the cargo ends at the ship's rail. The second stage is the move from ship's rail either to rail or to transit shed or to warehouse. When the quayside crane can plumb the hold these two operations are performed by the one crane. When the lift is too great for the quayside crane, the first stage is performed by the ship's derricks, the second by the quayside crane. The gang employed by the stevedore works only on the ship and provides all the labour (except for the winch men in charge of the ship's winches) required to lift the cargo from the hold up to deck. The crane men and all labour beyond the ship's rail required for loading the cargo into wagons or moving it to shed or warehouse is supplied by the railway company. The consignee decides how the cargo shall be dealt with, *i.e.*, to rail, to shed, or to warehouse, and the responsibility for the safe lifting of the cargo lies with the ship's agent—and so the consignor—as far as the ship's rail. Thus if an accident occurred to a load while being lifted, and the load was beyond the ship's rail, the damage has to be borne by the consignee or by the railway company executing the lift with its quayside crane. A timber load is the only exception to this. Cranes are usually loaned out at so much per hour by the railway company to the consignee—including risks usually—though sometimes cranes are charged for by the tonnage lifted.

It may be of interest to note how the labour is engaged for these two stages. At two periods of the day, usually 8 a.m. and 1 p.m., the dockers not already engaged for a shift of work gather near the gangway (or in some docks in pens) of a ship about to discharge or discharging its cargo. The stevedore stands on the gangway and, shall we say he wants six men, he selects his six by pointing at each of his selections. The sight, unfortunately, is very reminiscent of a cattle market. This method has to be adopted, however, since the labour required for each shift varies.

B. Below is set out the whole organization from which dock organization is built up:—



The Dock Superintendent is in charge of the dock, and in his operating capacity is responsible to the District Superintendent, and in his handling of cargoes is responsible to the District Goods Manager. He has under him:

1. *The Dock Master*, who deals with what might be called the sailor side of dock working, *i.e.*, operating the lock, getting the ships into and out of their berths, and movements about the dock.
2. *The Dock Agent*, a very important official who:

a. Allots berths to incoming vessels. This he does from a docking order—kept from information received from ship's agents, showing: Vessel (name), Dimensions (length, beam, draught), Remarks. In the remarks column is shown the contents and loading of the cargo. He keeps a daily plan of the docks, showing the quay accommodation occupied and empty.

b. Keeps a check on the handling of goods on the quays, in the transit sheds and in the warehouses, so as to keep goods moving and avoid congestion. He has to consider shed and warehouse accommodation just as he considers quay accommodation, *e.g.*, it is little use sending a vessel with 5,000 bales of wool to a warehouse quay with room in the warehouse for only 100 bales.

c. He allots and arranges ahead as far as possible coaling berths with coaling appliances to avoid delaying vessels in dock. It is one of the main principles of dock working to clear ships as soon as possible and, at the same time, keep the quays, sheds, and warehouses as clear as possible. Thus the maximum number of ships will be handled in the minimum of time, and there will be a continuous uncongested flow of traffic from and to the dock, though in the dock we are considering there will be chiefly a flow of loaded traffic from the dock and a flow of empties to the dock.

C. We shall now consider some of the more important cargoes and how they are handled.

1. GRAIN. There are three methods usually adopted to handle grain :

(*a*) *Silo.* This is a very specialized method and, as there are few docks in the world—only four in England—adapted to this method, it is of interest rather than importance to us. By means of a silo grain is handled in bulk in vast quantities entirely mechanically. The method is :—Photo 1 shows a 3-ton luffing jib electric crane fitted with a bucket elevator (each bucket holds nine pounds of grain) on an endless belt and a suction pipe. The bulk grain in the hold is ploughed either by steel or wooden ploughs (worked by the ship's winches through tackle on the ship's derricks) toward the elevator. The buckets raise the grain and discharge it into a hopper on the suction pipe. A specially fitted coach on the quayside contains the suction apparatus. The grain is drawn down the suction pipe and falls through a temporary hopper on the quay on to an endless belt erected in a tunnel under the quay. On this belt the grain travels to the end of the quay where it is discharged on to another belt which conveys the grain to the silo. A silo is a large granary adapted for the mechanical reception and discharge of grain—the large concrete building in the background of Photo 2 is a silo. From the belt under the silo the grain is raised by elevators to hopper shaped bins inside the silo, each bin holds 140 tons. The operation on one belt alone has been described above, but of course these belts are multiplied in practice, *e.g.*, there are four belts in the tunnel under the quay and so on. There are three methods of discharge from the silo—to rail, to lighter, or to motor lorries. The grain from the hoppers is automatically weighed as it emerges and is either poured into sacks which are loaded to wagon, or else poured down a chute to bulk grain wagons. Photo 2 shows in the background one of the four discharge chutes discharging grain in bulk to a lighter. Grain in bags is also poured down these chutes to men loading the bags in lighters. For discharge into motor lorries the grain, as it pours from the automatic weighing machine under

the hopper, is poured into bags which are wheeled on trollies, by men working the silo, to the lorries waiting on the road outside.

(*b*) *In Bulk to Lighters Automatically.* Photo 2 shows clearly in the foreground this method of discharge. The grain is raised by elevator from the hold as before and then discharged on to a horizontal endless belt. This belt discharges into an automatic weighing machine (Avery 2-ton), from which the grain passes down a chute into the lighter. The automatic weighing machine is erected on the column as shown, the column being erected on the deck of a barge which is moored alongside the vessel discharging. The weighing machine can thus be moved about the dock from vessel to vessel.

(*c*) *In Bulk or Bags to Lighters using Manual Labour.* The grain in the hold if in bulk is bagged by a stevedore's gang working in the hold, filling bags in the same way that sandbags are filled, except that a large flat metal saucer about 2′ diameter and 6″ deep is used instead of a shovel. The bags are then lifted by the ship's derricks up to the deck, weighed, and emptied down a chute into the lighter —overside discharge, or the bags are lifted off the deck into the lighter alongside. The grain in the lighters is thus either in bags or in bulk. Grain in bags in the lighter is then discharged in one of two ways. The lighter goes to a berth where there is a quayside crane and the bags are lifted by crane out of the lighter and (*a*) lifted into wagons still in bags or (*b*) the bags are lifted by crane to a first-floor door of a warehouse. Men then empty the bags down a chute into bulk grain wagons standing on a railroad alongside the warehouse. When grain is in bulk in a lighter loaded as above, it usually implies that the lighter is destined for some nearby miller. The grain is again bagged, this time in the lighter, and lifted to the miller's warehouse.

PROVISIONS. Butter is always packed in kegs, which are lifted from the hold in nets either by the ship's derricks or by a quayside crane if the latter can plumb the hold. The nets are lowered to the quay and the kegs are manhandled on trollies into the transit shed or loaded direct to wagon. All other provisions, including meat, fruit, potatoes, eggs, flour, etc., are discharged in the same way, though where the cases in which the commodity is packed are of suitable shape (square sides), slings instead of nets are used. When packed in sacks, such as potatoes and flour, slings are also used. There is nothing peculiar in the handling of provisions and ordinary methods of lifting and loading are adopted.

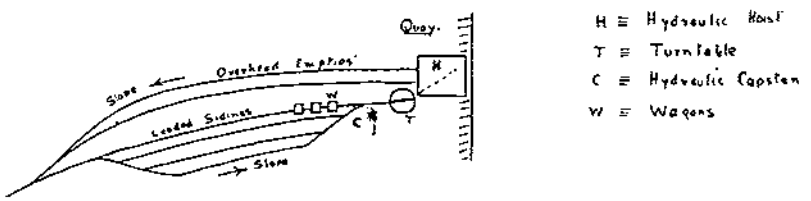
TIMBER is of special interest as it forms the bulk of engineer stores. Two main cases arise—round timber such as telegraph poles, pit props, etc., and sawn timber. In the case of round timber, the handling is perfectly straightforward. The poles and props, etc., are lifted by slings out of the hold and stacked in wagons,

either for restacking in the timber reserves near the dock, or are sent out by rail for use elsewhere.

Sawn timber is handled differently. A temporary platform of sawn timber is erected on the quay. The timber is lifted in a sling by the ship's derricks from the hold and then, while still in the sling, is guided by men on the temporary platform so that one end of the timber rests on the platform with the other end resting over the side of the ship. The sling is then removed, and men carry the timber to timber bogies (7-ton bogies) and stack it on the bogies. As each set of bogies is loaded it is drawn off by the pilot and empties shunted in.

COAL. Since we are considering an import dock, the methods of coaling a ship and the equipment required will be discussed rather than the methods of discharging coal from a ship. Though there are six methods of handling coal (as shown in Table IV), three types

DIAGRAM No. 1.



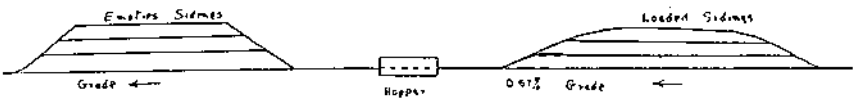
of equipment are chiefly employed, viz., hydraulic hoist, endless belt and crane.

1. *Hydraulic Hoist.* Photo 3 shows an hydraulic hoist in operation, and Diagram No. 1 shows the railway layout required. The wagons from the various collieries supplying coal to the ship are marshalled in the loaded sidings. Two men, a shunter and the hoist man, are required to operate the hoist as follows:—A steel hook on the end of a rope is hooked round one of the leading axle guards of a wagon and the rope then wound a couple of times round the hydraulic capstan *C*. The rotation draws the wagon forward on to the turntable *T*, where it is brought to rest on a rail chock. The loaded sidings slope towards the turntable *T*, and this movement of drawing the wagons forward is aided by gravity. On the turntable the steel hook is withdrawn and the wagon is run on to the cradle of the hoist and locked. A long ram then lifts the cradle and wagon to the level of the chute, and, while in this position, the back of the cradle is lifted and the wagon tipped. The coal then slides out of the wagon down the chute into the vessel. End-door wagons must, of course, be used. The cradle is then lowered to the level of the overhead empties roads which slope away from the hoist. The wagon runs off the cradle due to gravity (Photo 3), and is braked

down one of the empties roads by the shunter. The operation from the arrival of the wagon on the turntable to its placing on the empties road occupies two minutes for a 20-ton wagon, *i.e.*, coaling at a rate of approximately 600 tons per hour. In many cases ships require mixed coal of various classes. In such cases each kind of coal is marshalled in a separate siding, and the wagons drawn forward from each siding in turn, thus mixing the coal.

2. *Endless Belt.* End-door wagons are tipped by an hydraulic ram and the coal poured into a hopper built below ground level. The hopper discharges on to an endless belt, which rises steadily to the tower shown in Photo 5. The coal is discharged from the endless belt into the hopper on this tower and then passes down the chute into the ship. The height above quay level of the belt and the hopper in the tower can be raised by an hydraulic ram, and the slope of the chute thus varied to suit any particular ship. Two types of belt are used—a leather composition belt chiefly for small coal and a steel linked belt (rather like the tracks of a tank) capable of handling large coal. The rate of supply by

DIAGRAM No. 2.



this method depends chiefly on how fast wagons can be emptied into the hopper, and, of course, on the speed of the belt. The speed at which wagons can be emptied depends primarily on the railway layout. The simplest method is to employ bottom-door or hopper wagons discharging to a hopper below. The next improvement to this is to erect the hydraulic wagon-tipping apparatus described above, enabling end-door wagons to be employed as well. The best railway layout is shown in Diagram No. 2 and, as will be seen later, can easily be incorporated in the railway layout for whole dock. The single road over the hopper provides the unfortunate defile in the layout which is unavoidable. Speed of discharge can, however, be helped by suitable grades (1 in 150) from the loaded sidings to the hopper and away from the hopper to the empty sidings, and, above all, by a well-organized drill by the men dealing with the wagon on the hopper.

3. *By Crane.* Photo 4 shows an example of this simple method. Twenty-ton end-door wagons are lifted by two slings, one longer than the other, to provide the tipping as shown. Four men and a crane man are required. A single road past the crane is all that is required, provided the wagons have been suitably marshalled before being brought to the quay. Two men fix and unfix the slings and,

as seen in Photo 4, go up with the wagon when it is lifted. When the wagon is in its correct position, these two men slip the catches of the end door and so discharge the coal. One man controls the wagon by a rein as it is lifted (see Photo 4), and guides it to its correct position over the ship. The fourth man is seen about to draw forward another loaded wagon in the same way as described above by a rope round an hydraulic capstan. Horses could equally well be used for this purpose, especially as they are used to draw forward the empties when they are landed, and so keep the road in front of the crane clear. This method is very hard on the wagons, especially as the empties are being lowered to rail, but is far less specialized than the two previous methods described. The crane shown is a 25-ton luffing jib hydraulic crane. If a dock had no coaling appliances this method would undoubtedly be the first to be installed, as any kind of crane of the required capacity would do the job equally well.

D. Dock and Railway Layout and Data.

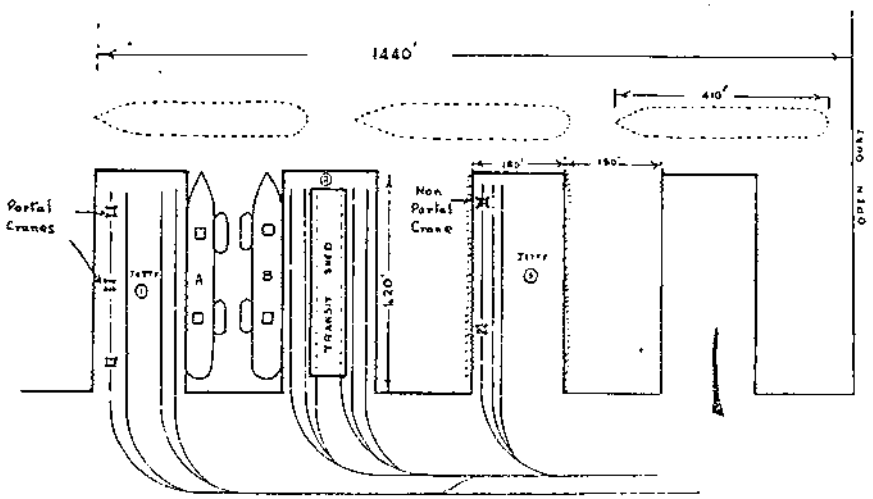
The question of dock layout is entirely dependent on the types of berth required for discharging cargoes. With the cargoes that have been discussed there are two methods of discharging, and the type of berth is named accordingly. A vessel may discharge to quay, thus requiring a quay berth, or may discharge overside and require an open berth. The terms are self-explanatory, and also give an indication of the cargo carried. For example, to a vessel with a cargo of heavy machinery an open berth is no use, as the powerful lift of a quay crane will be required. Of course, when possible a vessel in a quay berth will discharge the heavy portion of its cargo to the quay and the light portion overside to lighter.

To get the maximum out of a dock, the maximum number of ships must be accommodated per unit area of water. Keeping in mind the methods of discharge, the best layout for a dock to accommodate the maximum number of ships is the jetty berth layout, *i.e.*, a number of jetties or berths instead of a long open quay. Take an example (see Diagram No. 3). Suppose we have 1,440 feet of quay. Considering vessels 410 feet long at a maximum we can only accommodate three such vessels. Now on the same length of quay suppose we construct four jetties each 420 feet long and 180 feet wide, with a water space 180 feet wide between each jetty. Seven or eight vessels each 410 feet long can be accommodated in that same length of dock. There is no question then as to which is the better layout. In special circumstances, of course, such as for coaling, an open quay is usually best. The layout should, therefore, contain a few open quays fitted with coaling appliances, and the rest of the dock should be cut up by jetties. Continuing a step further: since we want to discharge from both sides of a vessel, and

since jetties are provedly most economical in dock length, a water space between jetties must be of such a width that with a vessel moored on either side of this water space, there is room for a row of lighters alongside each vessel and an open waterway (at least the width of a lighter) between the lighters down which empty lighters may, as it were, be shunted in to replace the loaded lighters alongside the vessel. Thus in the water space between two jetties we get, from left to right (see Diagram No. 3), vessel A, row of lighters moored to A, water space at least the width of a lighter, row of lighters moored to vessel B, and vessel B.

Having decided on the best type of layout, we next meet four important points to be decided: (i) length, and (ii) width of jetty,

DIAGRAM No. 3.



(iii) width of water space between jetties, and (iv) mechanical equipment required on the jetty. The answer to the first three points lies entirely in the tonnage of the vessels to be handled.

No hard and fast rule can be given, since the design of vessels of the same tonnage varies considerably. Table I has been arrived at by taking the averages of dimensions and tonnage of a large number of cargo boats as given in Lloyd's Register. From this table we see that if we have a jetty, say, 420 feet long, we can take vessels up to 6,000 tons, provided we have the depth of water required. Thus a basis for the design of jetties is arrived at. For example, to build a jetty 400 feet long, and only dredged to a depth of 20 feet, is pure waste—boats up to only 250 feet long can be accommodated at such a jetty, and 150 feet of jetty length is wasted. And, *vice*

versa, if the tonnage of a certain class of ships bringing a class of cargo that is wanted, say timber, is known, then the jetty can be designed accordingly. Continuing a step further, if the jetty is, say, 400 feet long, and of the correct depth, we know from Table I that the maximum tonnage of any vessel moored to the jetty will be 6,000 tons. We therefore design the crane power and rail layout to be able to deal with a 6,000 ton vessel. Jetties with inadequate crane power and clearance facilities are thus avoided, and so congestion in the dock is avoided. Since overside loading on one side at least of a ship is being considered in our layout—the dimensions and capacity of lighters, viz., 70 feet long by 20 feet wide, and 80 to 110 tons, should be noted.

TABLE I.

LENGTH.	*Maximum* BEAM *to be expected.*	*Max.* DRAUGHT *to be expected.*	TONNAGE *will not exceed.*
100′	25′	10′	160 tons
200′	34′	15′	1,000 ,,
300′	45′	25′	3,000 ,,
400′	55′	30′	6,000 ,,
500′	70′	38′	10,000 ,,

CRANE POWER. Having decided on the best layout and dimensions of the jetty, adequate crane power has next to be provided. The speed at which a vessel carrying a certain class of cargo can be discharged depends on (i) the number of holds which can be plumbed by crane and derrick, and (ii) capacity and siting of the cranes. Unfortunately, since the designs vary so immensely, there is no method of generalizing for the number and positions of the holds to be expected with any given tonnage of shipping. Cranes must therefore be portable all over the dock. The normal rates of discharge of various types of cargo as obtained in a modern dock must be known and are shown in Table II. If we know the length of the jetty and the depth of water, we know the total tonnage of any cargo that we may be expected to handle at that jetty. Knowing the rates of discharge for any cargo that it should be aimed at obtaining (Table II)—the crane power for the jetty is arrived at if rate of discharge of various types of crane with various cargoes is known

TABLE II.—RATES OF DISCHARGE.

Commodity.	*Method of Discharge.*	*Tons per 8 hrs.*	*No. of Men Employed per Gang.*	*Organization of Labour.*
GRAIN ...	1. Bulk to bag in hold. From hold in bags weighed and overside to lighter.	80	9	2 men in lighter. 2 men in wagons. 1 sheeter. 1 crane lad.
Ditto ...	2. Lighter to quay.	99	6	
Ditto ...	3. In bags in the hold lifted by sling and crane.	90		
FLOUR ...	In bags; from lighter to quay by slings, 4 to 6 bags per lift. 12 to 14 stone per bag. 30 lift per hr.	104	5	2 men in lighter. 2 men in wagon. 1 sheeter.
BUTTER ...	In kegs: lifted in nets; kegs 1 cwt. 1,000 kegs per hr. by crane.	400		By crane.
TIMBER Round ...	By slings.	460		4 cranes.
Deals ... Battens ... Boards ...	By sling and staging.	75	8	

Note.—Description of timber:

Deals, Battens, Boards: 1 Standard = 165 cu. ft. = 2½ tons.
Square timber: 1 Standard = 80 cu. ft. = 2 tons.
Round timber: 1 Standard = 100 cu. ft. = 2½ tons.

Unfortunately again, since the capacity of a crane depends on so many factors—type of crane, electric, hydraulic or steam—length of jib and whether luffing or fixed—maximum lift allowed—high-water level of ordinary spring tides (to plumb the holds)—the organization of human labour helping the crane, and finally the railway layout on the jetty, in practice, on taking over a dock, the various cranes will have to be timed with different cargoes (suggested in *M.E.*, Vol. VIII, para. 4, p. 28) and the crane capacity altered in any or all of the above details to try and reach the standard set by the rates of discharge given in Table II. As an example of how crane

TABLE III.—CRANE POWER.

Jetty each 420' by 180'.	*No. of Cranes.*	*Max. Lift.*	*Description.*
A	2 1	7 tons 3 tons	Portal, portable, luffing jib, electric.
B	2	5 tons	Portal, portable, fixed jib, electric.
C	No cranes at all.		
D	3	30 cwt.	Fixed jib, hydraulic.
E	3	25 cwt.	Ditto.
F	4	30 cwt.	Portal, portable, luffing jib, hydraulic.
G	3	30 cwt.	Portal, portable, fixed jib, hydraulic.
H	No cranes at all.		

power, even in similar jetties, varies, Table III is given to show the numbers, types and lift of cranes all installed on similar jetties in one modern dock.

RAILWAY LAYOUT. Finally, having discussed dock layout and crane power, the third very important factor in the design of a dock-railway layout must be considered. Photo 6 shows a bad railway layout for a jetty. The three 30-cwt. fixed jib hydraulic cranes are certainly portable on the railroad shown, but there is only one road beside the cranes for loaded and empty wagons alike. Thus, as

shown, those loaded wagons will have to be led and empties shunted in by the pilot before discharge can continue. This is a waste of time, especially when the importance of the time of discharge of a vessel is considered. In Photo 6 discharge, actually, is over and things are idle on that jetty, but it illustrates admirably a bad railway layout.

Photo 7 shows a good railway layout. Here, though there are, as in Photo 6, only two roads beside the jetty, there is always a spare road on which empties can be placed while the wagons on the other road are being loaded. Discharge is then continuous. This advantage, admittedly, is obtained by using portal cranes, rather than by alteration of railway layout, but it illustrates continuous discharge. It has a further advantage. In the layout of Photo 6, as soon as the wagons are loaded it is imperative that they should be led immediately and empties shunted in. This necessitates the pilot being available at the precise moment. With the layout in Photo 7, empties can be shunted in at any time convenient to the pilot during the loading on the second road, and also the loaded wagons can be led at any time convenient to the pilot. This greatly helps the working and cost of the pilot engine, and avoids sudden imperative demands on it, often, possibly, at the same time from a number of jetties. The four cranes shown are 30-cwt., luffing jib, portal, portable hydraulic cranes. Diagram 3, Jetty 2, shows the same good layout of Photo 7, with the addition of a transit shed.

Photo 8 shows a really good layout for a quay berth with warehouse. There are three roads—one under the portal cranes, the other two between the cranes and the warehouse. A three-road layout such as this should especially be adopted when the cranes are not portal (Diagram 3, Jetty 3). Note the hammerhead portable crane on the roof of the warehouse on the outward side—the quayside of the warehouse being the inward side. Note also the discharge to the quay and overside to lighter.

With regard to hydraulic cranes, the question arises as to how they can be portable. They are made portable (i) by running on railroads as shown in Photos 6 and 7, and (ii) valves on the hydraulic main are installed in the quay or jetty under a small metal cover every 20 feet along the quay or jetty. The cranes thus move in bounds of 20 feet when working.

DOCK RECONNAISSANCE.

M.E., Vol. VIII, Sec. 8, para. 1, p. 26, gives the principal considerations in the selection of a dock. The best sources from which to

gather information for a dock reconnaissance are the District and Dock Superintendents. The reconnaissance report is probably best given in the form of as large a scale plan as possible. The offices of the above two officials are the best places to look for a plan. Since he keeps a daily plan, the Dock Agent is also a likely source of information. The plan must then show :—

1. *Quay Frontage.* Dimensions must be given showing the length of quays and jetties, the width of jetties, width of water space between jetties, depth of water in various parts of the dock.

2. *Position.* Of all cranes, elevators and coaling appliances. The actual details of the dock equipment are best given in an Appendix attached to the plan made out as shown in Table IV.

TABLE IV.—DOCKS COAL CAPACITY.

Dock.	*Numbers.*		*Lift in Tons.*	*Motive Power.*	*Does it handle 20-t. wagons?*	*Capacity in 10-ton Wagons.*			*Max. Height of Ships above H.W.O.S.T.*	*Method of Handling.*
	Hoist.	*Crane.*				*Wagons per Hour*	*Weight per Hour*	*Weight per 16 hours*		
A	No. 2		20	H	Yes	20	200	2,500	34′	3
B		Nos. 1 to 10	3	E	No	—	120	1,000	36′	4
C		No. 23	40	H	Yes	20	200	2,100	30′	3
D	No. 1		20	H	No	45	450	5,000	33′	1
E			3	H	No	—	60	600	36′	5
F		No. 77	25	H	No	15	150	1,500	37′	6

Methods of Handling Coal.

1. Lifting wagons.
2. Wagons emptied into hoppers at quay level.
3. Lifting wagons on cradle.
4. Coal filled from side-door wagons into pans.
5. Coal tipped into hoppers at quay level, then conveyed by pans.
6. Lifting wagons by sling chains.

3. *Position* and dimensions of all transit sheds and warehouses.

4. *Position* of dock power house and details on a second Appendix of the pressure pumps and accumulators for the hydraulic cranes, the prime movers and generators for the electric cranes, the working of the power house in labour, coal and oil—a plan of the layout of the power house will be a great help.

5. *Position* of each timber drying shed with dimensions and the position and dimensions of all reserves round the dock which can be used for storing timber while seasoning or for storing other goods.

6. *Details* of the dredging plant for the dock should be given on a third Appendix. Dredging is one of the most important and often costliest features of dock working.

7. Last but not least the plan must show the whole railway layout including the signal boxes. Separate sketches, copied from the dock signal cabins, of the control provided by each cabin should be attached if possible. An idea of the railway working of the dock is then obtained and a good estimate of the capacity of the dock also obtained. The position of the loco shed for the dock pilots and details of the shed should also be included.

All the above points given in the reconnaissance report are necessary so that the three estimates of capacity as stated in *M.E.*, Vol. VIII, Sec. 8, can be obtained. As such a lot of the above information can be obtained quickly from existing plans kept by the District and Dock Superintendents, the report can be very detailed without taking undue time to make. In fact, half the art of making this reconnaissance lies in knowing how a dock works, and the best persons from whom the information can be gleaned.

Photo 1.—5-ton luffing jib electric crane, fitted with bucket elevator.

Photo 2.—Automatic discharge of grai into lighter.

Photo 3.—Hydraulic hoist in operation.

Photo 4.—Lifting 20-ton end-shoot wagon for unloading.

The working & recce of a working dock 1-4

Photo 5.—Hopper discharge on endless belt to tower.

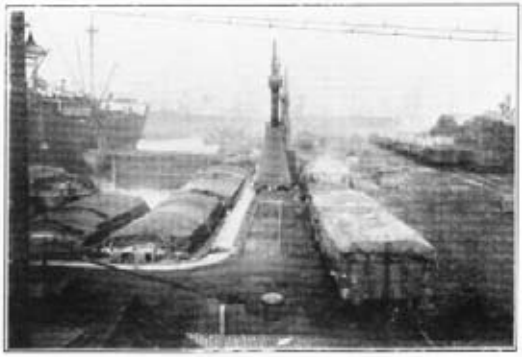


Photo 6.—Bad railway lay-out for jetty.

Photo 7.—Good railway lay-out for jetty.

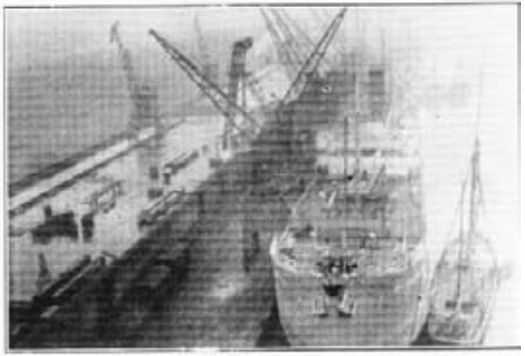


Photo 8.—Good lay-out for quay berth with warehouse.

The working & recce of a working dock 5-8.

NOTES ON TACHYMETRIC TRAVERSES.

By LIEUT. R. E. BAGNALL-WILD, R.E.

1. TACHYMETRY.

"TRAVERSES are normally run with prismatic compass or theodolite, level, steel tape and plane table, or with the tachymeter, which combines the functions of these instruments." (*M.E.*, Vol. VIII, page 143). In other words, the tacheometer or tachymeter may be called the surveyor's "one-man band." Many people think of the tachymeter as an instrument whose only use is the taking of topographical detail, which can be done as accurately and expeditiously by the plane table and clinometer. Others are either afraid of tachymetry as being altogether too "brainy," or contemptuously think of it as a lazy man's "guessing machine." It is, however, a simple instrument, the theory of which is fully explained in the *Text-Book of Topo. Survey*. It has many uses, but the object of these notes is to explain a method of traversing with the tachymeter that is rapid and, within limits, reliable.

2. INSTRUMENTS.

The instruments referred to here are those used by the Nigerian Railway.

(*a*) The Tachymeter. Cooke, Troughton and Simms, 5" Vernier Theodolite with converging lens between the object glass and diaphragm. The instrument is the same as the ordinary theodolite in appearance. It can be used for any work, including astronomical observations, that the theodolite is used for. An ordinary theodolite may be used, but entails adding on a constant in reductions. Special instruments such as the Jeffcot Direct Reading Tachymeter are unnecessary.

(*b*) *Staves.* Two types of staff can be used. The first is a home-made staff of wood 16′ long, divided into tenths of a foot, with black markings on a white background with red figures. The other type is a Cooke, Troughton and Simms 20′ telescopic staff divided into tenths of a foot with blue markings on a buff ground and red figures. The former are satisfactory, but the latter are useful in taking long shots on days when the "shimmer" is bad.

3. METHOD OF TRAVERSING WITH THE TACHYMETER.

In countries where there are no great local variations of magnetic declination, it is possible to set up the instrument by compass. The traverse is then run on the leapfrog principle as in levelling; that is to say, the instrument is set up by compass; the backsight is read; then any intermediate spots; then foresight to the forward station; the instrument is then moved on ahead of the forward station, which now becomes the back station, and the process is repeated.

This method has two advantages. One is that errors of direction are not carried forward, and the other is that the height of instrument need not be measured. In order to obtain the approximate ground level at the instrument station for sketching form lines, an assumed constant, say 5′, is deducted from the height of instrument. The horizontal plate is read on "A" Vernier only to the nearest 10 minutes, and the vertical plate to the nearest minute on "C" Vernier. In very hilly country "C" Vernier is read to the nearest 20 seconds. The normal length of shot when the bush is not thick is 900′: on very clear days 1,200′ shots are possible: on hazy days 600′ or less is the maximum.

4. ERRORS.

(*a*) *Book Reductions.*

These can be eliminated by a good system of booking (see para. 5).

(*b*) *Bad Adjustment and Setting Up of Instrument.*

Errors due to these faults have an uncanny knack of accumulating, but with care and practice they can almost be eliminated. It may be noted in passing that, unlike trigonometrical work, the bubble is not booked. As in levelling, the bubble must be correct, but if the instrument is not quite correctly set up, the bubble may be centred for each shot by a slight adjustment of the tribach screw without upsetting the line or level by an amount that will interfere with the accuracy desired.

(*c*) *Gross Errors.*

There is no greater liability to these in tachymetric traverses than in theodolite, or level work: in fact less, as the number of separate operations per traverse leg is less.

5. BOOKING AND BOOK REDUCTIONS.

The booking and reduction of a short traverse are shown in Appendix A.

(*a*) *Booking.*

Many errors are due to a bad system of booking. The ideal

method has a foolproof check similar to the height of instrument or collimation method of level book reductions.

(*b*) *Stadia Reduction.*

It is sufficiently accurate for most work to use a 4″ circular stadia computer, which is quick and easy to use. For more accurate work, or in very hilly country, it is better to use tables such as Jordan.

6. Adjustments.

The adjustments of the tachymeter are exactly the same as the adjustment of the theodolite, except that as the instrument is used on one face and swing only, adjustment of the vertical wire for collimation is unnecessary. As noted in para. 4 (*b*) it is most important that the instrument should be well adjusted and frequently checked for adjustment.

7. Accuracy.

Experience on the Lafia-Chad Railway Survey in Nigeria shows that, using the above methods, a consistent degree of accuracy can be regularly obtained.

A closed traverse five miles in length closes with a probable error of 0·2 foot for levels, and 50 feet for position. If the error is more than twice this amount there is almost certain to be a gross error. For longer traverses the probable error increases in proportion to the square root of the lengths. The longest closed traverse, without intermediate checks, was 42 miles in length, half run by one surveyor and half by another with a different tachymeter, and closed to 0·4 foot for levels and 200 feet for position. Another tachy traverse 21 miles in length was checked with a theodolite, and chain, and level, and closed to 100 feet for position, and 0·6 foot for levels. On an average about 50% of the error in position was due to errors in length and 50% to error in direction.

8. Speed.

Speed naturally depends on the nature of the country, vegetation, season, etc., and on the amount of topographical detail taken in addition to traversing. In undulating country with light "orchard bush," taking sufficient detail to show the direction and fall of spurs and re-entrants, one mile of traverse per hour in the field is a good average. In very easy country taking no detail 1½ miles of traverse per hour is probably a maximum. Book reductions and plotting by protractor can be done at 3 to 4 miles per hour.

9. COMPARISON WITH OTHER METHODS.

(*a*) *Theodolite, Chain and Level.*

1. Speed. Provided work with all three proceeds simultaneously, this form of traverse is as rapid as a tachymetric traverse.

2. Staff. This method needs 2 skilled and 5 unskilled men, as compared with 1 skilled and 2 to 3 semi-skilled men for the tachymetric traverse. In other words, two tachy traverses can be run by the same party as one theodolite, chain and level traverse.

3. Accuracy. See para. 7. It may be noted that for railway work, especially in war-time, the degree of accuracy of tachy traverses is sufficient to determine the possibility or otherwise of running a line, or which of two routes is the better.

(*b*) *Rapid Traverse (e.g., Compass and Wheel, or Compass and Pace and Abney Level or Clinometer).*

A traverse by these means is more rapid than a tachymetric traverse, but the accuracy of the levels and grades is very poor, unless there are plentiful spot levels, in which case there are certain to be good maps, and long traverses are unnecessary.

(*c*) *Rapid Traverse and Aneroid.*

This type of traverse is not so rapid as it appears, if reasonably accurate heights are to be obtained, owing to the advisability of keeping one aneroid in a fixed camp, not too far from any part of the day's work. Given motor transport, however, this type of traverse is much more rapid than the tachymetric traverse, and will produce reasonably accurate results with a small staff. It has the disadvantage for railway surveys, that the surveyor is liable to be influenced in his choice of route by existing highways.

10. CONCLUSION.

Tachymetry is as fast as any method of traversing that gives heights, except the motor-car and aneroid. It needs a smaller party than the theodolite, chain, and level method. With a little practice and great care in use it can be made to give results with a consistent degree of accuracy.

Station.	Staff at	Magnetic Bearing.	Vertical Angle.	Stadia.	Difference.	Corrected Dist.	Axial Wire.	Vertical Interval.	Back Sight.	Height of Instrument.	Intermediate.	Foresight.	Reduced Level.	Remarks.
B	A	271° 20′	88° 35′	955/4	555	555	6·8	+ 13·7	+6·9	774·5			781·4	Height of B 774·5 − 4·8 = 769·7
	1	86° 40′	91° 03′	973/2	773	773	5·9	−14·2			−20·1		754·4	Bed of stream.
	C	75° 00′	90° 00′	1156/2	956	956	2·3	—				−2·3	772·2	
D	C	251° 20′	90° 38′	1274/4	874	874	8·4	−9·7	−18·1	790·3				Height of D 790·3 − 4·7 = 785·6
	2	193° 00′	80° 04′	1036/3	736	714	6·7	+125·1			+118·4		908·7	Rock outcrop.
	E	81° 20′	89° 34′	1264/2	1064	1064	7·3	+8·1				+0·8	791·1	
													781·4	
									−11·2			−1·5	+9·7	This sheet does not refer to any actual traverse run.
												+11·2		
												+9·7	Check.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	

EXPLANATORY NOTES: Col. 3. To nearest 20′ on one vernier only.
„ 4. To nearest 1′ on one vernier only.
„ 5. Last figure is estimated. Lower stadia wire is on an even number.
„ 7. The correction can usually be neglected.
„ 8. Axial wire is either the mean of top and bottom stadia; or as in the forward shot from B to C, after the stadia intercept was read the top circle was clamped at 90 and the axial wire read.
„ 9. This is the stadia reduction from Tables or Computer.
Cols. 10, 12, 13. These are Col. 9 minus Col. 8.
Col. 11. This is the algebraic difference of previous reduced level and Col. 10..
„ 14. This is the algebraic sum of Col. 11 and Col. 12 or 13.
Cols. 10, 12 and 13 may be combined in one column, and column 11 may be omitted, the height of instrument being written in the "Remarks" column.

A SURVEY PARTY IN UPPER BURMA.

By CAPTAIN G. F. HEANEY, R.E.

THE writer of a paper on the Sierra Leone survey, which recently appeared in *The R.E. Journal*, expressed the hope that other survey officers would also write their experiences.

To the writer of the present article it has always appeared strange that although the great majority of officers in the Corps, who are on survey duty, are in the Survey of India, where they have experience of nearly every kind of survey work, in country and under climatic conditions as varied almost as are to be found in the world, practically nothing about their activities ever appears in the Corps magazine.

The aim of this article is not to impart anything new in the way of technical knowledge, but rather to give some account of the work of a normal Survey of India topographical party in an out-of-the-way part of Burma; and of the administrative and other problems that confront the officer in charge; and to throw a few sidelights on life in the field.

The survey year is divided into two periods—the field season lasting from about mid-November till May, and the recess from May till November. The recess is spent in the party headquarters in Maymyo, the summer headquarters of government, in the Shan hills not far from Mandalay and at about 3,500 feet above sea level. During recess, sheets surveyed the previous season are fair drawn for publication, triangulation and traverse work are computed, boards plotted and administrative arrangements made for the coming field season.

The officer in charge of the party is assisted by four gazetted officers, generally Europeans, of the Survey of India Department, who are in charge of drawing or computing sections in recess and camps in the field; in addition, he has four or five Indian or Burman Upper Subordinates, who act as assistants to the camp officers, do triangulation or take charge of small topo, or traverse camps. The rank and file of the party consists of sixty surveyors, traversers, computers and clerks and a varying number of *khalasis* (men for carrying instruments, chaining, etc.) and coolies.

The normal scales of work are half an inch, one inch and four inches to the mile. The first two are the scales adopted throughout the Indian Empire for topographical surveys in Indian states and undeveloped areas, and in normal areas respectively. The four-inch

scale is used for maps of reserved forests for the Forest Department. In addition, surveys are sometimes undertaken for other government departments or private firms, of areas for drainage, oil leases, rubber estates, etc. The total area surveyed and mapped during a year naturally depends on the scale, but is generally between three thousand and six thousand square miles.

While making preparations for taking the field, one of the main things to be considered is the provision of squads and transport for officers and surveyors. Each plane-tabler has a squad of five men, of whom two are Indians, imported from Hazaribagh in Bihar, to look after his instruments and equipment and act as mail runners: the other three are local men, or from the hill tribes of Burma and independent tribal territory.

In the Upper Chindwin District, where the writer's party has been working for the last couple of years, there are practically no cart roads and in large areas not even mule tracks. Coolie transport must therefore be largely employed. The local villagers, who are Burmans or Shans, make the worst possible coolies, or workers of any kind, for the matter of that, and the government regulations on the subject of coolie hire are hardly helpful. These lay down that coolies are to be paid at the rate of 2 annas 6 pies (2½d.) per mile, and that no coolie is to be given a load of more than 30 lb. Further, if the coolie is required to go more than 15 miles from his village he can make his own terms. Fortunately the average coolie does not insist on a too strict observance of these rules; but on one occasion recently in a disaffected area scales were produced, and every load was carefully weighed before acceptance, and the coolies stated that after the first fifteen miles (there were no villages farther on) their terms would be eight annas a mile. As several surveyors had to be moved and the distance was considerable, other arrangements had to be made at much inconvenience.

The Burman or Shan coolie can seldom be made to march more than eight to ten miles in a day, and although not a great worker is a great eater, and brings his rice from his own village. If he is required for more than a couple of days a point is soon reached where he cannot carry any of the baggage for which he is engaged, as he already has a full load of his own food. Which is absurd.

When coolies are wanted frequently or far from villages they must, therefore, be imported. Fortunately the hill tribes of Burma and independent territory, Kachins, Chins, Kukis and Nagas, are excellent workers, and each year numbers of these are recruited for the duration of the field season. Many of them are practically naked savages, but experience has shown that the farther from civilization the man comes, the better the worker. The best workers and most docile are the head-hunting Nagas of the independent territory of the Assam-Burma frontier. Presumably they have learnt from their

own chiefs the disadvantages of giving "backchat" to those in authority.

In areas where there are sufficient mule paths, officers, triangulators and traversers are provided with mules for transport. These come from the uplands of Yunnan, just beyond the Chinese border, and as they cannot live in the plains of Burma during the rains they must be imported on contract yearly. A Chinese muleteer is in charge of each batch of five mules. On being taken over from the contractor in Myitkyina or Bhamo, near the frontier, the mules are shipped by steamer to some convenient point lower down the Irrawaddi, and thence marched across country to the Chindwin, a march of from ten to twelve days.

At the commencement of the field season, camps' headquarters are the concentration points for surveyors, *khalasis*, coolies from the hills, mules and baggage. As most of them converge on the camps from different directions and travel by different methods, a careful timetable must be worked out beforehand to avoid time being wasted waiting, allowing a margin of safety for accidents such as blocked paths, flooded rivers, and missing the way, which all have to be reckoned with in long cross-country marches in jungle country with poor communications.

The Upper Chindwin District, the largest in Burma, is very thinly populated, and most of what population there is, is settled along the banks of the main rivers. Here alone extensive clearings are to be found. The remainder of the country is covered with dense jungle with hardly a clearing. Excepting the rim of the basin of the Chindwin, which largely coincides with the district boundary, and a couple of narrow ranges of hills, the height varies from five hundred to fifteen hundred feet above sea level. Much of the area can be triangulated by a skilful observer after heavy clearing for his stations; but such triangulation is of itself of little value to the surveyor who follows. The triangulator's intersected points are necessarily nearly all hill-tops, and the difficulty lies in the practical impossibility of finding these on the ground. From the theodolite station they are readily identifiable, but from the floor of the jungle the situation is very different. The surveyor, shut in on all sides and cutting his way through the undergrowth, cannot know whether the low hill he has just climbed is the one he saw from some miles away from the theodolite station. There may be a higher point a short distance away which he cannot see. Extensive clearing taking some days might prove him to be on the right point, but it would be more likely merely to prove the reverse.

In areas where work by resection is impossible, the main requirement in an intersected point is that it should be readily identifiable, not necessarily from a distance, but when reached on the ground. It then serves as the starting or closing point of a plane-table traverse

line. To achieve this it is necessary for the triangulator to visit a large proportion of his intersected points and either do some clearing or erect a large beacon or "flag" on a prominent tree, which will remain till the survey is finished. The surveyor thus knows when he has reached the point he is looking for.

Upper Burma, north of about latitude 23°N. has a very good cold weather from mid-November to March. In the mornings the plains are covered with thick mist which does not clear away till nearly noon. The triangulator who is at his station at sunrise finds himself looking over a level sea of cloud, above which groups of hills stand up like islands. If he is quick he can observe to his stations, provided they are on hill-tops, during the first hour or two. Then the clouds rise and blot out everything for some hours, before they finally disappear.

For the first couple of months in the field season the jungle has not dried properly after the rains, swamps are numerous and river crossings with mules are often difficult. Very often, too, the only practicable route is up the bed of a stream still fairly high, where quicksands are numerous and he who prefers to sit on a country pony rather than plod for miles through water must be prepared for numerous tosses. Mules, with their small feet, fare even worse than ponies, and a certain number are lost each year from exhaustion through getting bogged in quicksands or swamp; or as a Bengali surveyor put it when explaining the loss of a mule, "Sir, three times that mule fell down in the quicksand, and the third time he could not sustain."

The Chinese muleteers are adepts at improvising bridges and causeways over swamps. For the latter thick swathes of elephant grass, which is everywhere plentiful, covered with leaves and a layer of earth, generally answer satisfactorily. The two or three muleteers with an officer's followers form a strange little community. They make no attempt to fraternize with the other members of the party or with villagers; nor do they expect any assistance from anyone at any time, or give any. Each evening they collect round a solitary fire, cook their food and eat it with the aid of chopsticks, entirely oblivious of any interest the latter proceeding may cause. The majority are opium smokers, but the habit seems to do them no harm except occasionally to land them in difficulties with the police. On the mules being imported in the autumn permission is given to bring in a small quantity of opium per mule for medicinal purposes. How much of this is really given to the mules is always a matter of doubt; but one not worth enquiring into too closely. On one occasion the writer returned to camp one day to find his three muleteers had been removed to the lock-up, for illicit opium selling, by a zealous excise officer, and it was with some difficulty that he

succeeded in bailing them out, to enable him to continue his march the next day.

The early morning fogs, previously referred to, persist till the beginning of March or even later. Then follows a brief period of warm clear days. This is, however, of short duration, and very soon the smoke and heat haze sets in which heralds the approach of the hot weather. Very little rain falls between the end of November and the beginning of April, with the result that by March, when the leaves have mostly fallen, the jungle is like tinder and only a spark is needed to start an extensive fire. This is generally supplied by villagers, who burn off the old grass to improve the grazing for their cattle, and who in many areas burn clearings on the hillsides for their crops. By the end of March the air is so thick with smoke that triangulation becomes impossible, and plane-tablers have difficulty in seeing their points. The heat, too, becomes excessive except in thick evergreen jungle; and the thunder showers of April and early May, though they bring temporary relief, also bring in the first of the new season's malaria. It is, therefore, with a feeling of relief that officers and surveyors alike complete their field work in May and escape to the cooler and healthier climate of the hills.

It is a common fallacy that survey officers working in jungle country have unrivalled opportunities of big game shooting. This is by no means the case, at least so far as the officer in charge of the party is concerned. Big game shooting takes time; and during the field season the time of the officer in charge is divided into a week or ten days per month at his field headquarters, and the remainder touring his area inspecting the work of plane-tablers, traversers or triangulators. If he is to inspect their work adequately, each month provides a full programme of marches and inspections, and leaves very few days to spare for following big game, however plentiful its tracks may be.

The *shikar* enthusiast who commences by carrying a rifle in the hope of meeting something on the line of march gives up the practice before long. Huge areas of the jungles of Upper Burma are extraordinarily empty, or at least that is how they appear. Perhaps it is that being thicker than those of the Central Provinces of India, for example, the game has more chance of slipping away unseen. Be this as it may, the fact remains that one can tour for month after month in the jungle without seeing anything larger than a barking deer, and this only very infrequently.

There are a few areas, however, which are just the reverse of this, and where big game is altogether too plentiful for the comfort of the surveyor. One such area, in the low hills along the Irrawaddi-Chindwin watershed, was surveyed during the field season recently concluded. Here large herds of elephant frequent the beds of the

streams which constitute the only routes in the area, and bison are by no means uncommon. Two elephants and a bison were shot in self-defence by surveyors, and several times members of the party, including the writer, who does not carry a rifle while at work, had to leg it hard to escape solitary bull elephants, who objected to their presence and activities. On one occasion an urgent message was received from a surveyor for more men, as no less than three of his squad were laid up through throwing themselves over a bank in a frantic rush to evade a rogue elephant.

If the opportunities of big game shooting are disappointing, this is amply compensated for by the excellence of the small game shooting. In the swamps and shallow lakes which are frequent in the low ground, duck, geese and snipe are abundant, and jungle fowl are to be found round the edges of the freshly-reaped paddy fields. During most of the field season the inspecting officer who is at all keen on this form of shooting has more game than he can eat.

The edges of many of the swamps are converted into paddy fields in the spring, and a walk over the young "paddy" for snipe, an hour or two before sunset, followed by a wait for the flighting duck, will provide sport as good as could be desired; and this amid surroundings which could hardly fail to leave some impression on the most unimaginative. The young "paddy" stands out vivid green in the sunlight, which is reflected from the still surface of the lake. The hills along the skyline, lightly veiled with the faintest blue haze, blend with the deeper blue of the sky. Here and there groups of brightly-clad villagers, up to their knees in water, ploughing or planting out the young crop, provide a note of striking contrast to the prevailing blues and greens of the landscape.

The sun sets in a blaze of gold and pink, succeeded by a deep orange glow over the western horizon. The villagers and their buffaloes depart. A silence falls which is only broken by the occasional call of a barking deer in the surrounding jungle, or the distant quacking of wild duck. Then against the last glow of the sunset the flighting duck appear and flash overhead with the swish of many wings. For the next few minutes, while the flighting continues, the beauties of the scene are forgotten; and when it has ended the last of the glow is fading from the west and we make our way back to camp by starlight.

* * * * * *

The romance of frontier surveys is largely a thing of the past, and the borderland hills no longer screen the unknown; but even to this day a few blank spaces on the map remain. The country of the Naga tribes, on the borders of Burma and Assam, has been one of the last to yield its secrets to the surveyor; and until ten years ago

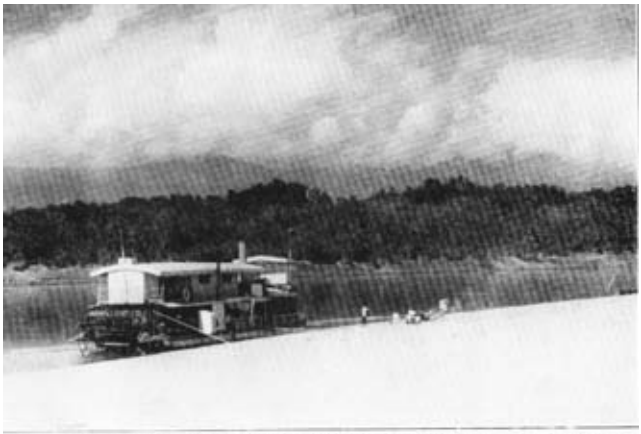
that on the Burma side was practically unknown. Since then military expeditions accompanied by surveyors have visited the Naga hills, and the greater part has now been mapped. The Nagas used to be notorious for their practices of slavery, head-hunting and human sacrifice, and the suppression of these was the main object of the expeditions ; but it is probable that in some areas the practices continue, though not so openly as before.

A hitherto unexplored part of these hills came into the area for survey last season. Owing to the rebellion in Lower Burma, then at its height, no military escorts were available to accompany surveyors, nor owing to the financial stringency would there have been funds to pay for them, had they been available. The political authorities considered it most unsafe to go into the area without escorts, as the principal village, Makware, about six marches west of the Chindwin, was thought to be hostile. It had been visited by a punitive expedition some twenty-five years before and burnt, since when no contact had been made with the inhabitants, who lived entirely cut off from the outside world. Seventy-five military police was considered the minimum escort for a visit to Makware, and even this would be attended with risks. It seemed, therefore, at first sight that any attempt to penetrate far beyond the administrative border, about ten miles west of the Chindwin, would be out of the question.

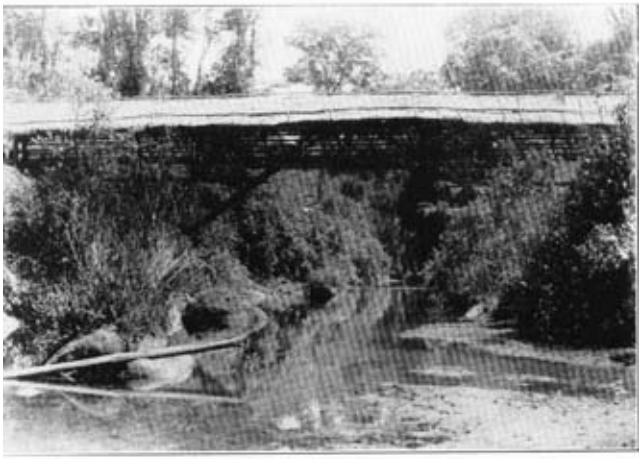
Reluctant to leave a blank in the map if there was the least chance of filling it, the writer selected two surveyors with experience of this part of the frontier and explained the situation to them. At all costs trouble with the Nagas was to be avoided, and at the first sign of hostility they were to retire. If, however, they succeeded in establishing friendly relations, and considered that work might be extended beyond the administrative line with safety, they were to go on. The hills ran up to over twelve thousand feet, and the principal tops had been fixed from a distance by triangulation, so there were no technical difficulties about the survey.

The results exceeded even the most sanguine expectations. After the first month the surveyor in the northern sector, one Narayan Singh, a Garhwali, sent in a message that he was pushing in from the river and would be camped in Makware in about three weeks' time. This report caused some anxiety to his officers, who thought that he might not realize the danger. A message was therefore again sent after him warning him to be careful.

The climax which came a month later was unexpected. His camp officer was camped on the Chindwin, when two of Narayan Singh's Indian *khalasis* arrived with a letter written from Makware itself. Anxiously he tore it open and was in the act of reading it, when a Naga clad in nothing but a loincloth, with a blanket thrown



—A government launch on the upper reaches of the Chindwin. The Naga hills ar
under the clouds in the background.



2.—A bridge in the hills built by villagers.

A survey party in Upper Burma 1-2

3.—Ferrying baggage across the Chindwin on a raft made from dugout canoes connected by a platform of bamboo.

4.—Hill coolies getting their loads ready.

A survey party in Upper Burma 3-4

over his shoulder, appeared at the door of the tent holding out a fowl as a present. He could speak not a word of Burmese ; and appeared rather frightened. This turned out to be none other than the headman of the dreaded Makware, whom Narayan Singh had sent in to ensure his messengers a safe conduct through the intervening Naga villages.

Friendly relations having been established with the inhabitants, the survey of the remainder of the area was carried out without difficulty ; and much to the surprise of the political officers, a visit of inspection by the O.C. party was welcomed. Even nowadays the element of romance and adventure has not entirely departed from the work of the Survey of India in Burma.

The officer in charge of a survey party, such as that described, has a freer hand in running his own show than in perhaps any other job in the Corps which he is likely to have with the same seniority. He it is who has to decide on the advisability of importing Kachin coolies from the eastern frontier or Chins from the west ; whether mules from China will be more satisfactory for his transport than ponies from the Chin hills ; or whether his Indian *khalasis* should be marched overland to Assam on repatriation or sent round by sea. He negotiates direct with the district officials over all problems connected with his work, such as the provision of escorts for surveyors or for the conveyance of money ; and must make his own arrangements for intelligence regarding the country in which he is going to work, the survey methods to be employed, the supplies and labour available locally, the communications, and the best form of transport to use. And the life is one that appeals to anyone who likes to visit peoples and places off the beaten track, and does not mind the partial isolation of six months a year in the jungle.

ELEVATED REINFORCED-CONCRETE RESERVOIR.

By MAJOR C. C. S. WHITE, R.E.

OWING to the provision of additional married quarters for the Q.V.O. Madras Sappers and Miners, it was found necessary to construct an 80,000-gallon reservoir at a height of 18 feet above ground level at the Meanee Lines, Bangalore.

Masonry, reinforced concrete and reinforced brickwork were each considered in turn for the construction of this work, but eventually the M.E.S. authorities decided to put the whole of the work out to tender as a lump sum contract, and see what the contractors offered. A specification sufficiently open to allow the reservoir to be constructed with any of the above materials was therefore prepared, and the work put out to tender. In order to prevent the contractor patching leaks, etc., to tide over the usual twelve months' period of guarantee, a special clause was inserted to the effect that he was to reconstruct entirely any portion proving faulty. Tenders were received from the majority of the leading building contractors in India. They were all for reservoirs built in reinforced concrete. So the design that was most characteristic of this form of construction, consistent with cheapness, was selected.

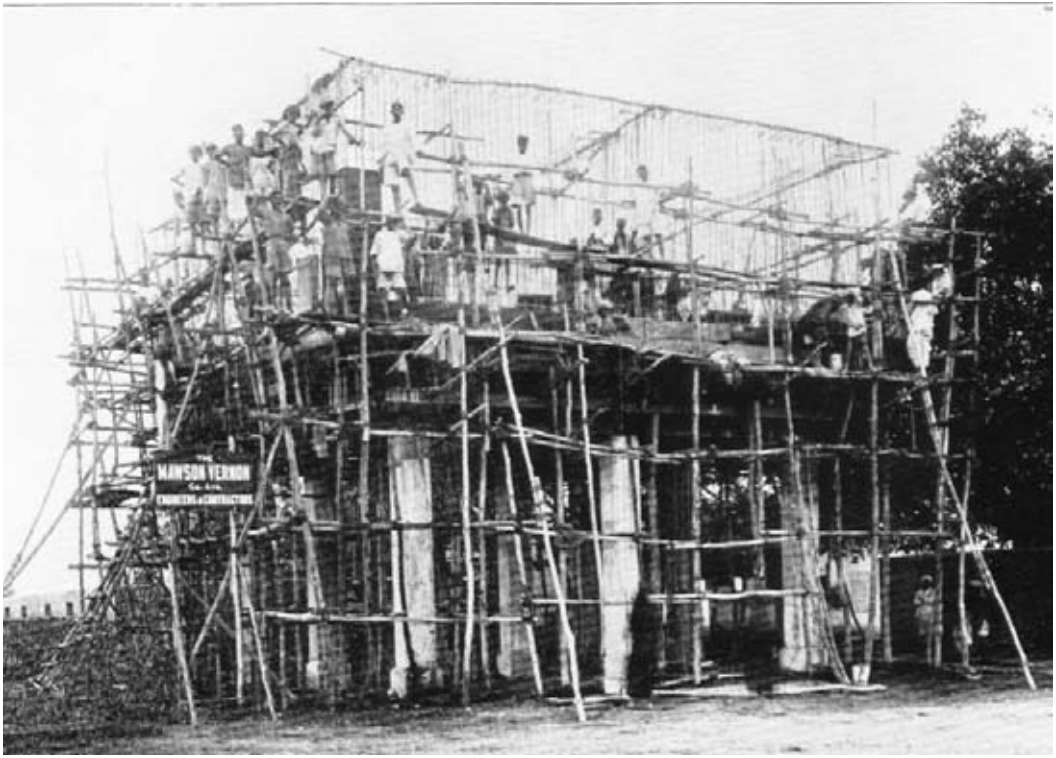
The contract was placed with the Mawson Vernon Co., Ltd., Bombay, who are reinforced-concrete specialists, on the 20th August, 1930. The time allowed for construction was four calendar months. Work was commenced on 9.10.30; it was expeditiously done and completed well within the time specified.

GENERAL.

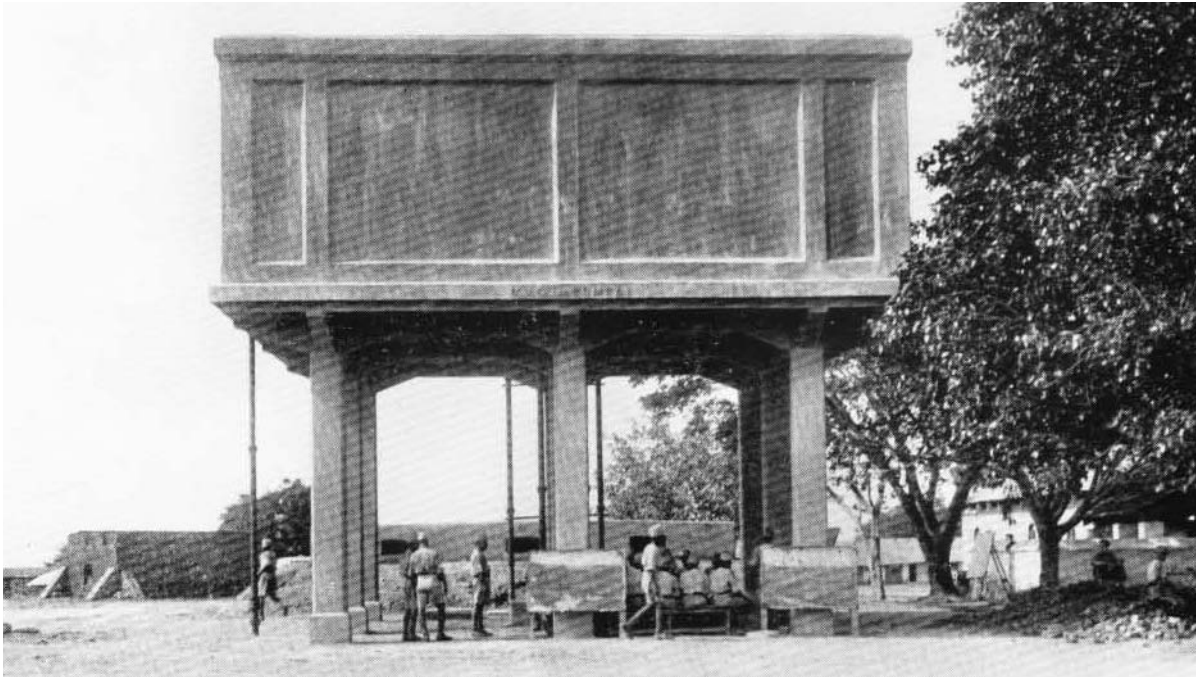
The reservoir is carried on nine columns each with its own separate foundation, and is supported by six continuous beams, which are designed as T-beams and project beyond each outside column forming cantilevers.

FLOOR.

The whole of the concreting of the bottom slab inclusive of these beams, cantilevers, and the first two feet of each of the walls, was done in one day of twelve hours, with an interval of one hour only. During this time 1,600 cu. ft. of mixture was prepared, lifted, and placed in position. This was the most important day in the con-



Elevated reinforced concrete reservoir 1.



Elevated reinforced concrete reservoir 2

struction of the work. Immediately the concrete was poured it was covered with a thick cement slurry to ensure it drying uniformly. Polishing the surface was begun as soon as it was set. This operation was done by the contractor's special skilled men.

Walls.

The vertical reinforcement of the walls was fabricated before the bottom slab was concreted (Photo 1). This left only the horizontal reinforcement to be inserted as the concreting of the walls proceeded. In order to ensure an absolutely watertight and hard surface, the inside of the walls was treated with "Ironite." This material was mixed with four parts by volume of water. In all three coats were used, each coat being applied after the previous one had dried, which normally took about twenty-four hours. The solution was stippled on the surface of the work. The concreting was brought up in two-foot courses, so as to avoid vertical joints. The centering was removed about six hours after each stage of concreting was finished. Then the inside of the wall was polished smooth whilst the concrete was still green.

Shuttering.

Special steel sheets, bolted together along their edges, were used throughout for the shuttering of the walls and columns. The lines of sheets were held in position by bolts and distance pieces. This obviated the use of outside supports for the formwork.

The shuttering for the bottom slab was erected in a very ingenious manner. The whole of the formwork was carried by twelve R.S.J's, which were temporarily fastened to the columns by 1-inch bolts. This not only saved a considerable number of timber supports and the labour involved in erecting them, but it also ensured a vibrationless formwork, which is essential for the proper setting of the concrete.

Labour.

The contractors brought their own engineer, carpenters, fitters and masons, whom they employ regularly. The unskilled labour was engaged locally. The engineer was present whenever work was in progress, and he made a special point of ensuring that the mixture was homogeneous throughout.

Reinforcement.

The bending of the rods was done entirely by this skilled labour. The percentage of reinforcement is approximately $2\frac{1}{2}\%$, and about

eighteen tons of British steel have been used; the rods vary from $\frac{1}{4}$ to 1-inch in diameter.

CONCRETE.

The cement used was manufactured in India by the Shahabad Cement Co., Ltd. The mixture was 1 : 2 : 4 up to the bottom slab exclusive. Above that, it was 1 : $1\frac{1}{2}$: 3 as an additional precaution to ensure watertightness. Sharp river sand was obtained locally.

The aggregate was the local "burnt" stone, a particularly good hard granite.

The concrete was mixed in a mechanical mixer of one cubic yard capacity. There is a total amount of 4,500 cu. ft. in the structure.

MISCELLANEOUS.

The maximum load on the foundations is $\frac{3}{4}$ ton per sq. ft.

The tank is divided into two equal compartments by a central wall, which has openings in it 6 inches below water overflow level. Each compartment contains one day's supply for the area served by the reservoir.

Separate inlet, outlet, and overflow wash-out pipes are provided to each compartment and necessary valves so that either compartment may be filled or emptied separately. All pipes which pass through concrete were embedded during concreting.

COST.

The total cost of the work inclusive of all piping within 10 feet of the foundations, water-level indicators, ladders, manholes, etc., was Rs. 22,350/-/-, which is equivalent to As. 4/4 per gallon. This compares very favourably with a steel water-tower, which would have required continual recurrent expenditure for painting, and would not have possessed any æsthetic appearance.

The finished reservoir is shewn in Photo 2.

THE PROBLEM OF COMMAND IN COMBINED OPERATIONS.

By MAJOR B. C. DENING, M.C., R.E.

IT has been an axiom on land that success in a theatre of war can only be ensured by placing all the forces operating under the command of one man (*vide F.S.R.* I, 2 (3)). In the following pages, from a study of history and modern conditions, an attempt has been made to arrive at how far in combined operations, particularly with the forces of the British Empire, this axiom can be applied.

INTRODUCTION.

In examining this problem, which is not totally new, it is advisable first to consider how command has been exercised in the past before discussing the question of one C.-in-C. for naval, military and air forces employed in a combined operation.

This question is more difficult when considered in relation to the forces of the British Empire than to those of any other great power, such as U.S.A., France, Japan or Italy, which also possess navies, armies and air forces. In the Empire there are not only the difficulties inherent in the combined action of three fighting Services to be dealt with, but also those which must arise when the forces concerned originate in a group of peoples, which are widely separated in point of distance, living conditions and material objectives if not in point of blood and ideals. In the other Powers, the fighting forces at least come from one continent and are under one government. It will be necessary, therefore, to investigate in addition the control of the forces of the Empire as distinguished from those of the U.K.

When dealing with the past, a student is always faced with the problem of where to begin. It is possible to go back to the Siege of Troy or to the Campaigns of Alexander, Scipio and Hannibal when seeking examples to prove a lesson for the future. But here it is suggested that to revert beyond the period when the fighting Services began to be controlled by ministries responsible to a parliament is unprofitable. In the first place, prior to those days operations of any size were primarily the affairs of soldiers. Secondly, they had their origin in some dominant personality, a king or an emperor, who himself closely controlled all the forces, whether naval or military. Thirdly, it is the comparatively modern conditions which have brought about the problem under consideration.

Not only is it desirable to restrict attention to comparatively recent history, but it will be of advantage to examine in the main English history rather than that of foreign nations. The Portuguese, the Spaniards, the Dutch, and the French have all in turn possessed Colonial empires and have fought combined operations in their cause. The Japanese in the present century have carried out combined operations of the first magnitude. But the methods of government, the organization of the fighting services, and especially the psychology of these peoples have been so different from those of the English, that too deep a study of the methods they adopted would perhaps be misleading. An arrangement that would suit a foreign race would very probably fail with the British. For this reason only restricted reference to foreign amphibious operations will be made.

1. THE COMMAND OF COMBINED OPERATIONS IN THE PAST.

To examine in detail all the combined operations in which the British have been engaged even in the past two or three centuries would again be beyond the scope of this article. Starting, however, at the point when, under Cromwell, England first began systematically to establish herself overseas, it is proposed to refer briefly to the principal operations undertaken, and particularly, as far as is ascertainable, to the method of command in each case.

A.D. 1650 TO 1914.

(*a*) *Hispaniola, Caribbean*, 1654.

The first expedition of note in the period to be examined was that planned by Cromwell against the Spanish base of Hispaniola in the Caribbean. Apart from a fleet of thirty sail the force contained some 6,000 troops, a large number for those days. It had a voyage across the Atlantic to face and a difficult task to perform on arrival. Two joint commanders were appointed, Venables for the army and Penn for the navy. To complicate matters, the government appointed three Civil Commissioners to report on the behaviour of the commanders. No instructions appear, however, to have been given as to procedure in certain eventualities. On arrival, before the objective, the commanders disagreed as to the plan. The commissioners sided with the General, however, and his plan was attempted. Through hesitation in front of the objective, all surprise was lost and the attack failed disastrously.*

(*b*) *St. Malo and Brest, France*, 1692.

The next expedition of note was that sent out in 1692 with a view to attacking the French bases of St. Malo and Brest. We read that the government gave the commanders no definite orders. The Admiral was instructed that "no certain resolution was yet taken in what service to employ them, but that this was left to be settled

* *Conjunct Expeditions*, by Molyneux, written 1759.

by a General Council of land and sea officers, when the transports should be joined."* That this method of controlling a combined operation was of no value was soon shown when the expedition arrived before the objectives. Both at St. Malo and Brest the navy refused to attack until the Army had reduced the coast batteries, and the army refused to attack the batteries until they had the co-operation of the fleet. Thus nothing was accomplished, and in the end the expedition returned.

(*c*) *Haiti, Caribbean*, 1694.

Following a failure in 1692 of another expedition sent to the West Indies, through an absence of orders to the commanders and a refusal of the soldiers to co-operate, a combined force was collected in 1694 respectively under Commodore Wilmot and Colonel Lillingston, to capture Haiti from the French. This time the government attempted to ensure success.

" When all things were ready the Commodore had his instructions given him. . . . Instructions were also given to Colonel Lillingston, for the regulating of his conduct and for giving him a clear view of the extent of his command. Before they set out for Plymouth, both the Commodore and the Colonel were separately exhorted to be extremely careful in keeping up a right correspondence ; . . . and that this might be the easier, their commands were made as distinct as possible."† Nevertheless, the commanders managed to disagree as to the landing-place. In the end, however, the expedition was successful, more, perhaps, owing to the weakness of the French than to the system of control over the combined operation.

(*d*) *Minorca, Mediterranean*, 1708.

The first record of a combined operation being carried out harmoniously and successfully is that of the attack on Minorca in 1708. Marlborough advised the Government to send a strong expedition, and a fleet under Admiral Leake with some 4,000 men under General Stanhope was collected. The expedition was a surprising success, due apparently less to official instructions to the commanders than to " the excellent co-operation between the two Services . . . a rather rare phenomenon in those days."‡

(*e*) *Pondicherry, India*, 1748.

The next interesting case is that of the attack on Pondicherry in 1748, interesting because again a different method of controlling the combined operation was attempted. Following upon further disastrous quarrels between soldiers and sailors in the attack upon Cartagena in 1741, this time the government decided to ensure success by placing the troops under the orders of the sailor, Admiral

* *Conjunct Expeditions*, by Molyneux, written 1759. † *Ibid.*
‡ *The Army and Seapower*, by Pargiter and Eady, pp. 56, 67, 68.

Boscawen. But this method apparently had its limitations also. Immediately upon arrival, the Admiral attacked Pondicherry with his troops, "but the rough and ready sailor methods . . . failed when applied against well-trained troops under a leader like Dupleix."* This expedition showed that a commander of one service cannot be expected to understand technical and tactical problems peculiar to another.

(*f*) *2nd Capture of Louisburg, Canada*, 1758.

The next important operation, the capture of the French Canadian naval base of Louisburg in 1758, has several interesting features. First, it involved a larger force, *e.g.*, 12,000 troops and 23 ships of the line, than had hitherto attempted co-operation. Second, the naval commander concerned was the same Admiral Boscawen who had failed at Pondicherry. Third, it marked a reversion to the system of independent commanders for the army and navy in action.

The army was under General Amherst. He and the admiral appear to have collaborated most loyally. The attack resulted in complete success, though carried out in the face of great difficulties both from the weather, which caused large numbers of boats to be destroyed in the landing, and from the enemy, who offered determined resistance.

(*g*) *West Indies*, 1778 *and* 1794.

Two further large operations, one against the French island of St. Lucia in 1778 under Admiral Barrington and General Grant, and the other in 1794 against the same enemy in Martinique, Guadeloupe and St. Lucia under Admiral Jervis and General Grey, are next worthy of record. Though the details of these expeditions are unimportant, it is to be noted that in both cases the commanders appear to have been unfettered, but that in both there was the most excellent co-operation resulting in brilliant successes.

(*h*) *Corsica, Mediterranean*, 1794-95.

In contrast to the exemplary co-operation on record for the operations in the West Indies, at this period the history of the combined attacks upon Corsica is a continuous tale of bitter quarrels between the Services. Admiral Hood was the sailor in command and General Dundas the soldier. These appear rarely to have seen eye to eye. The operations against the fortress of Bastia ended in complete disagreement between the Services. The navy, attempting a single-handed attack, failed. It is noteworthy, however, that when General Dundas, in bad health, returned home and a new general, Stuart, took his place, the latter appears to have brought about a degree of co-operation with Admiral Hood.

The account of the attack on Corsica is of value in indicating the effect of the personality of commanders upon combined operations.

* *The Army and Seapower*, by Pargiter and Eady, pp. 56, 67, 68.

(*i*) *Walcheren, Holland*, 1809.

The expedition to Walcheren has become famous on account of the degree of the disaster incurred there. It was the largest attack attempted up to that time, 40,000 men under the Earl of Chatham sailing with a fleet under Sir Richard Strachan, which numbered over 100 ships of war. This time the objectives were defined to the commanders, *e.g.*, "The capture or destruction of the enemy's ships, either building at Antwerp or Flushing or afloat on the Scheldt; the destruction of the arsenal or dockyards at Antwerp and Flushing; the reduction of the Island of Walcheren and the rendering if possible, of the Scheldt no longer navigable for ships of war."* The plans were as complicated as the objectives, three separate landings being intended. Two landings were frustrated by the weather, though the third by a force at Walcheren was successful. Part of this force then co-operated with the fleet in the capture of South Beveland and Flushing. Thus far the Services had worked together under their separate commanders. But advancing on Antwerp, the admiral and the general could not agree on a plan of action, and a Council of War was called, which decided to give up the attempt upon that city. The force fell back and, suffering heavily from sickness, when evacuated contained only 4,500 of the original 40,000 men.

This operation is of interest in that it was undertaken close to home, and there were thus facilities for continuous control from home which were denied in the case of operations in Canada, India, etc. Furthermore, being closer to the present, the planning of the operations by the Cabinet and the conduct thereof bear greater resemblances to modern times. Unfortunately the expedition was doomed to failure for very lack of this control at home. The Commander-in-Chief of the army had just been dismissed, and the Cabinet was disunited over a conspiracy to eject the Secretary of War. "The plot in the Cabinet and the public scandal which drove the British Commander-in-Chief from his office, left the Walcheren expedition drifting like a derelict ship on stagnant waters."† Further, the military commander known as "the late Lord Chatham,"‡ was dilatory to a degree, and disregarded his instructions. In a case where above all rapid action was necessary, partly to forestall the moves of Napoleon and partly to escape from the fever-stricken districts, this failing in the commander was particularly fatal. There is no doubt that the system of command, which was that of complete independence for each Service, acting under separate instructions from a disunited Cabinet, was not entirely to blame for the failure at Walcheren, for weather and sickness played their part. It is equally true that the relations between the Services were a contributory cause, for an army officer, writing in

* *The Army and Seapower*, by Pargiter and Eady, p. 141.
† *How England Saved Europe*, by W. H. Fitchett, Vol. III, p. 104.
‡ *Annals of the Wars of the 19th Century*, by Sir E. Crest, Vol. II, p. 258.

the *United Services Magazine* of 1838, tells us, "The soldiers were all on deck and every thing was ready for shore-going when it was discovered there were no boats." ! !

(*j*) *Mauritius, Indian Ocean*, 1809.

A smaller operation, involving some 10,000 men, collected mainly from the forces in India for the capture of Mauritius is worthy of mention. This operation was particularly difficult on account of the difficulties of landing rather than on account of the military opposition, which numbered only 3,500. A complete success was eventually achieved. But the lesson as regards command here is that the commanders concerned, Commodore Rowley and Colonel Keating, had spent some two years together in previous operations, and thus knew each other thoroughly.

(*k*) *Canton, China*, 1840.

From the close of the Napoleonic wars there was a long period of peace, sufficiently long evidently for the varied experiences of the eighteenth century to be forgotten. At any rate in 1840, on the need for a combined operation against Canton arising, it is interesting to record that the government of the day reverted to the principle of 1748 of placing the whole force, naval and military, under the naval commander. Seventeen warships and 4,000 troops were sent, all under Commodore Bremer. Unfortunately this system of command was not fully tested, neither the nature of the opposition nor the operations being sufficiently strenuous. The Canton River defences were, however, captured by assault under naval bombardment under this system.

THE METHODS OF FOREIGN POWERS JUST PRIOR TO THE GREAT WAR.

(*l*) *The U.S.A. at Cuba*, 1898.

In June, 1898, an American combined operation was carried out against the Spanish fleet sheltering in Cuba by 16,000 men under General Shafter and a strong fleet under Admiral Samson. The U.S. had at the time no method of central control at home. The Admiral and General were independent and left to their own resources. While complete success was achieved, this was attributable more to the inefficiency of the defence and the good fortune in possessing good commanders rather than to the system of control.

(*m*) *Russia and Japan at Port Arthur*, 1904.

At Port Arthur it is interesting to note that while the Russians, who had there an army of 40,000 and an important fleet, placed the supreme command in the hands of the Army Commander, General Stössel,* the Japanese naval and military commanders were independent. Yet again it would be too unwise to conclude that the result

* See *Official History of Russo-Japanese War.*

of the fighting here was due to the system of command, for other factors were operating. In fact, the Japanese system might have been expected to have caused a reverse result. But we read that the Japanese depended for success upon " the intimate association of naval and military officers in peace time."*

(*n*) *German Opinion.*

Though Germany has no history of combined operations prior to the war, Von Schellendorff, in his book on the duties of the General Staff, advocated making either the Admiral or the General supreme, according to whether the sea or land part of the operations was likely to be the more important.

In 1917, when the Germans carried out a combined operation against the Russian islands in the Gulf of Riga, in which two battle squadrons and a light cruiser group were used with some 20,000 troops, they adhered to this principle, the whole force being placed under the Army Commander, General Von Hutier.†

The Great War Period.

The Great War, though the greatest in history, supplies in proportion to its size less examples of combined operations than some earlier wars, owing to the fact that after the first months, few enemy objectives for combined operations remained in which the results to be expected were commensurate with the risks involved. We have, however, the big example of the Dardanelles. This period is, however, of particular importance in that, for the first time, with the creation of the Royal Air Force, a third service took part in operations, even though at first it was small and not yet independent.

(*o*) *The Dardanelles*, 1915.

The operations against the Dardanelles fall into three parts. In the first, the forces employed were purely naval, *e.g.*, at the attacks on Nov. 3rd, 1914, and on Feb. 19th and March 18th, 1915. In the second, particularly during the preparations for the landings and the initial landings, the operations were, perhaps, as much naval as military. In the third, the period of long drawn out siege attack, problems were primarily military. It is, therefore, during the second period that the question of command is chiefly worthy of study.

The outstanding feature of these operations as regards command was that at no time was there any question of either the naval or military commander taking supreme control. Each of these commanded the portions of the Air Service operating with them, and the British General was given command over the French troops.‡

* *Letters on Amphibious Wars*, by Sir G. G. Aston, p. 360.

† " A German Landing," by Brig.-General Sir J. E. Edmonds, C.B., C.M.G., *Army Quarterly*, July, 1925.

‡ *The Dardanelles*, by Maj.-Gen. Sir E. Callwell, pp. 32 and 273.

But the navy and army remained independent throughout, acting on separate instructions. A weakness of this system, shown at the Dardanelles, was that however good instructions and communications were, instructions could not always take account of local conditions. We read* that Sir Ian Hamilton's original instructions visualized only landing parties for the destruction of forts whereas the General's inspection of the situation convinced him of the need of a military operation of the first magnitude. He was obliged then to cable for fresh instructions, causing delay and losing the effect of surprise.

The Dardanelles experience, however, does show that sailors and soldiers are perfectly capable of working harmoniously together and of consummating intricate plans. The history of this campaign contains many references to fresh and difficult situations being met by the Admiral and General in consultation. Sir Ian Hamilton wrote in a dispatch " the Royal Navy had been father and mother to the Army during the Dardanelles Campaign."†

(*p*) *The Belgian Coast Project*, 1917.

The project prepared in 1917 for an attack on the German submarine bases at Zeebrugge, though it was not carried out, is worthy of mention in that a combined operation involving all three Services was planned. The main feature of the plan was a landing of an infantry division under cover of naval and air attack in conjunction with the advance of the army in Belgium. The plan had its inspiration in the army, and though there is no definite statement to that effect in the records of the army commander‡ concerned, for the purposes of this operation the naval and air forces concerned appear to all intents and purposes under the contol of the military C.-in-C. This was perhaps the first example of the growth of the idea of vesting operational control in the predominant partner in a combined operation, to which reference will be made later.

(*q*) *The R.A.F. in France*, 1918-1919.

The control of the large air forces in France during the later stages of the war offers a final example of command exercised in combined operations. Combined operations between the army and air force were of daily occurrence. Until the independent air force, based in Eastern France, was formed for independent operations in 1919, under the direct orders of the Air Ministry, the air forces in France were, for operational purposes, at the disposal of Lord Haig. Again here we see the lesser partner placed under the control of the greater in the interests of the whole. This principle is now recognized in the Royal Air Force regulations, which state :—" Air force formations and units detailed to co-operate with the Army will be placed under the orders of the military C.-in-C."§

* *The Dardanelles*, by Maj.-Gen. Sir E. Callwell, pp. 32 and 273. † *Ibid.*
‡ *The Life of General Lord Rawlinson of Trent*, pp. 194-197.
§ *Royal Air Force War Manual*, 1928, Chap. XII, para. 6.

2. The History of the Use of Colonial and Dominion Forces in Combined Operations.

In view of the shortage of white manpower in British overseas territories until comparatively recent years, naturally there have not been many occasions upon which it has been possible for overseas forces to co-operate in combined operations. In fact, from the instance of the New Englanders at Louisburg in 1745, we jump right into the Great War before further examples are provided.

(*a*) *Louisburg, Canada*, 1745.

The first case of the co-operation of overseas British forces in a combined operation is to be found in the history of the first capture of the French Canadian naval base of Louisburg in 1745. Here the New England Colonies supplied some 4,000 troops under a colonel of Militia named Pepperell, while England sent out a naval squadron under Commodore Warren. The two commanders worked well together and the fortress was captured after a seven-weeks siege—" perhaps the most brilliant feat of arms ever achieved by British Colonists."* The interesting point as regards command here was that the naval commander, whether by chance or by intention, was an officer who had served for many years on the American coast, and so was one likely to understand the outlook and circumstances of the Colonial forces, and to be able to co-operate with them.

(*b*) *The Dardanelles*, 1915.

The other big occasion upon which overseas forces have taken part in combined operation was at the Dardanelles. The Dominion forces here were merged into the attacking army alongside Regular and New Army troops from Great Britain. In consequence the lessons to be derived as to the command of purely overseas troops in combined operations were restricted. Nevertheless, the Dardanelles showed that overseas troops have different methods and characteristics, and that in combining them in action with home services, it is necessary to place in command and on the staffs on both sides officers familiar respectively with home and overseas conditions of service.

3. Summary of Methods of Command in the Past.

As far as the past is concerned, then, we find that various methods of ensuring unity of effort in combined operations have been attempted. In one case the naval and military commanders were saddled with Civil Commissioners as representatives of the government. In the next, the co-operation of the Services was to be obtained from a " General Council of land and sea officers." In a third, detailed instructions were given to each commander as to his sphere of action. After that, on two occasions at wide intervals the placing of the one Service under the orders of the other was

* *The Empire at War*, by Lucas.

tried. At Walcheren we find at the start independent commanders ending up in a joint and ineffective Council of War. In the majority of cases, however, it appears that independent commanders have been sent out, and for unity of effort reliance has been placed entirely upon the common sense and loyalty of the commanders concerned. Even up to the time of the Dardanelles it seems that no hard and fast system, proof against failure, had been evolved. No two Great Powers were agreed upon a method. At the very end of the Great War, a tendency for the predominant Service in any operation to take charge is noticeable. With regard to the co-operation of overseas forces in combined operations, in the command and staffs, the need for officers thoroughly familiar with the characteristics respectively of home and overseas forces has been proved.

4. FACTORS AFFECTING UNIFIED COMMAND IN COMBINED OPERATIONS.

A number of important factors affect the problem of whether unified command is possible and desirable in combined operations, to which due considerations must be given before any decision can be arrived at. Such are :—(*a*) The disadvantages of divided control. (*b*) The difficulties of a supreme C.-in-C. (*c*) The effect of modern conditions. (*d*) Dominion considerations.

(*a*) *The disadvantages of divided control.*

The disadvantages arising out of divided control include (i) limitation of the objective, (ii) violation of the principle of economy of force, (iii) absence of responsibility for secrecy and intelligence, (iv) absence of co-ordination in battle.

(i) *Limitation of the Objective.*

Where three fighting Services are acting independently, obviously the zone of action of each is restricted. The navy can only act within gun-range of the shore, the army according to the limits attainable by marching, and the air force within its bombing range. One authority over the three, using each Service to help the other as appeared best for the whole rather than for that particular Service, would have far greater scope in choice of the objectives.

(ii) *The violation of the principle of economy of force.*

Without some supreme control, it is clear that the forces operating are unlikely to be used in the most economical manner from the point of view of the Services as a whole. Each Service is likely to have objectives of its own, perhaps the navy some submarine base, the army an important land area, and the air force hostile aerodromes. The pursuit of each of these tempting objectives may be detrimental to the progress of the main plan of campaign. Without higher control, forces are likely to be wasted.

(iii) *Absence of responsibility for secrecy and intelligence.*

A combined operation, perhaps more than any other, depends for success upon absolute secrecy in preparation and upon good intelligence of the enemy, the theatre of war, the objective, etc. If three independent services set about preparing for such an operation without supervision, one or other of them is highly likely to give away information. Furthermore, in the provinces of deception of the enemy and of counteraction against espionage, each Service is apt either to leave action to the others, or to overlap the action of the others, which latter in matters of contra-espionage is not only wasteful but dangerous. As regards intelligence, independent collection by the Services can lead to contradictory information being submitted on important matters at a vital moment and to action in opposite directions being taken by the Services concerned.

(iv) *Absence of co-ordination in battle.*

When a combined operation has been brought to the stage of actual battle, the absence of co-ordination between Services may possibly have disastrous results. The simultaneous employment of three Services, in, for example, an opposed landing, is a most delicate operation, in which the least error on the part of one Service may throw the whole plan out of gear. Through a lack of co-ordination, it is conceivable that the naval and/or air attack upon an objective might either not coincide or be late for the attack by the army, with the result that the effort of each Service may be defeated in detail. Further, particularly if the army is able to advance rapidly with the aid of armoured forces, the naval and air forces require to be in the closest touch if they are not to mistake friends for enemies and fire into the army. Next, if smoke comes into use in all three Services, without control its employment may cause the gravest confusion. Lastly, in an era in which all Services are dependent for every movement upon wireless, without supervision its use in battle by every ship, tank and aeroplane will become quite impossible.

(*b*) *The difficulties of a supreme C.-in-C.*

Having set out the disadvantages of not appointing a supreme C.-in-C., it is desirable to consider some of the difficulties facing the creation of such an appointment. These may be classified under: (i) the responsibility of the Services to different ministries, (ii) the independent training and administration of the Services, (iii) the technical and tactical problems of each Service, (iv) the personal element.

(i) *The responsibility of the Services to different ministries.*

The mere fact that the head of each Service in the field is responsible to a different authority at home is bound to open up a crop of difficulties for a supreme C.-in-C. It has been well said that no man

can serve two masters, and though in the different Services many examples can be quoted where officers are forced to do so, such practice is fundamentally unsound. The commander of each Service in a combined operation under a C.-in-C. would own allegiance both to him and to the chief at home. The effect of possibly contradictory instructions being issued to one section of the forces under his command would necessarily be crippling to a C.in-C. It is easy to picture circumstances in which the intentions of a C.-in-C would run foul of those of one of the three ministries in charge of his forces at home. The discovery of every difference of opinion would necessitate reference back and delay, if not to whole-hearted friction. It is not reasonable to expect a ministry, with possibly grave responsibilities of its own in other parts of the world, to give a C.-in-C. *carte blanche* with regard to his use of its forces. Neither is it fair on the C.-in-C. to tie his hands as to the employment of the forces placed at his disposal. In this matter is found one of the chief obstacles to the success of a supreme C.-in-C.

(ii) *The independent training and administration of the Services.*

Any attempt to make three Services, temporarily at least, into one is far more difficult than the unification of various sections of one Service into a homogeneous body. For the Services have entirely different methods of training, discipline, staffwork, intercommunication, feeding, ammunition supply, reinforcement, administration of every type. In consequence, their joint employment presents the greatest difficulty to a C.-in-C. Taking for example the instance of varying methods of staffwork—a C.-in-C. issuing orders for an operation on perhaps naval lines would be very apt to be misunderstood and let down by his military and air forces, and similarly those on military lines might fail to satisfy the conditions of the naval and air forces. In a matter of supplies, it may be that it is the practice of one Service to take out to a campaign two months' provision, while the others may be organized for one and three months respectively. Or while the one Service can count upon a regular replacement of wastage, possibly in the others reinforcements are non-existent. The innumerable problems of training and administration which, appearing small in themselves, yet in practice have far-reaching effect, make the control of three Services by one commander a matter of, if not insuperable, at least very great, difficulty.

(iii) *The technical and tactical problems of each Service.*

Another reason why, in the past, the policy of one C.-in-C. has not been pursued more often is that arising out of the technical and tactical problems inherent in each Service, there is a further major difficulty. Any commander who has not a sound knowledge of the working of the forces under his command is very liable to make mistakes in their employment. Hitherto it has taxed the powers of

most commanders to the utmost to master the problems arising out of the many sections of their own Service. To attempt to grasp the technique and tactics of the different parts of three Services is a colossal task. With the Services each day becoming more intricate, more scientific, this difficulty for the future has not been lessened. The failure of Admiral Boscawen at Pondicherry, referred to earlier in this article, shows the danger of the commander of one Service planning an operation with the units of another, without being fully conversant with the problems of that Service.

(iv) *The personal element.*

Another difficulty facing the employment of a supreme commander is that which has always been found in the past, of fitting suitable personalities together. However definite the orders to the commanders of different Services may be from their respective chiefs at home, unless the persons concerned pull well together in harness, a unified control is hardly likely to be effective. Within a Service, if subordinate commanders do not blend, the remedy is plain. Where chiefs of other Services are concerned, the solution is not so simple. Where Services are independent in a combined operation, and their leaders do not suit each other, it is easier to effect a change than when once such leaders have been placed under a C.-in-C.

(c) *The effect of modern conditions.*

The effect of modern conditions upon this subject may be examined under: (i) the size of forces, (ii) the range of weapons, (iii) means of communication.

(i) *The size of forces.*

History indicates that, at least in the past, the tendency has been for the size of forces engaged in combined operations to increase with each successive war. In the seventeenth century the troops embarked numbered 5 to 6,000. At Walcheren in 1809 they totalled 40,000. At the Dardanelles at the beginning there were 78,000 British and French troops,* a large fleet, and many aircraft. While increased use of air power and mechanized military forces, together with enemy submarine action, may in the future check this tendency, it is certain that in point of *power*, forces for combined operations will be greater with each generation. As defensive measures are improved each year, so offensive power requires to be continually augmented, whether on sea, land or in the air. The continued expansion of the Services in action in course of time renders them unwieldy and adds considerably to the difficulty of controlling them with one chief.

(ii) *The range of weapons.*

The range of modern weapons also adds materially to the problem, both from the point of view of their use by the forces of a C.-in-C.

* *The Perils of Amateur Strategy*, by Sir E. Ellison, K.C.B., page 90.

and by the enemy. Ocean-going submarines have a radius of action to which no limit can be set, provided that facilities for refuelling are available. Aircraft have already flown non-stop across the Pacific and Atlantic Oceans. Even land forces, though in small numbers, at least armoured and powerful, are capable of moving many hundreds of miles in a short space of time. In consequence, the area which a C.-in-C. is now forced to consider, both offensively and defensively, in three elements, is immense. No longer is the zone of operations some narrow sea or a limited stretch of coast. It may well be in the future a quarter of the globe's surface.

(iii) *Means of communication.*

Present-day means of communication, wireless, cable and telegraph, assist a C.-in-C. in certain directions, and add to his difficulties in others. Rapid communication enables a commander, however distant, to maintain touch, not only with his guiding authorities at home, but also with all his widely dispersed forces and with his outlying sources of intelligence. There is now no possibility of a force in any part of the world being out of touch for more than a few hours. Conversely, the rapidity of modern communications enables the enemy to receive information at great speed. The C.-in-C. will be given far less time than in the past. The tendency will be for everything to be quickened up, and the commander will be required to move the complicated pieces upon his chessboard with a lightning hand if his opponent is not to forestall him.

(d) Dominion Considerations.

Another set of factors governing this question emanates from the present and future position of the Dominions in the British Empire. The points which require consideration are: (i) the circumstances in which forces of the British Empire may be expected to undertake combined operations, (ii) methods of control of Dominion forces, (iii) the redistribution of the British Empire.

(i) *The circumstances in which forces of the British Empire may be expected to undertake combined operations.*

It is, first, to be noted that the British Empire, spread as it is all over the world, is more likely to be concerned with combined operations than any other nation. Next, since the forces of the Empire are situated mainly in islands or detached portions of continents, to bring them into action at all results in the first instance in a combined operation. Third, the widening of the definition of combined operations to include any action in which an air force is engaged with either the navy or the army means that practically every operation of war becomes a combined operation.

Since the Empire has no aggressive intentions, operations will be fought in defence of the existing Commonwealth of Nations and since

the weakest parts of this structure are its lines of communication, it is safe to assume that combined operations will be primarily concerned with the defence of those communications. As these communications are equally important to the Dominions at their far end as to the mother country at this, apart from the motives of unity and loyalty to the throne which were so universally manifest in the Great War, it is clear that in any important operation, Dominion forces will certainly be present.

(ii) *Methods of control of Dominion forces.*

The essence of the arrangement by which the British Dominions form part of the Empire is that each Dominion shall be an independent nation, with full sovereign rights. It follows as a corollary to this axiom that each Dominion has complete command over any forces that it may dispatch for a combined operation. We thus see the possibility of added complications in a field already difficult enough. Not only might a C.-in-C. have three home Services to deal with but perhaps three Services from one or more Dominions. Not only might he have to keep touch with London but also perhaps with several Dominion capitals as well. On the other hand, there might be six or more independent forces and commanders.

(iii) *The redistribution of the British Empire.*

While the Empire is distributed as it is to-day, and while Dominion forces are small compared to those of the mother country, the prospective difficulties outlined above may appear far-fetched. But when the Empire is redistributed, they will become yearly more real. Can it be doubted that the present proportionate location of white population, industrial resources and armed forces is bound to alter considerably in the next half century? In the past all three have been largely concentrated in Great Britain. Since the war the rate of increase in the population in Great Britain has been greatly checked. The manpower of the Dominions is, however, steadily increasing, and the distribution of the white British peoples, which to-day is perhaps 66% at home and 34% overseas, is more likely in time to show the figures reversed. Similarly, the Dominions are all concentrating on local industrial development, and in course of time Britain will no longer be the only source of weapons and war material. With the advent of that era, presumably the Dominions will take a far greater share in the defence of the Empire than is possible in their state to-day. From the point of view both of the more equal location of the armed forces of the Empire amongst its members, and of the prospect of united action being required from many Services, owing allegiance to various independent Governments, the creation of some system of controlling forces used in combined operations appears to be a paramount necessity.

5. THE SOLUTION.

(*a*) *The lessons of history.*

In coming to a conclusion on this subject, it must be confessed that the study of how command has been exercised in the past is to some extent disappointing. Owing to the radical alteration in the conditions of war the methods of the past are in many ways unsuitable for the future. Furthermore, history gives us no line as to a system of command that has answered well in the past, and on the contrary shows that right up to the end of the Great War no policy was agreed upon between the Services for general application in combined operations. History is also prolific in examples of how such operations should not be conducted.

To the past, however, we owe the idea of the predominant partner in a combined operation taking general control, which, attempted in 1748 and 1840, advocated by a German school of thought, was re-born at the close of the Great War.

(*b*) *Summary of the factors affecting unified control.*

In the earlier parts of this article, the disadvantages of divided control even amongst the home Services have been pointed out. These of themselves are seen to be serious enough. On the other hand, as enumerated, the difficulties facing a C.-in-C., and the effect of modern conditions on the problem of command, appear to be so formidable as almost to close the discussion as to the possibility of appointing one C.-in-C. Finally, however, the examination of the increasing part which Dominion forces are likely to take in combined operations leaves the impression, that, whatever the difficulties, some form of unified control over the Services in such an operation is bound to come if chaos and confusion are not to result.

(*c*) *The best form of control.*

Having arrived at the conclusion that the Services in future cannot be permitted to drift independently side by side, the next question is how is such control to be exercised and from where? Is control to be by committee or by a commander, and is it to be situated at home or in the zone of operations? Official regulations give some guidance on this point. They state that "The armed forces of the Empire consist of the Royal Navy, the Army and the Royal Air Force. There must exist unity of direction and control of the armed forces. This is exercised by the Ministers of State, who have executive responsibility for the conduct of the war, and who, with the assistance of the heads of the three Services, decide on the plan of campaign."* These instructions, framed for war in general, particularly apply to an operation in which all three Services are engaged. As far then as the origin of a plan of campaign and the

* *Field Service Regulations*, Vol. II, Chap. I, Sec. 3.

use of the home Services are concerned, provision is already made for one form of control.

(*d*) *Control at home.*

There is to be at home a form of War Committee or War Cabinet, advised by the heads of the Services, which will regulate combined operations as far as they can be from home. This Committee should meet one of the main difficulties of a C.-in-C., *e.g.*, the dealings with three independent ministries at home. But two points in connection with this arrangement arise. First, no provision is made for the participation of Dominion forces on a large scale. Second, it is clear that the controlling authority at home, however excellent communications may become, cannot command combined forces in battle.

As regards the first point it would seem that the case of Dominion forces can be met if the Dominions receive adequate representation in the controlling committees at home.

This implies representation in all the grades of the Naval, General and Air Staffs and not only at the head. In actual practice the War Committee or Cabinet referred to above receives expert advice from the Committee of Imperial Defence, which itself is advised by the Chiefs-of-Staff Sub-Committee, composed of the chiefs of the three Services. The chiefs themselves are served by numerous joint sub-committees, formed at present for various investigations from members of the three home Services. The writer submits that when their forces are likely to be involved, Dominions should supply equal and additional members to all these committees. They should start with one or more representatives in the War Cabinet, just as General Smuts sat in that Cabinet in the late war. A Dominion Chief-of-Staff or his deputy would be a welcome addition to the Chiefs-of-Staff Sub-Committee, while Dominion members on all subordinate staffs could only be a source of strength. By an appreciable increase in the system of interchange of staff officers between home and Dominions in all Services, not only would the outlook of all concerned be influenced and officers be prepared for combined Empire action, but Dominions would be enabled to find officers for the various committees without an expensive expansion of staffs. Only by some such methods does it appear that the problem of large Dominion forces co-operating in combined operations can be met.

As regards the second point, the inability of home committees to control the Services in battle, it is apparent that a form of control, in the zone of operations is necessary.

(*e*) *Control in the zone of operations.*

In the zone of operation, action must be rapid. Immediate decisions are required. Committee control here is clearly out of

place and a C.-in-C. is necessary. The problems are: who should he be and is it possible to expect any one man to fill such a post?

As regards the selection of the commander, the past suggests the choice of the predominant partner. It will usually be the case that one Service is more concerned than another. Often the nature of the objective will indicate which. If it be mainly the objective of one Service, that Service, perhaps, should be in control, though not always. Sometimes the size of the respective forces may decide. In others, perhaps the Service with the greatest difficulties and the most complicated part to play should be in charge. In most cases, the predominant Service will be apparent. Where it is not and interests appear equal, as it is essential that a C.-in-C. should be appointed, a selection should be made.

As to whether any one man can master the control of three Services, it is suggested that action in two directions may make such a situation possible. Firstly, it is necessary to create the combined Service brain and to train commanders in terms of three Services. Already this is started, in the combined exercises held at the Service Staff Colleges and in the course at the Imperial Defence College. Combined operations in peace at every opportunity will do more. Secondly, it is essential that the C.-in-C. be provided with a combined staff, containing not only representatives of each Service but officers selected for their knowledge of the three Services, and, where applicable, of the overseas forces engaged. Such a staff will partly counteract some of the main difficulties mentioned earlier as facing a supreme C.-in-C., *e.g.*, the different training, administration, technical and tactical problems, and the personal element in the three Services and the overseas forces.

(*f*) *Final conclusions.*

From this investigation then, the final conclusion is not only that the principle of a supreme C.-in-C. over naval, military and air forces in future is applicable in combined operations, but that, on account of the circumstances in which the forces of the British Empire may be expected to operate, a supreme commander is essential.

Admittedly this is a complete departure from practice in the past, as evidenced as recently as 1915 at the Dardanelles. But modern conditions, the creation of a third Service, and the increasing importance of Dominion forces, appear to dictate such a course.

If the Services and the different parts of the Empire are well represented in the chain of control, if each of them grows up in a tradition of the subordination of self in the interests of the whole, if each studies the higher problems of the others, then the new system should function. Much will even so depend upon the selection of the leader, upon his brain power and upon his ability to harmonize with the heads of the forces under him.

PROGRESS RECORDS FOR MAJOR NEW WORKS.

By MAJOR G. MACLEOD ROSS, M.C., M.ENG., A.M.INST.C.E., R.E.

THE officer charged with the supervision of a Part I service is required to do two things at regular intervals. He must first make payments on account to the contractor which shall bear a definite percentage relationship to the work completed and the materials on the site, and he must submit a quarterly account on A.F. K.2426A, in the last column of which he is required to give by means of a percentage some idea of the progress of the work. Since the key to the fulfilment of both these requirements is an accurate estimate of the amount of work done, and since the degree of accuracy in forming this estimate is likely to be enhanced should some system be employed, the following method is offered of analysing any contract which is let on a bill of quantities.

The first step is to determine from the priced bill of quantities the value of the work to be done by each trade.

In the case illustrated in Plate I these values for each trade will be seen along the bottom of the graph, taken from the bill in the order in which they occur—the concretor totalling £1,073 and the bricklayer £2,299 and so on. The sum of the values of all the trades is the total contract figure which amounts in this case to £9,114.

The next step is to express the value of each trade as a percentage of the total contract figure, *e.g.*, concretor ·118, bricklayer ·252, etc.

These percentages for each trade are now plotted proportionately as the abscissa.

The scale in the present case is one-tenth to one per cent. of the total contract figure.

The contract time in weeks to a suitable scale becomes the ordinate.

The lines drawn parallel to the abscissa mark the quarters corresponding to the War Department financial year.

As work proceeds it is necessary once a month to estimate by eye the progress of each trade and to enter it on the chart. It will be found convenient in the case of certain trades to subdivide them as shown in the case of the concretor, where foundations, roads and paths, and the filling of solid floors are all shown separately.

On each quarter day the total percentage progress is obtained by counting across the appropriate quarter day line the number of tenths cancelled by the dotted progress curve for each trade.

For example, progress to the end of September, 1931, is made up as under :—

Preliminary bill (complete)	·013
Excavator (complete)	·014
Concretor, say	·052
Bricklayer	·080
Drainlayer	·022
Mason	·010
Carpenter	·025
Joiner	·020
Cold water	·005
Total progress	·241

By means of six columns at the right-hand side of the chart it is possible to present a very complete financial picture of the service.

Column 1 shows the quarterly percentages of progress arrived at as previously explained. Below each percentage is shown the equivalent sterling value of work completed up to the given date.

Column 2 gives the value of the deviations ordered. On the left the monthly totals and on the right the total value of all deviations to date.

Column 3 shows—above the line—the amount of the payment on account and below the line the total sum paid to the contractor to date.

It is informative to check payments on account against work done. At the end of the December, 1931, quarter £3,500 had been paid to the contractor against an estimated value of work done of £4,300, which discloses an ample balance in favour of the War Department.

By September, 1932, it will be noted that £9,161 had been paid to the contractor against a total of £9,114 in column 1. Here the requisite reserve in War Department hands is accounted for by the amount of the deviations ordered (column 2), amounting to £958.

Column 4 shows the liabilities for War Department Stores as they were incurred, whilst column 5 shows the total of bills paid to given dates; that is, contractor's payments on account plus stores bills. Finally column 6 shows the revised estimate figure quarter by quarter. This, of course, is made up of—Total contract figure, plus total value of War Department Stores to be ordered, plus deviations to date.

A scrutiny of the graph is instructive not alone as disclosing the contractor's methods of organizing his work, but also as exemplifying how the several trades work in together. Consider, for example, the progress curve for "roads and paths" under concretor and paviour.

From May to August, 1931, the contractor was busy with the bottoming of his approach roads so that he might bring all his heavy stores, mainly bricks and masonry, on to the site.

Having done this there is no occasion for him to do more work on the roads until they have been consolidated and all heavy traffic is done with. However, there was no valid excuse for the complete inactivity seen from August, 1931, to April, 1932, and in fact, the roads were not complete until a month after the revised completion date.

It will also be noted that the slater had completed his work by the middle of February, 1932, and, therefore, the roof being on, the joiners could have commenced on the bulk of their work earlier than the first week in April, as is disclosed by their progress curve.

The plasterers, too, could have got to work earlier than the beginning of April.

Two and a half months extra time over and above the contract completion period was allowed on account of the £1,000 odd deviations found necessary, but failure to concentrate the right type of labour as soon as it could usefully be employed resulted in the job being completed a month late.

The foregoing remarks have all been made from the point of view of the supervising officer, but it can readily be seen of what value charts of this nature would be to the contractor. When he has first decided his most economic rate of working, having regard to the type of building, the supply of labour, and his financial arrangements, it is possible for him to plan ahead and decide dates not only for the completion of work by the individual trades, but such a chart will act as a guide in ordering the material so that it is available on time. These latter points will be referred to again when the second curve, shown in Plate 2, is considered.

The Labour Density Curve.

For all Part 1 services a Works Diary is kept, and filled in daily showing the number of men at work by trades, together with notes on the progress of the work. For many years it has been the practice to keep such a diary on all War Department work, and whilst it is proposed to demonstrate what a valuable record the diary may prove when suitably analysed and interpreted, it is felt that, as a rule, little or no real value is obtained from these diaries. From the facts and figures as they stand recorded on a page-a-day diary it is submitted that little or no information can be gained.

Occasion was, therefore, taken to work out from the diary the daily average for each week of all trades employed on the job represented on the Progress Chart in Plate 1. These are shown plotted week by week in Plate 2, and this curve therefore represents the density of

labour employed on the site of work, and since labour is dependent on a supply of material this curve forms a very useful commentary on the contractor's powers of organization. It is, therefore, suggested that curves produced from similar data might almost be termed the " characteristic curves " for the given contractor.

Examination of the curve shows how labour on the job gradually increased up to the fifth week, during which period the foundations were being excavated and poured and some bricklaying had begun, and it was possible to work a large number of men on the site. Thereafter numbers drop away week by week until a minimum is reached in the middle of August. All this was due to the poor supply of bricks.

As a result of much negotiation and pressure the brick supply improved, and so we witness during October and November nearly two months of steady bricklaying in addition to work on the reinforced concrete floors.

Frost now intervened until the middle of January, accounting for the irregularity displayed by the curve.

It is noteworthy that had the bricks been to hand in July, August and September, work would have been so far forward as to have been immune from weather delays in December and January; the roof might have been completed in December instead of February, and the bulk of the work outstanding being internal, bad weather would have caused no stoppages.

During March labour dropped away to a minimum of only seven men per day during one week. This great break is interesting since it was due to a dispute between contractor and supervising officer over alleged bad workmanship and material. The contractor appealed to higher authority, but the case was finally settled in favour of the supervisory staff, and so in April labour was returned in large numbers.

The contract completion date being only a couple of months ahead, it would seem that this fact had induced the contractor to put on all the labour possible, since a maximum of thirty-five per day was reached at this date.

In the latter part of June interest waned again, and reference to the diary shows that the tiler and wood-blocklayer had failed to appear, holding up heating and decorating. Thereafter the curve sinks, with two breaks, to the close of the work in September, 1932.

Now it is contended that with such a graphical representation of the Works Diary before him, the supervising officer is in a very much stronger position than he would be after merely looking through the pages of his diary. By means of this graphic portrayal he notices the labour changes week by week, he sees the situation becoming

Colonel Lord Sydenham of Combe. GCSI, GCMG CCIE GBE FRS.

Defence Committee, he was given the K.C.M.G. He was promoted colonel in 1898.

" Under the age clause Sir George Clarke was placed on the retired list of the army in 1905. He was given the G.C.M.G. in the same year. Two years later he was appointed Governor of Bombay.

" There he proved himself emphatically the right man in the right place. He succeeded in keeping in touch with the activities of the persons who were understood to be leaders in the seditious movement, and he dealt promptly and sternly with every case of outrage. Mr. Tilak, the leader of the extremist party, was arrested by the Governor's order for publishing seditious articles in his newspaper, and his conviction led to violent rioting in the native quarters of Bombay, which was eventually put down by military force.

" At the moment there was unquestionably a strong revolutionary feeling amongst the natives of the city. But among Orientals, and especially in India, personality counts to an exceptional degree, and the resolution and the inflexibility of purpose of the ruler of the Bombay Presidency at this anxious time undoubtedly created an immense impression throughout the land, and proved an all-important factor in causing the troubles to abate.

" When Sir George Clarke, who had been raised to the Peerage with the title of Lord Sydenham in the New Year's Honours, 1913, handed over the governorship to his successor in April, 1913, the Presidency was loyal and contented, and he left behind him an enviable reputation as a just and fearless ruler and as a prescient and sympathetic administrator. He had joined the band of our great Pro-Consuls.

" When compulsory service during the Great War was introduced, he was made Chairman of the Central Appeal Tribunal. He afterwards served on the Air Board, but retired from that body at the end of 1916 as a protest against changes in administration of the air service, which he held to be fraught with grave risks during a crisis in the war.

" He was Chairman of the Executive Committee of the British Empire League from 1915 to 1921 and President of the British Science Guild for three years.

" Lord Sydenham was one of the occupants of the cross-benches in the House of Lords and made a number of able and interesting speeches there on the air service, Indian administration, the blockade of Germany, and other topics of the day.

" He married first, in 1871, Caroline Emily, daughter of the late General P. H. Fellowes. She died in India in 1908, and his only daughter by the marriage died in March, 1909. In 1910 he married Phyllis, daughter of the late George Morant, and widow of Captain Arthur Reynolds.

" He was created G.C.I.E. in 1907, G.C.S.I. in 1911, and G.B.E. in 1917. He was a Fellow of the Royal Society and a Knight of Justice

of the Order of St. John, and was Hon. Colonel of the 63rd Australian Infantry. A voluminous writer on military subjects and defence questions, his principal publications were: *Plevna; Fortification, Past, Present and Future; The Last Great Naval War; The Navy and the Nation; Imperial Defence; My Working Life* (1927); and *Studies of an Imperialist*—a collection of his articles and addresses published in February, 1928.

"Lord Sydenham leaves no children, and his title dies with him."

The following appreciation of Lord Sydenham's earlier career has been contributed by an old friend:—

"I first met George Sydenham Clarke when in 1880 he was posted to Chatham preparatory to taking the 5th Company of Royal Engineers to Bermuda. He was then living with his small family at Englefield Green, where he had spent nine out of twelve years since in 1868 he had passed first and with unusual distinction out of the Royal Military Academy. In the course of these nine years as instructor in Practical Geometry and Engineering Drawing at the Indian Engineering College at Cooper's Hill, he had published two works of recognized merit on these subjects and, as examiner to the Science and Art Department of the Board of Education, he had influenced the instruction in practical geometry of thousands of young people throughout the country. Towards the end of his time at the College he had turned to the study of Military Art, and particularly to that of Fortification, notably as illustrated by the provisional works with which Osman Pasha had successfully defended Plevna in the Russo-Turkish War of 1877-78. A book by him on this subject attracted considerable notice and the lessons he learned in writing it, in the course of short tours of service in 1881 and 1882 at the antiquated fortresses of Bermuda and Gibraltar, and in the preparation of a report on the bombardment of Alexandria in July, 1882, led him to evolve ideas which in the years that followed had a profound effect alike on the principles and details of the defence of the ports and commerce of the British Empire.

"Sir Andrew Clarke, who, as Inspector-General of Fortifications, had sent Captain Clarke to Alexandria, called him, on his return from taking part in the later phases of the Egyptian War of 1882, to the War Office. There he and Captain Jekyll and some other R.E. officers were put to design works for the defence of the places that had been laid down as fortresses and coaling stations in the recently issued final report of Lord Carnarvon's Commission upon the Defence of British Possessions and Commerce Abroad. In these designs the deductions drawn by Clarke from the effects of the fire of the fleet on the forts of Alexandria received practical application. He laid down at the end of 1883 in a *Memorandum on the Protection of Heavy Guns for Coast Defence* as main points at which to aim: dispersion and elevation of sites for direct fire guns; protection of

them by thick earthen parapets, if possible, of sand ; reduction to a minimum of visibility of emplacements ; and the making use of curved fire from howitzers. Later on, after experiments at Inchkeith had been carried out at his suggestion in August, 1884, he laid stress on the protection against machine-gun fire given to a breech-loading gun by a steel hood.

" Clarke shared fully the views of his Chief, Sir Andrew, as to the need for the closest association in all coast defence matters of R.N. and R.A. officers with those of the R.E. With the succession of naval men and gunners, attached from 1883 onwards to the Fortification Branch of the War Office, he had intimate personal as well as official relations, and the able papers he wrote on the technical side of fortification appeared as often in the *Journal of the Royal Artillery Institution* as in the *Professional Papers* of the Royal Engineer Institute. His association, direct or indirect, with this military science lasted some 25 years. In actual planning of works he was, however, only engaged during 1883 and 1884, when he may be said to have created a new school of fortification design. In 1885 his War Office service was broken by his employment at Suakin, first of all as Special Service Officer to the expedition which was to clear the way from the Red Sea to Berber on the Nile and later as Political Officer ; the value of his good work in the latter capacity was lost when on the withdrawal of the Expedition it was decided not to attempt to open trade with the Arabs.

" When Major Clarke returned to the War Office, questions relating to defence of the Colonies had become acute owing to the likelihood of this country finding itself at war with France and Russia, and a small committee had been set up to obviate the inter-departmental correspondence and minute-writing that were involved by the many appeals from the Colonies for help and advice. Captain Jekyll, who had been appointed Secretary to that committee, had resigned to take up another post, and Clarke took his place. He held the appointment for seven years until 1892, and it was largely due to the committee he served and guided that the Colonies were made ready to meet the test of war. The task was a difficult one. At first, when their authorities were asked to say how they would utilize the resources at their disposal in men and material in the event of threatened attack, they replied by bewailing the inadequacy of these resources, and had to be told in one of Clarke's epigrammatic sentences, ' Schemes of defence should not embody counsels of despair.' As forts were built and guns were mounted, organization to enable full use of them was created, while, most important of all, the realization of the probable nature of attack was impressed on the local military and civil officers who had to conduct the defence. They were made to understand the leading part which the onslaught of the British Navy on the enemy's fleets would play in the defence of colonial territory from attack by his ships. Clarke implicitly

believed that coast defences would be useless if the navy failed to keep command of the sea, but he never doubted the need for a limited measure of such defences to prevent the disorganization of naval plans which would result if dockyards and coaling stations were exposed to the unresisted attack of one or two cruisers. He had the opportunity of pressing these views on the statesmen of the Colonies in connection with the holding of the First Imperial Conference in 1887. He had for some time urged the pressing need for such a Conference.

" By action that seemed at the time to be of the nature of intrigue, possibly provoked by Clarke's free handling of what he considered antiquated methods and institutions, he was taken from the Colonial Defence Committee about the time when the full effect of its varied and practical recommendations had begun to make itself apparent. An instance of this free handling occurs in a paper written for the *Journal of the R.A. Institution* on ' Submarines in relation to War,' in which, after telling appositely Hans Andersen's fairy tale of *The Emperor's New Clothes*, he asked for free discussion of the value of that mystical adjunct to coast defence which had been so autocratically imposed by experts.

" While he was still on the Colonial Defence Committee, Clarke was sent on various foreign missions—to Sweden, where he was impressed by the possible future of the submarine ; to Bucharest, to report on trials of artillery cupolas ; to Plevna to supplement his former studies on paper by an examination of the battlefield on the ground ; to Malta and Gibraltar to inspect, in conjunction with an artillery officer, the forts and their armament and to make recommendations. Then there was a visit to America to report on the defences of Halifax and on a pneumatic gun at Fort la Fayette, which eventually failed to come up to the favourable opinion he formed of it. Later a visit to Antwerp, to make an independent report on its defence to the King of the Belgians, led to Clarke holding lightly the value of the forts there.

" After what he called his eviction from the Colonial Defence Committee, Clarke, made K.C.M.G. in 1893, served for two years (1892-4) at Malta, where he says that he learned all that it could teach from the naval and military point of view. Then in the autumn of 1894, he took up the post of Superintendent of the Royal Carriage Department at Woolwich, and here for more than seven years (1894-1901) all his official duties centred on artillery questions. He succeeded, in spite of hindrances which he attributes to the civilian government of the Ordnance Departments, in making gun-mountings less cumbersome and in improving the loading, sighting, and directing of guns. A spade attachment he devised for checking recoil of field guns stood the severe test of service in the South African War. Failures of the War Office in that war led to the appointment of a War Office Reorganization Committee, of which Sir George

Clarke was a member. Only a few of the recommendations of that committee were acted on, and it was not until after his return from being Governor of Victoria (1901-03) that he had the satisfaction of seeing effect given to his views on army administration. This followed on his appointment with Lord Esher and Sir John Fisher to a committee with wide terms of reference, which generally adopted his ideas as also the recommendation, on which he had for some time laid stress, that there should be a Council of Imperial Defence to keep the Government in the closest possible touch with those responsible for advice in defence matters and for the organization, training and administration of the defence forces. To this Council Clarke was created Secretary, a position he held till September, 1907. In that capacity he came into touch with many matters of foreign policy with regard to the military aspects of which he had to see that the Prime Minister had the best information.

"Sir George Sydenham's departure for India in October, 1907, in effect closed not a chapter but the whole period of his splendid 25 years' career as a military scientist and writer. Not only did fortification in its technical aspects drop out of his life, but all his literary connections were now severed. The public had realized little, though the War Office had possibly suspected greatly, the extent to which military opinion in this country had been influenced by Clarke through the public Press. For many years he had written for *The Times* articles in good literary style and combining wide general views with detailed expert knowledge. Probably the letters of 'Vetus,' 'Navalis,' and 'Reform,' of which even his intimate friends did not at the time they appeared know the authorship, were a predominant element in bringing about the reorganization of the War Office. Many must still remember the great interest they aroused when they appeared in the course of the 'nineties. Apart from these and other communications to *The Times* he contributed to a number of papers of less note, as well as to the *Edinburgh Review* and other magazines. His works in more permanent form, on Fortification, Imperial Defence and the navy, secured his election to the Fellowship of the Royal Society.

"An interlude in the life above recorded were the two years spent in Victoria. They occurred shortly after Federation, when a State Governor's advice was probably more sought after by Ministers than it is nowadays. Nevertheless, such a governor's time was then, as it is now, mainly taken up 'by innumerable functions of an official and social character, trips to distant country gatherings, institutions to open and assist and always speeches to be made.' All these things were done with Clarke's characteristic thoroughness and understanding, and they secured him great and lasting popularity in Australia. His Governorship of Bombay was a more arduous matter. But that belongs to another period—the last 25 years of his life, which in the absence of personal recollection to supplement

published accounts and appreciations, I must leave to be recorded here by others.

"I am glad of the opportunity that has been given to me to make a contribution to *The Royal Engineers Journal*, to which George Sydenham Clarke contributed so often, and thus once again to follow *a lungo intervallo* a path that he trod. It is 49 years ago since we translated, he the 1st part and I the 2nd, a German pamphlet on *Fortress Warfare* that appeared in the *Occasional Papers* of the Royal Engineers Institute. Two years later I find that in a letter from India I expressed the desire, presently to be fulfilled, of being allowed to put into practice in that country the right principles of coast defence—those he had taught me. I was one of his many assistants in examining in geometrical drawing for the Science and Art Department. When he gave up setting and correcting papers in engineering drawing for Cooper's Hill College, he made over the work to me. I have always attributed to him my appointment, three years after he left it, to the Secretaryship of the Colonial Defence Committee, which, but for lack of his brilliancy, might have led me to a career on the lines of his own. While holding that appointment, I was given, on his recommendation to the editor of the *Encyclopædia Britannica*, the task of writing the article on Coast Defence which appeared in the edition of that time. Whether working with him on these various occasions or learning from him in the early cheerful days of the War Office, or visiting at his home in Cheniston Gardens, it was always a keen pleasure to be in his company, a pleasure in no way affected by our being of opposite views in politics; he was what was then called a Radical, while I held very much to the usual Toryism of the young officer of that day. Whatever was the subject of our talk I can recall well the kindly smile, the amusing criticism and the useful suggestion that I could always get from him. I still feel the old admiration for his immense powers of work, his thoughtful views and his gift of expression. I need not dwell on the qualities that, judging from his autobiography, sometimes made life difficult for him. He was ambitious and counted the year lost in which he had made no progress in securing the advancement of his ideas. He held his opinions strongly. He did not suffer fools gladly, and was apt to see folly in the acts of those in authority who did not share his views. To those who worked for him and with him he was, as I have indicated, a stimulating and helpful companion. His and my tours of foreign service unfortunately did not synchronize even during the period I have sketched, and after that came an inevitable drifting apart in the altered circumstances of our lives. I think I only once saw Lord Sydenham after his return from India, but some years later a volume of literary sketches by my dear little friend, his daughter, who had died in India, came to 'M.N. from S., 22nd Febry., 1914.'"

M.N.

Colonel Sir Edouard Percy Cranwill Girouard, KCMG, DSO

COLONEL SIR EDOUARD PERCY CRANWILL GIROUARD, K.C.M.G., D.S.O.

THE career of Colonel Sir Edouard Percy Cranwill Girouard, K.C.M.G., D.S.O., late R.E., is one that should be recorded.

He was born in Montreal on the 26th January, 1867, and died in London, at the age of 65, on the 26th September, 1932.

He was the second son of Hon. Desiré Girouard, who was Senior Judge of the Court of Appeal of Canada. His mother belonged to the family of Cranwills in New Orleans, U.S.A.

He was educated at the Royal Military College, Kingston, Canada. The Judge intended that his son should follow in his footsteps in the legal profession. He was particularly averse to an army career. The son's views about his future were quite different. His ambition was to be an engineer. He even thought about being a Royal Engineer, but in consideration of his father's prejudices he did not apply for one of the commissions usually offered to graduates of Kingston College. The discussion of a career led to serious differences between father and son, so that home had some drawbacks during the vacations from Kingston College. Consequently many vacations were spent in whatever employment could be picked up on some engineering work, usually on railways.

On leaving Kingston College in 1886, he took up a junior appointment as an engineer on survey and construction work on the Canadian Pacific Railway. This appointment influenced his whole career. He was heart and soul an engineer and threw himself with vigour into the work which gave him particularly valuable experience. It was pioneering work developing a new country, and to the day of his death Girouard remained by nature a pioneer and a developer of new countries or new resources. He was not many generations removed from his adventurous French ancestor who had left France to take his part in a hard life opening up and developing Canada. The same adventurous spirit was a continual urge to Girouard throughout his life. Because railways were a prime factor in the opening up of new countries, because he was born an engineer by nature, because the best brains and the biggest men in Canada and America were devoted to railway work, because his first executive appointment was on the C.P.R., railways always fired his imagination and absorbed his attention.

In 1888 some war scare in England caused the War Office to look for more 2nd-Lieutenants for the Royal Engineers, and they offered a limited number of commissions to Canadians below a certain age

who had graduated recently at Kingston College. Girouard was eligible for the offer and accepted it. His father was bitterly opposed to the decision and declined to help in any way. The pay of a very junior engineer on the C.P.R. had not permitted any saving, but an aunt came to the rescue with a cheque for £100 and with that he started for England and reported at Chatham 26th July, 1888.

He was two years older than the 2nd-Lieutenants from "The Shop"; the work done in his vacations from Kingston and on the C.P.R. and the pioneering life he had been living had made him already into a practical engineer. He had a superabundant vitality, which served him well throughout his life and even fought and often triumphed over the bad health from which he suffered in the last few years. It gave him a *joie de vivre* which made him always the best of company. The original bent of his imaginative mind caused him to approach every task from an original point of view. He was, therefore, no ordinary Y.O. and immediately attracted attention.

On leaving Chatham his previous experience on the C.P.R. caused him to be posted on 1st July, 1890, to be Traffic Manager of the Railways within the Royal Arsenal, Woolwich, an appointment which he held for five years. Had he confined himself solely to the duties required of him, they would hardly have fitted him for the important work that was to be offered before long. But Girouard was not the man to live within the precincts of a large and important arsenal without absorbing all the knowledge that was demonstrated daily to his discerning eyes.

More important still, he took the opportunity to study deeply and continuously the whole subject of the employment of railways in war. He read voraciously everything that he could find on the subject, in particular a most illuminating book by a Mons. Jacqmin, describing the working and the breakdowns of the French railways in the war of 1870. He also read the accounts of the working of German and Austrian railways from their first employment in war up to the war of 1870.

In every country he traced the same chain of events. First, the assumption that a railway could do anything required of it in war and that it should be commanded in the same way as any other military unit; next, the discovery that a railway was a delicate organization requiring particular treatment without which it rapidly became congested and ceased to function. This had led to regulations for working railways in war being promulgated in Germany, Austria and France, which bore a strong family likeness to each other and adhered to the same principles.

This is common knowledge to every army officer now. Our movement regulations are well known and established on the same principles as those of Continental nations, but in 1890, and for a very long time afterwards, we had no regulations on the subject whatever, and

at that date the only British officer who knew or even thought that certain definite principles and organization must be adhered to, in order to develop the full utility of railways in war, was Lieut. E. P. C. Girouard, R.E.

This knowledge acquired by diligent study at Woolwich was to serve him in good stead later and to be of great service to his country.

While at Woolwich, if he did not originate the idea, at any rate he brought prominently to notice the practicability of mounting the very heaviest guns on railway rolling stock. Before long he was to have an opportunity to put his ideas on this subject into practice.

While stationed at Woolwich he was frequently seen at Chatham. He was particularly in request on guest nights to sing the French Canadian song " Alouette " in his inimitable way, which roused his audience to join heartily in the chorus.

The Sudan.

In March, 1896, his opportunity came. Lord Salisbury's Government decided with startling suddenness to begin the reconquest of the Sudan. The Italian disaster at Adowa had given rather a thin pretext upon which to persuade public opinion to a course which was very necessary for many much more weighty reasons. The intention was camouflaged for political reasons by orders to Colonel Sir Herbert Kitchener, the Sirdar of the Egyptian Army, to make a limited and gradual advance up the Nile to Dongola.

Sir Herbert Kitchener had long expected such an order and prepared his plans to execute it. A young man himself, he preferred to employ young men. He had the knack of finding out the right ones and so he had heard of Girouard. Colonel Sir Herbert Kitchener (let us call him by the letter which fame soon appropriated to his exclusive use, " K ") intended to keep his forces within reasonable reach of railhead. The progress of the railway was to regulate the pace of the advance which would be made in bounds, followed by halts to bring up the railway. He intended, however, that the pace of construction of the railway should be phenomenal. " K " sent for Girouard,* who arrived at Wady Halfa in March, 1896, as a subaltern, aged 29. He was appointed Director of Railways in the Egyptian Army and told to produce a railway at the minimum rate of a mile a day forthwith. It was a demand for " rabbits out of a hat." " K " was accustomed to demand rabbits to be bred in this way and to be supplied with them. The suddenness of the order to advance had given no time to collect carefully at Wady Halfa (1,000

* Major-General R. N. Harvey writes :—" I was at Halifax in 1896 when Girouard passed through on his way to England. I asked him what he was going to do, and he told me he was going to Mauritius to raise a black company of R.E. He actually arrived in England just as his services were required by " K," and he thus escaped from service at Mauritius. Suppose he had gone to Mauritius. Would he ever have had his railway opportunity ?

miles from the sea and several hundred miles from the Egyptian railways) all the numerous requirements of a railway. The Egyptian Army had already advanced some 50 miles to Akasheh and the railway was to arrive there at once if not sooner.

The work had to be done by collecting on the spot the debris of former abandoned railway schemes partially executed in the campaign of 1884. On 16 miles of railway between Wady Halfa and Sarras one short train ran once a day. Some small railway workshops suitable for such a modest railway existed at Wady Halfa. A limited number of derelict locomotives badly in need of repair were lying in sidings, where a few railway wagons were rotting. A few miles of rails, but no sleepers or fishplates, were to be found in the desert where they had been abandoned in the retreat of 1885. The local resources of Egypt were combed to rush up to Wady Halfa the minimum requirements for a railway. A Railway Battalion of Egyptians of all ranks, completely innocent of any railway or other engineering experience, was improvised. Five R.E. subalterns were allotted to help the Director of Railways, and a small but invaluable detachment of "other ranks" from the 8th Railway Company, R.E., was asked for, but did not arrive for some time.

It was from such beginnings that Girouard rapidly built up an efficient railway organization which, in the excessive heat of the summer of 1896, extended the railway from Sarras 92 miles to Kosheh, which was reached on the 4th August. Here it supplied the army with gunboats transported in sections and with all the supplies for a base, from which the army made a rapid bound to Dongola and on to Merowi.

By May, 1897, the railway had reached Kerma in the Dongola Province, 203 miles from Wady Halfa. It was common knowledge that the production of these rabbits from a hat was entirely due to the "drive," the knowledge, the resource and the indomitable perseverance of Girouard in the face of great difficulties in a very trying climate.

He worked without resting, never sparing himself. Disregarding the warnings of old residents in the Sudan, he took great risks with his health. He was the personification of cheerfulness, obviously enjoying the mastering of every difficulty. He inspired the greatest enthusiasm, confidence, loyalty, and affection in all his subordinates, British and Egyptian. He was a man after "K's" own heart. There was mutual sympathy and understanding between the two men, so that Girouard, with his strong sense of humour, which found its echo in "K," was on terms with the Sirdar that astonished men who stood in awe of that reputedly stern man.

The success of the Dongola Expedition caused the Government to authorize "K" to prepare an advance to Berber.

"K" was now free to put in hand a long-cherished project.

Between Abu Hamed and Wady Halfa the Nile makes an enormous loop, several hundred miles in length. The chord of this loop across the barren desert is now known to be 235 miles for a railway, which would outflank all the cataracts and give access to navigable water extending well beyond Berber. From Abu Hamed an advance to Berber would be comparatively short and easy.

The task for Girouard in 1897 was to build 235 miles of desert railway from Wady Halfa to Abu Hamed.

Pharaohs and Khedives had made many efforts to find water in that desert, but not a drop had been found except at Moghrat Wells, some distance from the route of the railway.

Girouard made it clear to " K " that this was not an enterprise which could be undertaken by the methods usually associated with conjurers. Nor could the railway scrap-heaps of Egypt be the source of supply for such a railway, even if they were not already exhausted by the construction of the line to Kerma. There must be a brief period for careful preparation, for the working out of an estimate and a detailed indent for the thousand-and-one items required for such work.

With many admonitions to be economical, as the straitened Treasury of Egypt had to meet the bill, Girouard and his assistants sat down to the task of thinking out what was required, of specification, of indent and of estimate. He took a bold line. Realizing that a great deal of the trainload must be water tanks for the locomotive, it was obvious that trainloads must be large, and therefore locomotives heavy and powerful. Contrary to some expert advice, he followed American and Canadian practice in adopting a high ratio between axle load and weight of rail, but well-sleepered. Cecil Rhodes, Prime Minister in Cape Town, realized that " K " and Girouard were working on his pet scheme of a railway from Cairo to the Cape, and used his influence to meet Girouard's demand for the immediate loan from the Cape & Natal Railways of 70-ton and 80-ton locomotives.

In February, 1897, Girouard paid a flying visit to England to place the orders for everything required and to urge early delivery.

Three more R.E. subalterns and a few more " other ranks " from the 8th and 10th Railway Coys. R.E. were added to his establishment, but as two subalterns had died the net increase was only one officer.

His railway constructing machine had been forged the previous year in the fire of the Batn-el-Hagar (belly of rocks). The Railway Battalion was now capable of laying permanent way at a rate of well over a mile a day.

It was in May, 1897, that the work on the desert railway began in real earnest. A miracle happened. An abundant supply of water for locomotives was found by sinking wells at mile 77 and again at

mile 126, but nowhere else. The Girouard "Fez" was still producing rabbits. This increased the useful trainload by reducing the trucks required to carry water for the locomotives and so speeded up construction, which proceeded at an average rate of $1\frac{1}{6}$ miles per day, the greatest length laid in one day being 3 miles. On October 31st, 1897, the railway reached Abu Hamed and immediately orders were received to push it on through Berber to the River Atbara, another 150 miles. The Atbara, 385 miles from Wady Halfa, was reached in May, 1898; adding the 203 miles of the Kerma line, the total length of railway construction in 2 years and 2 months had been 588 miles.

The jumping-off place for the final bound to Khartoum had now been reached. The first half of 1898 was therefore spent in preparation for the advance to be made at high Nile in September. For this a division of British troops was to be added to the force and transported from Alexandria to the Atbara.

A new link in this long line of communications was being built in lower Egypt by the extension of their railways from Luxor to Assouan. The administration of the Egyptian State Railways guaranteed the Sirdar a delivery to the army by this railway of 10,000 tons per day. The Sirdar travelled along this new line and doubted whether it would be ready in time to deliver what had been promised. He ordered Girouard to inspect and give his opinion. Girouard made a detailed inspection and very full notes of the condition of this railway, and reported that, unless drastic and immediate steps were taken, the outside limit of its capacity would not exceed 5,000 tons per day. A conference was called by Lord Cromer, who thus met Girouard for the first time and was very much impressed by his grasp of the situation and the soundness of his opinion as to what was necessary to remedy matters. The result of the conference was that Girouard was bidden to take over the defaulting length of railway and put it right in three months, demanding everything he required from the administration of the Egyptian State Railways. This task he also accomplished successfully.

In June, 1898, Lord Cromer offered Girouard (still a subaltern aged 31) the appointment of "President of Egyptian State Railways and Alexandria Harbour." It was a great prize that was being offered to him, but it meant leaving the force that was about to advance on Khartoum. "K," however, urged Girouard to accept it. His work for the advancing army had been completed when the railway reached the Atbara. "K" was fully conscious of all that he owed to Girouard and was not going to stand in his way to prevent him taking up another big task.

When the battle of Khartoum had been fought, Girouard sent a telegram of congratulations. "K" must have received thousands

of such telegrams, but his reply to Girouard was telegraphed immediately :

" Thank you my dear Girouard your good work in 1896 1897 and 1898 has borne fruit."

Egypt.

Taking up his new appointment, Girouard realized at once that he had stepped into an Augean stable.

Since Egypt had become bankrupt under the Khedive Ismail Pasha, the bailiffs had been in possession of the country.

The maximum revenue had been screwed out of the State Railways and the Port of Alexandria to pay the international bondholders. Not a *piastre* had been returned to the railways or the Port for improvements. Not enough had been allowed for the minimum of bare maintenance.

Girouard made a thorough inspection of the 1,200 miles of railway system in all its departments and of the Port of Alexandria. The facts disclosed were startling. One hundred and fifty miles of permanent way were classed as dangerous, many more miles as thoroughly bad. The carriage and wagon shops were antiquated. The passenger carriages were a disgrace.

In a flat country with negligible railway gradients the goods trainload was only 500 tons, owing to the use of small goods wagons and light locomotives. The bridges and permanent way could not carry heavier and more powerful locomotives. A great deal of traffic was going by water which would have preferred to travel by rail. The system of traffic working and the methods that were customary were fantastic.

Port Said was not connected to the State Railway system and had not been developed as a harbour. Alexandria was the only port of the country. The methods for loading and unloading ships and for clearing the traffic at that port were archaic.

A harbour and a railway system capable of stimulating a great development of prosperity in the country and of multiplying revenue considerably had been starved into bare existence.

Armed with these facts, Girouard interviewed Lord Cromer, who immediately backed his proposals and undertook a difficult struggle with the international *Caisse de la Dette* to extract a very large capital sum to reconstruct and reorganize the railways and the ports of Alexandria and Port Said.

It required all the powerful influence and the unrivalled skill of Lord Cromer to conduct the struggle with the *Caisse de la Dette* to a successful issue. A considerable amount of time passed before obstruction ceased and a very large sum of money was extracted for a programme of reconstruction that was to extend over four or five years. Fortunately, Egypt had emerged from the period of lean

years and was now prosperous. The time absorbed in these financial negotiations was required by Girouard and the departments under him to work out in full detail and to co-ordinate the great programme of work. Briefly, this programme may be summarized as follows :—

(*a*) Increase of the goods trainload from 500 to 1,200 tons.
(*b*) A large increase in weight and power of locomotives.
(*c*) Relaying the permanent way throughout the system with heavier rails and sleepers.
(*d*) Replacement of all bridges by stronger ones.
(*e*) Reorganization of the workshops.
(*f*) Provision of new passenger rolling stock of the most modern type.
(*g*) Provision of large-capacity goods wagons.
(*h*) Complete reconstruction of the Port of Alexandria and provision of modern equipment.
(*i*) Port Said to be developed and equipped as a port and connected to the State Railways.

This was an ambitious programme, but within a few years it was carried out in its entirety and in accordance with the original plan.

Girouard remained in Egypt long enough to work out the schemes, to start them on sound lines, and to secure by Lord Cromer's efforts the necessary funds, but he did not remain to supervise the execution.

In May, 1899, Girouard went to England and America to order equipment for the great programme of work in Egypt. Covering much ground in America, visiting engineering works and undertakings, he picked up a great deal of valuable knowledge.

South Africa.

Before the summer was over Girouard was back from America and in London, dealing with the orders for Egyptian railway equipment in England. Everyone was talking of the imminence of war in South Africa against the Boer Republics.

Girouard chanced to meet at dinner Colonel the Hon. George Gough, Private Secretary to the C.-in-C., Lord Wolseley. Girouard said that he hoped the War Office had realized the railway problem that would confront them in the operations in South Africa, and that they were preparing to deal with it on an adequate scale. Colonel Gough invited Girouard to explain. Girouard pointed out that there was about 1,800 miles of railway in the territory of the two hostile republics, that a successful advance must mean taking over all this railway in a damaged condition and entirely denuded of railway personnel. Moreover, in our own territory in Cape Colony and Natal there were some thousands of miles of railway which must be utilized to their maximum by the army. Then, unloosing the stored-up knowledge about the working of railways in war, which

he had acquired in his voracious and continuous reading at Woolwich, he explained the history of this side of war on the Continent, the disasters that had occurred from the congestion and stoppage of railways when there was no proper system of working between army staff and railway staff, and how several Continental nations had independently evolved an identical system for solving the problem, but that in the British Army it was not even known that the problem existed.

Colonel Gough said that he thought the C.-in-C., Lord Wolseley, would like to hear what Girouard had said. The next day there was a telephone call to go and see the C.-in-C. Girouard went over the same ground with the C.-in-C., repeating what he had said to Gough.

Lord Wolseley was very quick to grasp a situation and he was a man of action. He asked Girouard if he could go to South Africa as Director of Railways on the Army Staff. Girouard explained that Lord Cromer must be asked if he could be spared and lent for the campaign.

As usual it was generally supposed that the war would be short, six months at the outside. After an interview with Sir Redvers Buller, C.-in-C. of the army for South Africa, a telegram was dispatched and answered. Lord Cromer agreed to lend Girouard, and he began his work at the War Office at once.

He found that the *War Establishments* provided two small Railway Companies R.E. and that the staff of the Director of Railways was one batman. A battle ensued with the *War Establishments* Committee that was sitting at the War Office to settle the composition of the force. Girouard demanded a staff of eight R.E. officers and a proportion of other ranks, also four Fortress Companies, 6th, 9th, 20th and 42nd, to reinforce the two Railway Coys., 8th and 10th.

The War Office Committee was staggered at the suggestion that the one batman allowed should be multiplied to this extent. A threat to return to Egypt instead of proceeding to South Africa and an appeal to the C.-in-C. caused the stupefied Committee to countersign the demand. Later he gathered in most of the subalterns who had served him in the Sudan. Girouard's next demand was for £100,000 to purchase railway and engineering stores and material.

With our knowledge of the demands for engineer and railway stores in the Great War, Girouard's request appears quite modest, but in 1899 the War Office had no experience of modern war, and a demand for £100,000 for this purpose seemed outrageous. This time Girouard mobilized the Secretary of State for War to countersign the demand.

His staff sat down to examine reports from the Intelligence Branch, and to evolve an indent for what should be purchased with the hundred thousand.

Another shock was experienced by the War Office when Girouard demanded that a cable should be sent to South Africa ordering that

any British railway employees who left their employment on the railways of the Boer Republics should be taken into pay at once and placed at the disposal of the Director of Railways. A guarantee was given of reinstatement in their previous employment. About 300 trained railwaymen were thus secured.

In October, 1899, Girouard embarked with his staff. He was graded as an A.A.G. and given the local rank of Lieut.-Colonel. Three months previously, at the age of 32, he had been promoted from Subaltern to Regimental Captain and Brevet Major, now he was a local Lieut.-Colonel. Promotion in the army had tarried long, but was now moving rapidly. He carried with him to present at Cape Town a letter of credit from the Secretary of State for a million pounds. This so staggered the Command Paymaster at Cape Town that he burst into the Garrison Mess at lunch-time saying: "A hell of a fellow has arrived. He calls himself Jerrymo, and he's got a letter of credit for a million!" Girouard's strong sense of humour was tickled with this story, and he laughed heartily whenever he was addressed as "Jerrymo!" The name stuck to him for a long time and became abbreviated by his intimates to "Jerry."

Immediately on arrival at Cape Town he raised a most valuable unit called the Railway Pioneer Regiment. The Mining Engineers and their skilled artisans who were refugees from the Rand goldfields provided splendid personnel for this unit. The R.P.R. added to his six R.E. Coys. and his 300 railwaymen from hostile railways gave him a useful force for the coming operations.

The story of his work in the South African campaign cannot be told within the limits of a "Memoir." Two large official volumes have recorded it in considerable detail.

Briefly it may be said that, as expected, the enemy blew up practically every bridge and culvert and several miles of railway, and left 1,800 miles of line denuded of any employees. But Girouard's foresight had provided the nucleus round which to improvise a new railway administration. The bridges and permanent way were repaired with phenomenal speed so that the operations of the army were never delayed for lack of railways.

Equally important was the liaison he established with the friendly railway administrations on our side of the frontier upon the principles which he had studied at Woolwich and which are now familiar to all in our *Movement Regulations*. It was a difficult task, not accomplished without much obstruction, to disseminate throughout the whole Army Staff this special knowledge which at the outset he alone possessed.

For his services in the campaign he received a well-deserved K.C.M.G. At the age of 35 he was Brevet Major Sir Percy Girouard, K.C.M.G., D.S.O. As the long campaign (two years and eight months) was drawing to a close, Lord Milner, High Commissioner for South

Africa, began to organize the Crown Colony Government that was to administer the conquered territory after the signing of peace.

For the re-organization and further development of the railways in the newly-acquired territory, and for co-ordination of the relations between this system and the railways in adjoining Colonies, Lord Milner required a Commissioner of Railways. It is not surprising that he asked Girouard to accept the post.

Girouard had been nearly three years away from his appointment in Egypt. His substitute was thoroughly established there, carrying out to the letter the programme of work prepared by Girouard, so he accepted Lord Milner's offer.

Without rest he plunged into his new and arduous duties. His first task was to create from very little available personnel a new civilian railway administration for the conquered territory. Nearly all military personnel left at the termination of the campaign.

The next task was to use the new railway organization to serve the reconstruction of the country after the ravages of war, and to arrange terms of working and traffic with adjoining railway systems.

South Africa, after its war, had similar experiences on a much smaller scale and of shorter duration to those which the world has passed through since the Great War. Those who lived in South Africa from 1902 to 1906 should have known what to expect between 1918 and 1933.

First there was a false and hectic but short-lived boom. In this period megalomania was rampant throughout the sub-Continent. Every industry was expected to multiply its resources and prosperity. The railways were expected to develop to deal with this new era of prosperity, which was to last for a long period. A programme of several hundred miles of new railways was prepared and money borrowed for the purpose.

The railway system in the new territories was in far better condition than the system which Girouard had taken over in Egypt, but it was capable of great improvement. Girouard followed his usual practice of increasing the trainload by arranging to supply heavier and more powerful locomotives for main-line work, which involved heavier permanent way and stronger bridges.

Eighteen months later, at the beginning of 1904, the crash came, and a severe slump settled on the country, which was to last for some years. Economy, ruthless wielding of the axe, scrapping of all schemes of expansion and development, however promising they might appear, were the order of the day. Those who had been the biggest megalomaniacs were now shouting the loudest for economy and criticizing those who had prepared plans on a basis of prosperity.

Discussion in the Legislative Assembly on railway matters became acrimonious. More ominous still for those who held posts in the Crown Colony Government was the imminence of a change of

Government at home. The incoming Liberal Government were pledged to give self-government to our late enemy territory. The days of the Milner administration were numbered.

Under these circumstances Girouard resigned his appointment in December, 1904, and returned to England. In November he had been given a Brevet Lieut.-Colonelcy.

He took with him to England the wife whom he had met and married in South Africa ; Gwendolen Solomon was the only daughter of the Hon. Sir Richard Solomon, Attorney-General in Lord Milner's Government and later High Commissioner for South Africa in England. Their only son survives them both.

He was now a Regimental Captain and a Brevet Lieut.-Colonel, and as such was posted to be Staff Officer to the Chief Engineer, Eastern Command.

For nearly nine years he had held the most important and responsible positions in command of enormous organizations. It was not easy for any man, least of all for one of Girouard's restless and original temperament, to settle down to the routine duties of a subordinate in an office. But had not a greater man, General Charles Gordon, descended from Commander-in-Chief of the ever-victorious army to be Garrison Engineer at Gravesend ?

It was a severe test of character and of patience. After 21 months' chafing in this employment, he was appointed in September, 1906, to be A.Q.M.G., Western Command. But the routine duties of a " Q " office were even less to his taste than the routine of an engineering office. Quite possibly this period of comparative rest and normal regular life was the best thing for his health after the strain of working as few men can work for eight years.

With the great reputation which he had established in Africa, North and South, he was well known to the public, and it seemed impossible that no one had work to offer which would give full scope to his capacity. It was impossible. In January, 1907, opportunity called on him again.

NIGERIA.

In January, 1907, Mr. Winston Churchill, Under-Secretary of State for the Colonies, was struggling with a large bundle of files dealing with the question of a railway for Northern Nigeria, which had not a mile of railway in all its vast territory.

Everyone agreed that a railway was necessary, but there was no agreement about the many problems that the proposal raised. There were masses of conflicting opinions from local engineers, from consulting engineers, from civil servants in Nigeria, and from civil servants at home. Sir Frederick Lugard had been pressing for the railway for some time, but nothing had been done because of the conflict of opinion how to do it.

Mr. Winston Churchill had met Girouard in the Sudan, in Egypt,

and in South Africa. He knew all about his work and his capacity and admired both. He asked Girouard to call and see him. When they met, the Under-Secretary of State metaphorically flung all the files at Girouard, told him that there were plenty of opinions to be found there, but he wanted only one ; he wanted Girouard's opinion, which he was fully prepared to back. Girouard took away the files and was very soon back in the office of the Under-Secretary with all the points in the case at his fingers' ends.

As regards the route to be followed, he declined to express an opinion without travelling over the country, but after dealing with several engineering aspects of the question, and giving decided opinions upon them, he pointed out that the engineering aspect was perhaps the easiest part of the problem. From the point of view of the administration of the country, the advent of a railway in a territory entirely devoid of railways raised numerous knotty problems. The supply and conditions of labour, rates of wages, disturbance of existing transport systems, rates for traffic, acquisition of land, etc., etc.—a long list of other headings.

At that moment it occurred to Mr. Winston Churchill that, by a fortunate chance, a vacancy had just occurred in the post of High Commissioner (later called Governor) of Northern Nigeria.

He offered the appointment to Girouard and promised him a free hand to deal with the railway question as he thought best. He promised to back Girouard's opinions and to find the money. Here again was work worthy of Girouard's capacity and entirely suited to his temperament: more development of a new country and pioneering work: supreme command in a new territory and a free hand.

In February, 1907, the new High Commissioner and C.-in-C. of Northern Nigeria embarked to take over his kingdom. The following year the title was changed to Governor and C.-in-C.

At first his main preoccupation was the construction of a railway, but he did not allow it to absorb all his energies. He very rapidly settled all the main difficulties which had hitherto blocked the undertaking of railway construction. He was soon free to devote the whole of his attention to the administration of the country which, from the first moment of his arrival, was his constant care.

In Mr. (now Sir John) Eaglesome, Director of Public Works of Northern Nigeria, he found the man he required to be his Director of Railways, to whom he was soon able to hand over entire responsibility for that work, having cleared out of his way the difficulties due to delay in arriving at sound decisions on the main features of the problem. Girouard himself took part in the reconnaissance for the route and settled it. Mr. Eaglesome was given the authority to collect the necessary staff of civil engineers, and Girouard also arranged for a valuable detachment of three officers and 30 N.C.O's and men of the Royal Engineers to work under Mr. Eaglesome.

The officer in charge of this detachment writes :

" Girouard galvanized every official in the Colony into enthusiasm for the construction of the railway. It was a question of ' our ' railway for everybody. As a result the ' Residents ' used to turn out in person to supervise the smooth working of the labour problems. There was a peculiar *camaraderie* which extended from the Governor down to the junior foreman, and to which in no small measure the records of speed and low cost of construction were due."

Another R.E. officer in this detachment, who had also served under him in South Africa, writes :—

" One of Girouard's most remarkable gifts was that of inspiring the devotion of the rank and file. I can give you two illustrations of this. When Girouard resigned his appointment in South Africa, such was the devotion that he had inspired in the workmen in the railway shops that these men who barely knew him, and in many cases had never seen him at all, subscribed half a day's pay to present him with a casket of farewell.

" The second instance I saw was in Nigeria. My drivers on construction, who were nearly all Sappers, only saw him about once a year when he came down the line. He used on these occasions to go along to the engine and thank the driver quite briefly. But every man of them would have worked himself to a standstill for Girouard."

Sir John Eaglesome writes :

" The problem before him was how to organize this vast Protectorate which, added to Southern Nigeria, is about a third the size of India, to equip and train a military force, to open out communications and establish medical services, posts and telegraphs on a credit capable of supporting a Grand Duchy. Girouard used to say to his Staff : ' The greatest asset you possess is that invaluable spirit of economy, not to say meanness, which has been left behind by Sir Frederick Lugard.'

" Much of Girouard's success was due to his wise choice of the men he employed, and he had an excellent custom of living in a Mess with his small staff so that he was always accessible to information and the opinions of everybody he met. Many of his ideas were novel and to a Colonial staff radical. He proceeded in his own way, ignoring precedent. He would call up a resident by telegraph early in the morning, and have a conversation with him in which every branch of political work was enquired into, advice was given and asked for. The resources of the country along the line of railway were made use of in this way."

The foregoing remarks give some explanation of how 366 miles of railway were constructed from Baro to Kano in record time for the very low cost of about £3,300 per mile.

But it was as an administrator of the country that Girouard gained a reputation greater than that which he already possessed as a builder of railways. He was an earnest disciple of what is known as the "Lugard policy" in Africa, viz., governing the country through its own chiefs. To this he adhered consistently. In this connection Sir John Eaglesome writes:

"In the political and administrative sphere begun by Sir Frederick Lugard, the creation of a complete civil service was continued, which increased from half a dozen officers in 1900 to something like a hundred in 1909.

"His guiding principle, following Sir F. Lugard, whose genius he never failed to recognize, was indirect rule through the native chiefs, the powers delegated to whom varied with their degree of enlightenment. Girouard also continued the great work of Lugard in the abolition of slavery, which was universal in Northern Nigeria in 1900."

A distinguished member of the Colonial civil service who served under Girouard writes as follows:

"Girouard's appointment was popular from the start, and one of the reasons for his popularity was the fact that, unlike so many governors, he did not say that what his predecessor had done was all wrong and that he himself would show how a country should be governed. Girouard had the personality of a strong man, and, although a tiger for work and with a capacity for digging into minute papers, he knew how to get the most and the best out of his staff.

"While Girouard's first tour of service in Northern Nigeria was largely occupied with formulating a railway policy and with the construction details of the Baro-Kano line, the important question of policy—initiated by Lugard—was uppermost in his mind. Sir Percy had great vision and was content to build on the foundations laid by his predecessor. He gave his support to native rule and rulers, their councils and courts, customs and traditions, where not repugnant to our ideals. He felt that there was need of an increased knowledge on our part of methods of rule and native law and custom before any dislocation of institutions should take place—institutions which, however faulty, had the traditional sanction of the people. Residents of provinces were to be administrators in the true sense of the word and not direct rulers. By their sympathy, patience and knowledge of the language and customs, it was hoped not only to utilize existing machinery, but gradually to improve it, and thereby better the condition of the

people. Girouard wrote: 'There are not wanting advocates of more direct rule, but even if it were possible to support that policy —which I am not prepared to do—it is quite out of the question on financial grounds. Direct personal rule of British officers would not be acceptable to the people who look to their natural leaders for guidance and control. It is not from the present generation of rulers that we must look for much advancement, and what is required on our part in our dealings with them is great and enduring patience. Exasperating it may be to witness slow progress, but this will not be hastened or accomplished by upsetting ideals and customs but little understood.'

"Girouard was responsible for the comprehensive investigation into land tenure in Northern Nigeria, and he wrote an able and lengthy memorandum on the subject which he submitted, with residents' observations, to the Secretary of State for the Colonies with his recommendation that expert advice should be sought upon a subject of such vital importance to the present and future welfare of the inhabitants of the Protectorate, and in view of the early development of communications, one calling for immediate solution. The condition of tenure obtaining in Northern Nigeria disclosed a situation apparently allowing of a policy which would promise lasting benefits and protection to the native population. Attention was also called to the tenure of land granted to Europeans, and more particularly traders. The result of Girouard's effort was the appointment of a highly representative and expert committee sitting in London under the chairmanship of Sir Kenelm Digby, G.C.B., to consider the whole question. To-day Nigeria is reaping the benefit of Girouard's labours in this respect.

"Although Sir Percy served only two tours of service in Northern Nigeria, they were tours of service of splendid achievement. He left his mark in the country as an administrator of a high order. He had great personal magnetism which endeared him to his staff. He was known to us as 'Jerry,' and we who are left behind have happy memories of his unselfishness and kindly thought for others. His quaint sayings were numerous. Incidentally Girouard was the first to introduce the motor-car to Northern Nigeria."

Another distinguished contributor, formerly a member of the civil service, writes:

"Girouard had a most wholesome contempt for the pomposities, snobbishness and 'frills' which often afflict officers administering governments. He very strongly supported and carried through the policy initiated by Lugard which safeguarded the natives in their land, and made it impossible for European capitalists to acquire 'concessions,' thus saving the Protectorate from the troubles and scandals which have arisen elsewhere in Africa.

"His popularity was largely due to the fact that his energy and determination in getting things done was not accompanied by the least trace of the rigid disciplinarian or martinet. I don't know how he did it. He had a certain jollity of disposition, and never gave the impression that he was condescending or unbending. I remember him singing a French-Canadian song ('Alouette') after one of the North Nigerian dinners in London, and he sang it very well, and we all joined in the chorus. Can you imagine such a thing being done by some of the Governors we know, and yet I never heard of this amiable quality being abused."

Girouard's governorship of Northern Nigeria, although it continued only two and a half years up to September, 1909, was a great success and conferred lasting benefits on the country.

British East Africa.

In September, 1909, he was promoted to be Governor and C.-in-C. East Africa Protectorate.

The testimony of those who knew Girouard's work as Governor in East Africa is unanimous as to the great success which he achieved. The Treasurer in his Government, who became later a very distinguished Colonial Governor, writes as follows:

"Two matters occur to me as being of special importance. The first is his conduct of the financial affairs of the Protectorate with which, as I was Treasurer at the time, I was closely associated. Sir Percy speedily realized the importance of getting away from Imperial 'Treasury control.' When he took over the Government the budget was balanced by means of a grant-in-aid from Imperial funds, and because of this the Imperial Treasury insisted on maintaining the closest supervision over the finances of the Protectorate. The annual estimates had to be approved in detail by the Imperial Treasury as well as by the Colonial Office, no new appointments or revision of salaries were possible without Treasury consent, and this all meant vexatious delay in getting anything done which involved the spending of any sum of money however small. Sir Percy overhauled the estimates of each Department in the minutest detail and explored every possible source of revenue with the result that before his retirement in 1912 he had been able to present balanced budgets, abolish the grants-in-aid and to adjust the Protectorate's finances so that the Imperial Treasury was eliminated as a controlling factor.

"This was a great achievement, and the way in which he carried out his investigations and the remarkable quickness with which he appreciated the position and spotted where economies could be effected without loss of efficiency was a constant source of admiration to myself and my staff.

"The second big thing for which he was responsible was the move of the Masai from Laikipia and the Northern Reserve to the Southern Masai Reserve. This move was not only most beneficial to the Masai themselves by bringing them together and strengthening the tribal authority of the chiefs, but also opened up for beneficial development by Europeans a very large area of land which had been most wastefully used for grazing cattle by the nomadic Masai. The actual move was approved by the Colonial office and took place when Sir Percy was on leave in 1912 pending retirement. By that time I had become Chief Secretary to the Government and was Acting Governor when the Masai moved across the Rift Valley to their permanent Reserve in the south.

"Sir Percy was deeply interested in the scheme and kept in touch with the progress of events. The move went off without a hitch, and he was himself responsible for the main part of the arrangements, having drawn up his scheme before he went on leave.

"Socially he was a delightful host with a keen sense of humour. He was deeply interested in the social life of the Protectorate and took part in many forms of sport."

In Lord Cranworth's book, *Profit and Sport in British East Africa*, we find the following:

"In 1909 Sir James Hayes Sadler was promoted and his place was taken by Sir Percy Girouard.

"The advent of the latter marked another epoch in the advance of the Protectorate, as his wide sympathy, broad views and courageous policy cut many of the bonds which had bade fair to strangle the country at its birth, and she was started in a career of prosperity from which she is never likely to look back.

"During his reign the views of all classes received careful consideration, communications were improved, labour was provided in quality and quantity to the satisfaction of white and native alike, and the previous attitude of entire subservience to the Colonial Office received a considerable check.

"No Governor can expect to rule either without mistakes or to the complete satisfaction of all parties, but Sir Percy Girouard left a name which grows increasingly bright as time goes on; and many of those who did not always see eye to eye with his policy have found that time and reflection prove that they themselves were in the wrong."

To obtain a clear idea of how boundless was the admiration for him as a Governor in British East Africa, one must read the many extracts from the Press of that country when his Governorship terminated. A perusal causes one to notice the constant repetition of the words "consternation" and "dismay" at his departure.

One extract from the *East African* dated 29th September, 1932, must suffice to reflect the universal opinion in the Colony:

"Transferred to the British East Africa Protectorate as Governor in 1909, he continued to pay great attention to railway development, and under his rule the Protectorate made great progress. Inspired by the great example of Lord Lugard, Girouard introduced fresh ideas and greater efficiency into the administration of the Protectorate.

"His policy was a firm one of preserving East Africa for white supremacy combined with absolute justice to the natives. On his arrival he found a difficult situation existing between Government officials, settlers and natives, but by his personal charm, approachability, dislike of formality, love of sport and constant hospitality, he smoothed over all difficulties and gained so sound a reputation as an administrator that when he decided to retire in July, 1912, the news was received with consternation in the Protectorate, and a mass meeting at Nairobi even invited the Colonial Office to reconsider the appointment of his successor.

"Sir Percy was a keen supporter of athletic clubs in East Africa, especially of the Mombasa Sports Club and the Nairobi Gymkhana. He gave a trophy to be competed for in Association football, and the struggle for the 'Girouard Cup' is still a feature of the sporting life of the Colony."

"ARMSTRONGS."

The cause of Girouard's resignation of the Governorship of the East Africa Protectorate in July, 1912, and his simultaneous retirement from the army in the rank of Major and Brevet Colonel, was the receipt of an offer from the great armament and engineering firm, "Armstrongs," to join their Board as Managing Director.

No doubt it caused him a struggle to break off his successful career in the public service, but he had private reasons for accepting the important position offered to him in industry. Lady Girouard's health prevented her from spending much time in East Africa. His own health required some attention which he had never given to it. His fine constitution and abundant vitality had enabled him to continue unremitting and strenuous work for many years in climates, some of which are not noted as healthy. He had always disregarded the climate entirely and never eased off at any time of the day, either out of doors or in his office. But the climates had not disregarded him, and it was time that he should give his health a chance.

He had little private income to supplement the pay which barely sufficed to meet the heavy expenses of the important posts which he had held. At Armstrongs he would have a chance to build up some provision for his family.

He had served his country devotedly and given full measure for 24 years. He was entitled to turn his attention to a very important post in a firm which was one of the pillars of British industry.

THE GREAT WAR.

At the outbreak of the Great War in August, 1914, Girouard had been established at Armstrongs as Managing Director for two years.

There was some talk of calling upon him to be Director of Railways to the British Forces in France, but already the importance of "munitions" began to be realized. Before long munitions were to cause Cabinet Ministers and even Governments to fall in every belligerent country. Girouard held a key position in the biggest armament firm in the country. He could do better work for the country there than in railways in France.

Had the decision been otherwise, possibly the breakdown of French railways in 1916 would not have occurred.

By April, 1915, the supply of munitions had become a burning question. Lord Kitchener sent for his former trusted Lieutenant, who was now in a position to advise him about the armament firms of England and their capacity. It was no longer possible for a few expert firms to handle the enormous demands. The time had come to turn the whole country into a workshop and to negotiate with Trade Unions concerning the dilution of labour.

On the 22nd April Girouard was established in the War Office with the local rank of Major-General. He created a branch under the orders of the Master-General of Ordnance, who, however, gave him an entirely free hand. He was called Director of the War Office Munitions Department. His business was to be in liaison between the War Office and the armament industry to stimulate output.

The agitation over munitions was, however, growing rapidly. Very shortly it became a primary cause, though not the main cause, of the dissolution of the Liberal Cabinet and the formation of a Coalition Government. Mr. Lloyd George was appointed to create a Munitions Ministry.. Girouard's branch at the War Office was transferred complete to the new Ministry. Mr. Lloyd George appointed him to be his right-hand man as Director-General of Munitions.

But the Lloyd George and Girouard temperaments were not created to work smoothly together. The country had been calling for a man of "push and go" to deal with the munitions problem. It had now got two men of that description. When two men push, one generally has to go. Needless to say, it was not the Cabinet Minister who went, but Girouard. He returned to his post at Armstrongs, where he was able to play a large part in the war effort of that great shipbuilding and armament firm.

A few years after the war, Girouard found himself in disagreement with the policy of his colleagues on the Board of Armstrongs. It was some time before the crash came which necessitated the drastic reconstruction of the firm's business.

Failing to carry his colleagues with him in the policy which he wished to see adopted, he resigned.

Private Enterprise.

He now had the opportunity to devote himself to a long-cherished project. He had always been interested in the manufacture of Portland Cement, and had his own ideas how it should be done.

He formed a small company, which started a cement factory at Snodland, near Chatham, under his management. Very soon he had created a model factory, producing cement at unusually low cost.

The automatic labour-saving equipment and layout was the delight of every engineer who saw it. It was too good. It became the Naboth's Vineyard of a powerful cement company. Girouard had no desire to sell it, but those with whom he was associated could not resist the tempting offer that was made. It was sold, and Girouard immediately started to do the same thing at another place which, from a geological point of view, was even more favourable. As usual, he had some very original ideas for the new factory. This time, however, the preliminary small-scale tests of his methods misled him, and, when the full-scale factory was ready to work, it failed. Money was not available to remedy matters, so the factory was disposed of.

In recent years Girouard's health had deteriorated considerably. In September, 1932, he was suddenly attacked with serious illness that necessitated an immediate operation from which he could not recover. He died in London on the 26th September.

His career should be an inspiration to the officers of the Corps. On the long roll of distinguished Empire builders, there should be an honoured place for the name of Girouard.

H.L.P.

All Reviews of Books on military subjects are included in the provisions of K.R. 522c.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

IMPERIAL MILITARY GEOGRAPHY.

By MAJOR D. H. COLE, M.B.E.

(Seventh Edition, 1933. Published by Sifton Praed & Co. Price 10s.)

The constitutional practice and theory of the British Empire has advanced by such an important step since the last edition of Major Cole's admirable work was published, that it is in no way surprising to find in the current edition that the book has been extensively remodelled. Let it be said at once that the result is excellent; Major Cole has now gone beyond the strict terms of the title of the book, and the introduction of sections dealing with the principles of Imperial Defence and the organization and distribution of the armed forces has completed the picture in such a way as to form in effect a manual of Imperial Defence. This book, carefully and thoughtfully studied, will give a clear insight into the practical problems in every part of the globe that face the responsible Service authorities, problems that severely limit us in the organization, distribution and training of our military forces and that are far removed from the delusive theory of the brand of military critic whose horizon is limited by war on the rolling downs of the Somme or Salisbury Plain.

Turning to the improvements and additions to the text of this book, it is first noticeable that Major Cole has wisely and boldly altered the arrangement of his chapters with the result that his matter is now presented in a logical sequence somewhat lacking in previous editions. We start with a short introductory chapter defining the term "Imperial Defence," and outlining the major responsibilities of the Services. Then follows a chapter on the political organization of the Empire, the relations between the component parts and the all-important matter of the means of achieving co-operation between the self-governing units that comprise the British Commonwealth of Nations.

The next chapter, on the Defence Forces of the Empire, is altogether new. Following this comes logically enough the original chapter on man-power, brought up to date, followed by that on Imperial resources. In possession now of the all-pervading factors of politics, effectives and material, we are introduced in succession to the practical problems that constitute the care of those charged with the responsibilities for the defence of the Empire. Finally, raised from the obscurity of the appendix to the dignity of a chapter, will be found a note of the Treaty obligations of the Empire; at the end, obviously, for generally speaking our commitments under these treaties must be implemented not only by the navy, but by the use of our military and air expeditionary forces, and the organization and size of these forces are determined not by any relation to specific duties that they may have to perform, but by financial and organizational limitations forced upon us by the normal requirements of peace duties in a multitude of overseas stations.

The first addition of importance to be noticed in this edition deals with the position created by the Statute of Westminster, significantly summed up by an addition to the principles included in the definition of Dominion status, "(b) The complete

" power of each (self-governing nation of the Empire) in respect of its internal and " external affairs." This recognition of the sovereignty of each Dominion within the ambit of the British Commonwealth is a matter of far-reaching importance in the realm of Imperial Defence, for the Dominions thereby assert their right to remain neutral in any war in which another part of the Empire is engaged and arising from treaty or other commitments to which such Dominions are not parties. In other words, no self-governing Dominion can be committed to any obligation without its full consent. It is clear that the recognition of this principle implies that, if the Empire is to speak with undivided authority in world affairs, close co-operation by statesmen in the co-ordination of policy and, under the instructions of the statesmen, by the Service departments in the co-ordination of defence is most essential. How much has already been done in this direction is described in detail by Major Cole in a new paragraph on page 15. Another new paragraph on page 21 gives the other side of the picture, the position with regard to treaty commitments. It should be observed that, in the case of Great Britain's most important commitments, namely, the Straits Convention (1923), the Locarno Treaty and the Treaty with Irak, the Dominions are not signatories.

The chapter on the defence forces is a valuable addition to this book; it contains a mass of material which should give food for thought, particularly to students for promotion or Staff College examinations. Two points in particular may be noticed: from the table showing the distribution of the British regular army, it will be seen that, of our 126 line battalions, 65 are abroad or 2 more than provided for by the Cardwell System. In addition, a battalion of Foot-guards is overseas. It is evident from this that, even in peace, we have reduced our forces below the requirements of the normal police duties and the maintenance of law and order for which the military forces exist. Secondly, the list of stations of units is illuminating. If we consider the Cardwell System, examine the duties of the units overseas and the areas in which they serve, if we remember that in the maintenance of law and order, particularly in towns, the man with the bayonet, using fire action as a last resort only, can apply pressure more economically and with closer control than any other form of armed force, if we consider further by what means within existing budgets it is practicable to convert existing units into armoured units, we shall gain a clearer realization of the practical problems that face the responsible authorities in increasing the mechanization of the army.

In the survey of petroleum resources, no longer a separate chapter, one or two points call for notice. First, a comparison with the table of output of the chief producing areas in the last edition is illuminating; although the U.S.A. still heads the list by a long way, production in that country has fallen by over 50 million barrels. On the other hand, Russia's output, thanks to the five-year plan, has doubled. The coming importance of the new Irak oilfield is recognized on page 76. A study of the strategical problems that this new commitment adds to the many already confronting us is well worth while.

Chapter VI, naval and military defence of Britain and overseas bases, has been largely re-written and expanded; every word is important. Paragraph (a) on page 88 should be noted in connection with the chapter on Dominion status; it will be seen that, whereas for the purposes of the limitation of naval armaments, the Dominion naval forces are included in the tonnage allotment for the British Empire, these forces may not always be available in war, should one or more of the Dominions decide not to take part.

In Chapter XVII, dealing with the Middle East, there is much new matter of interest, particularly the paragraph dealing with the defence of Palestine and Transjordan, in which the respective roles of the military and air forces are clearly brought out. There is a somewhat important misprint on page 310. The date of the election of King Feisal to the throne of Irak should be 1921, and not 1922. Furthermore, the statement (p. 325) that the transfer to Air command immediately reduced cost by

one-third is not correct. There is much misapprehension regarding the events in Irak during the years 1921 and 1922, partly due to inaccurate statements that have been made in public speeches from time to time. Owing to various causes, mainly the legacy of the war years, and partly due to the change of personnel on reverting from a military to a peace administration, to the rapid withdrawal of troops and so on, a hidden, widespread rising of the Arabs of Mesopotamia took place in August, 1920. Troops had to be brought back from India, but the energetic measures taken by the military commander resulted in the rapid collapse of the rebellion, the tribes were disarmed to the tune of tens of thousands of rifles, and by May, 1921, the bulk of the troops had left the country. So successful was the military command in pacifying the country that it was possible, in the autumn of 1921, to hold an election for the selection of a monarch, a national government was installed, a commencement was made with the organization of an Irak army and, the remains of our Persian adventures having been liquidated, a commitment which had helped to swell the cost of defence in 1921 to £20,000,000, the prospects for 1922 were more satisfactory than could have been anticipated. It was found possible to reduce the British Imperial forces to nine battalions by May, 1922, the cost of the defence budget to the British taxpayer for that year was less than half of that for 1921, the Irak Government was daily getting more firmly into the saddle, so that the situation in all these respects was satisfactory when the Air Ministry took over the defence responsibilities in the autumn of 1922. There remained the pacification of the mountainous frontier districts of Kurdistan, and the operations necessitated by the Turkish incursions, all successfully dealt with by the Air command.

Apart from the inaccuracies in the text to which attention has been drawn above, there is much valuable instruction to be gained in this chapter on the Middle East, for the interdependence of troops and aircraft, the separate functions of each, and the methods of co-operation are clearly brought out. It is a study that is of the highest importance to all military officers, for the increasing value and necessity for air co-operation in all operations by military forces is evident in every aspect of Imperial Defence.

In the chapter devoted to India, Major Cole brings our information almost up to date with a brief *résumé* of the situation created by the Round Table Conference. But matters progress apace and students of Indian affairs cannot take this as in every case the last word, though many useful additional facts affecting the Indian situation are given. This chapter includes a new section dealing with internal security. A feature of the past 18 months in India has been the tendency of peoples of native States to revolt against rulers of a different religion. In each case, British troops have been called upon to maintain peace and order pending a satisfactory settlement. It is indeed just this fundamental fact that the British soldier, in the last resort, holds the balance even between antagonistic communities, that colours every aspect of the Indian problem.

Altogether this is an excellent book and will well repay intensive and thoughtful study. It would be extremely difficult for an examiner in Imperial organization to set a question to which an answer is not to be found or at least implied in its pages.

R.L.B.

ENGINEER FIELD MANUAL: VOLUME II, MILITARY ENGINEERING (TENTATIVE).

PART I—COMMUNICATIONS.

(United States Government Printing Office, Washington, 1932.)

The Engineer Field Manual is in two volumes; Vol. I deals with Engineer troops and Vol. II with military engineering. Vol. II is in three parts, bound separately. Part One is of convenient pocket size, 7½ by 4½ inches by only about 3/8 in. thick.

It contains some 250 pages and is well printed and illustrated, but the paper is not quite opaque enough. The covers are only of paper, and would not stand up to much handling on the works.

The illustrations are incorporated in the text, which is unquestionably the most convenient place for them since the whole of a subject—text and figures—is under the eye at the same time. There are no appendixes; all the tables appear at the appropriate chapters. There are frequent " bills of materials," or stores lists, for the various works described.

Part One is divided into 3 chapters—Roads, Bridges and Railways. Each chapter begins with general principles and an explanation of the nomenclature. This is followed in each case by a section on reconnaissance.

Under " Roads," macadam, plank, and corduroy roads are fully treated, and there are also descriptions of concrete, plank, metal and corduroy-tread roads, the treads being 2′ 6″ wide and 2′ apart in the clear. Wire-netting tracks are described, but there is no mention of any substitute for plain chicken-wire, such as wire-weaving for example. Maintenance and repair receive the attention they deserve. It is interesting to read that " bituminous roads are used where they exist, but new construction is not undertaken on account of the scarcity of materials, slowness of construction and expert personnel required." Tables of reference data include figures for excavation; quantities and weights of materials for lengths of various roads—macadam, plank, corduroy, and plank-tread; transportation figures; particulars of crushers; and a table of man-hours required for making good the passage of a mine-crater. A plank detour is said to require in man-hours nine times the diameter of the crater in yards. There are short descriptions of quarrying plant and earth-grading equipment.

Military bridges are classified by capacity into foot, light and heavy. These are designed respectively to take infantry soldiers fully equipped in single file; the loads of an infantry division; and the heaviest military load. A table of bridge loads is given with all the weights in pounds and all the dimensions in inches—a very sensible way of trying to reduce the number of mistakes due to confusion of units. The factor of safety recommended is four for steel and similar homogeneous materials, up to six in piled structures. The following statement is interesting if read in conjunction with table " H " of our *M.E.*, Vol. III: " If the stringers (*i.e.*, roadbearers) are placed directly under the wheel-tracks of the load and the floor planks are sufficiently stiff to distribute the load among the stringers, each stringer will carry about its proportional share of the load. A safe working assumption in this case is that any one stringer may have to carry 25% more than its *pro rata* share, but if the stringers are evenly spaced on cap, as is frequently the case, or if the floor planks are not sufficiently stiff to distribute the load equally among the stringers, any one stringer may have to carry more than its proportional share of the load. A fair working assumption in this case is that any one stringer may have to carry one third of the total bending stress in the span."

Trestle legs are calculated by a straight line formula, and the safe load on piles by Wellington's formula with a factor of safety of six instead of four (see *M.E.*, Vol. III, p. 157). Useful tables are given for each of these, and also for the safe unsupported projection of timber mud-sills. The drawings of abutments, cribs and trestle bents all have a familiar look, and the " demountable steel-highway bridge " is first cousin to the large box-girder.

Suspension bridges are dismissed with the formulæ for the tension, length and slope of the cables and a table of lengths of slings. It was disappointing to find, when looking for the latest ideas on the carrying capacity of arches, only a replica of table K (i) of *M.E.*, Vol. III.

In the erection section come knots, lashings, tackles, and the use of spars. These are naturally much the same in all languages, but it is noted that picket holdfasts are not finished off by our method of frapping; the connecting lashings are wind-

lassed by rack-sticks, the points of which are then driven into the ground. Much space is saved by the use of the imperative tense, thus: "Raise the top of the gin pole as high as possible by hand. Haul in the back guy with a running tackle. Let the fore guy out. Take in all the slack on side guys. Continue this until spar is pulled into position, keeping all slack out of the guys." Dogs are not mentioned in connection with building wooden trestles. Drift-bolts are used, and scabbing pieces (*i.e.*, fishplates) are nailed to the sills and legs. They are of 8″ by 2″, about 3 ft. long. Launching methods are all very similar to those given in *M.E.*, Vol. III.

Turning to floating bridges we find that the present position as regards pontoon equipment is a little confusing. There are no less than four types in use, namely :—

Light equipage M 1926.
Heavy equipage M 1869.
Light canvas equipage.
Heavy equipage M 1924.

Of these the first and second are said to be very similar and serve the same tactical purpose; yet one is called "heavy" and the other "light." (A load that was heavy in 1869 is heavy no longer.) The light canvas equipment is obsolescent, and M 1924 is the only one capable of taking the heaviest army loads.

The system is much the same in each case. The chief divergences from our practice are (i) that gunwale loading is used, and (ii) that the use of at least one trestle is essential between the shore transom and the first floating pier with both the latest types of equipment, viz., M 1924 and M 1926. The first point is interesting in view of the R.E. Board's thorough investigation a few years ago of the question of gunwale-*versus* saddle-loading, as a result of which saddle-loading was retained. The second point is a serious disadvantage in the eyes of those who like to avoid the use of trestles if they possibly can. In order to connect the first floating pier to the trestle a "hinge-span" is required; the inshore ends of the hinge-span roadbearers rest on the trestle transom, and the offshore ends rest on a special sill which is fastened below the roadbearers of the first floating bay. The point of fastening is just offshore of the first pontoon. This sill is something like our old stiffening transom.

The Lampert footbridge is apparently not designed as an assault-bridge, as it has to be built by booming out and seems to have a very limited up-and-down articulation. It consists of collapsible wooden frames over which paulins are stretched. The footways are 2′ wide and about 11′ long.

The Kapok footbridge is launched in the same way as ours, but it is of quite different construction. It consists of wooden crates 12′ long and 3′ wide containing Kapok pillows. Each crate is, therefore, a miniature raft. The crates are fastened *end to end* with special clips which admittedly restrict the flexibility of the bridge and have to be left off while the bridge is being carried over very uneven ground. Hand-ropes are provided, and the whole width (3′) is available as a footway. The impression given is one of lateral instability, which is confirmed by a recent article in the *Military Engineer* suggesting the use of outriggers in order to make the bridge more stable.

I.S.O.P.

The chapter on railways is necessarily very short and abbreviated, and is far more a book of reference than a training manual. The information given agrees in most cases with British practice, but there are certain points of difference which are interesting and worthy of note.

Light railways are included as a section of this chapter, whereas we definitely exclude them from our broad- and metre-gauge railway training.

There is one statement in the general section that should not be allowed to pass without comment. It is that "a military road is best operated with an ample supply

of motive power and rolling stock. . . . On a civil road the tendency is to increase speed and loads to economize motive power." This surely gives a false idea of the condition which would prevail in war. A minimum of rolling stock and power would be available, and a rigid economy of both would be necessary.

The suggested layout of a typical railhead for a division is rather cramped. There is merely one loop for accommodating the pack train, and no other facilities at all. This would probably suffice for a division, but it is not a typical railhead as it is described. There should be some mention made of facilities required for dealing with locomotives, empty rolling stock, petrol, etc., which would all come within the scope of a typical railhead. In addition it is suggested a covered store be placed alongside the siding for the protection of articles from the weather. This is most surprising and would seem to break all known rules about reserved Transportation Areas.

The survey and location sections are merely short summaries of normal elementary practice. It is interesting to note that no mention is made of transition or vertical curves.

The sizes suggested for the banks and cuttings are a good deal smaller than ours, one foot across the formation in the former case and no less than six in the latter. This, of course, means a big saving in earthwork, but if it is intended for semi-permanent lines I doubt if it would pay.

The operating section is merely a bald statement that the railways would be operated by railway troops, and under the existing American Railway Association rules. This could be elaborated upon with advantage.

There are some very sound notes on " maintenance of way," and a good list of tools required, but absolutely no indication of the number of men required per track mile. Bills of quantities for various types of bridges are given which would be of great use in estimating for construction work. It is interesting to note that they are all for complete timber bridges. Under conditions such as we expect they would have to be modified considerably.

G.N.R.

FIELD ASTRONOMY, 1932.

This is, in effect, a revised and modernized edition of the book of the same name formerly published by the School of Military Engineering. The change of authorship is significant. It provides a striking commentary on the sad fact that the instructional course in survey at the School of Military Engineering has become so congested by the intrusion of modern developments that the time devoted to astronomy has had to be severely reduced. This new edition is intended, then, less for the instruction of young officers than as a guide to those who are confronted with a piece of practical work in the field.

In the main, it follows the lines of the earlier work in its general introduction to the subject up to the use of co-ordinates and the astronomical triangle. It leaves out, however, at this stage all detailed reference to the moon and planets, as their use is not discussed in later chapters.

Then follows a description of the new *Nautical Almanac* and a chapter on corrections to observations which is taken from the old book.

Chapter VI, on general instructions and practical hints in carrying out observations, might have been made more comprehensive in view of the new object of the book. More complete lists of stores might have been grouped here or put into an appendix. The type of theodolite which is recommended by implication is now obsolescent, and no mention is made of chronographs under the heading of time-keepers. As there may be no instructor at hand to guide the reader, it is thought that a few practical hints on such subjects as picking up stars in a telescope and finding the same star after changing face would not be out of place.

Chapters VII to XIV deal with the determination of time, azimuth, latitude and longitude in the field. This section of the book is brought up to date by a clear account of the methods of obtaining longitude from wireless signals and a chapter on the use of the prismatic astrolabe, in which the very ingenious 45° instrument, designed for the Admiralty by Instructor Captain T. Y. Baker, R.N., is described. A new feature also is the chapter on time and azimuth from circum-meridian observations. This is the adaptation of an observatory method for use in the field and should under certain conditions prove useful. It would appear, however, that there is a certain danger in advocating for general use a method which involves either ignoring errors due to the bubble or to collimation or applying them in an unspecified way. The method as at present described is likely to be of more interest to the theorist than to the average field surveyor. To bring it into line with the rest of the book, it would be necessary to curtail the exposition of the general theory and to state with more precision what practical procedure is advocated. The tables required for the computation should also be included in an appendix.

A new and welcome chapter is included on the use of altazimuth tables. The great importance of azimuth observations is, however, perhaps insufficiently stressed. In particular the importance to the soldier of being able to obtain an azimuth rapidly with an accuracy sufficient to give line to the artillery is not mentioned, nor the need for being able in this connection to use stars in any part of the sky. The special case of observing a north star at dusk in conjunction with an opaque signal might be included.

In the chapter on latitude, a fuller exposition of the Horrebow-Talcott method is given, and more credit has been given to the very useful method of meridian altitudes.

The explanation of the method of computing from a star catalogue the position of stars not included in the *Nautical Almanac* might with advantage be transferred to the chapter on the *Nautical Almanac*, whose title might be expanded to include star catalogues. Such stars may be required for many observations described in the book, and in the absence of an index the description of the procedure may be hard to find. The inclusion in this section on observations of examples worked out on the geographical section's computation forms is a welcome innovation.

The inclusion of the plates with the text instead of in a separate volume is a great improvement, as also is the provision of star charts and an explanation of their use. References are made in each chapter to works dealing more fully with the subject under consideration, and tables in the appendix have been given the same numbers as those in the *Text Book of Topographical Surveying*, which will tend to avoid confusion. In general the book admirably fulfils its function as a guide to officers on a practical job in the field.

A copy will be issued free to any R.E. officer who wishes to study astronomy, on an application being sent to the Permanent Under-Secretary of State, War Office, Whitehall, S.W.1, quoting as authority, W.O. Letter No. 26/Manuals/617.

G.C.

THIRTY-FIVE YEARS, 1874–1909.

By HENRY SPENSER WILKINSON, Fellow of All Souls', some time Chichele Professor of Military History.

(Constable & Co., Ltd. 1933. Price 16s.)

The last fifteen years of the period covered by this short and interesting autobiography were important years in the history of the modern British Army. Reform was in the air. In that reform Spenser Wilkinson, a keen volunteer and a journalist of repute, had no small share.

Lord Wolseley and his faithful henchmen, Sir Henry Brackenbury and Sir Frederick

Maurice, were the pioneers of army reform, but there were few officers in England outside " the Wolseley clique " who had seriously studied the question. It required more than this handful of professional soldiers to make the nation realize that all was not well with the army and that it was hardly capable of dealing with " small wars " on the frontiers, much less taking its place alongside of a Continental army. Sir Henry Brackenbury was one of the few soldiers (the late Lord Sydenham was another) who dared to write on military matters in the newspapers, but his articles in *The Times* were never signed. Fortunately the same restrictions did not apply to officers of the Volunteers who were able to make use of the Press and write books on military and political matters without their being censored when they wished to disseminate their views.

As far back as 1881 some keen Volunteer officers in Manchester, of whom the author of this volume was the guiding spirit, founded the Manchester Tactical Society, in order to teach themselves something about the art of war. How that Society came to be formed makes interesting reading.

Spenser Wilkinson had been brought up in a political atmosphere at his home in Manchester, and was intended for a public career. He had no relations or friends in the army: he had only once, as child, seen a body of British troops on parade. After spending six years at Owen's College, Manchester, taking the examinations for the London B.A. degree and acquiring a thorough knowledge of English literature and of the German language, he went, in 1873, to Oxford as a scholar at Merton. There he read for Classical Moderations and Greats, frequented the Union and took an interest in politics, being like his father a staunch Liberal.

Then occurred the incident which influenced his whole career. While in Germany during his first long vacation, he picked up in a bookshop an Austrian pamphlet giving a statistical account of the armies of all the European States and their comparative strength. We can quote his own words as to what happened: " At the " age of 21, I was surprised to find that the Continent was full of great conscript " armies, while my country had a very small army, recruited for pay, in the fashion " of the eighteenth century. The contrast seemed to me of great importance, and " I was determined to understand it. This led me to become a student of war. . . ."

On his return to Oxford, he got hold of all the military books he could find, mastered Hamley's *Operations of War* and Maurice's *Wellington Prize Essay*, on the system of tactics best adapted to enable the British Army to meet a Continental army in the field. He also translated a set of rules for the conduct of the war game (*Kriegspiel*) which he had picked up in Germany.

He was now too old to enter the army and he had no taste for fighting or for a soldier's life. His interest in war was patriotic and political. The questions he put to himself were: Was it a citizen's duty to defend his country? Were John Bright and the Quakers right in refusing to have anything to do with international conflicts? Could war in any case be avoided?

He found that he could not learn much about soldiering by merely reading books. So he decided to join the O.T.C. of those days—the University Volunteer Corps. He gave, not took, the shilling and became a Volunteer. In his first march with a band, he was startled to find himself thrilled with an entirely new emotion! A keen Volunteer he was disappointed, if not disillusioned. He writes: " The discipline " seemed to be slack, the officers to be by no means masters of their business, and the " manœuvres to have very little relation to the tactics I was studying in French and " German books." So he had recourse to the war game, and with some keen friends he formed the Oxford Kriegspiel Club. At the end of his book the author mentions that when, in 1909, he was elected to the Chichele Professorship of Military History at Oxford, the first message of congratulation he received was: " The Oxford " Kriegspiel Club welcomes its founder."

It was after he had gone down, eaten his dinners and practised for a while at the bar, returned to Manchester as a journalist and become a Volunteer officer, that he

founded the Manchester Tactical Society, which was to be the first of similar societies formed at many volunteer centres.

The result of his becoming a keen Volunteer can best be described in his own words: "The first results were a series of efforts at reform, first of the Volunteer "Force, then of the Regular Army, and finally of the Navy and Admiralty system: "incidentally I advocated a reform of the Ordnance Survey, which was carried out "(speeding up of the production of the 1 inch to the mile Ordnance map and its "printing in four or five colours instead of one colour only). In conjunction with "Sir Charles Dilke, I made a study of Imperial Defence, and then under the guidance "of Lord Roberts, visited the North-West Frontier of India.

"It became clear that the measures requisite for defence were dependent on a "sound foreign policy, of which the keystone must be the maintenance of a navy "adequate to secure the command of the sea in war. I therefore wrote a series of "essays pleading for a national policy, and then proposed an organization for the "reform of the Admiralty, an organization which took the shape of the Navy League. "My military studies had early caused me to give up the bar for journalism, which "seemed to offer the best opportunity for advocating the reforms which I thought "desirable. As a journalist it was my duty to comment on such wars as took place "from 1882 until the beginning of the Great War. . . ."

These few lines contain the story of the military side of his life, but Spenser Wilkinson was not merely a writer on military subjects. He had a taste for and acquired a deep knowledge of literature, art and the drama, and when he transferred his allegiance from the *Manchester Guardian* to *The Morning Post*, he became its chief dramatic critic. A man of such varied tastes could not fail to make a host of acquaintances and many good friends, through whom he got to know many of the great men of his time both at home and on the Continent. A glance at the index—of names, not places—will give some idea of the number of distinguished men with whom he came in contact in the course of his work. Soldiers and statesmen were always glad to avail themselves of his advice.

Needless to say that the book is pleasant reading, lightened as it is by anecdotes of famous men and by an amusing chapter entitled "A Spy in Cracow," written originally for the first number of *Printer's Pie*.

A biography necessarily means past history which will perhaps only interest the elder generation, but this volume is worth reading by the younger because it will give them an insight into the difficulties attending any attempt at reform. With a voluntary system and a small army such as ours, men of the type of the author are needed outside the army to keep the nation alive to its needs. The nation and its military and naval forces owe a debt of gratitude to Professor Spenser Wilkinson.

H.B-W.

HISTORY OF THE GREAT WAR.

MILITARY OPERATIONS, MACEDONIA. VOL. I.

FROM THE OUTBREAK OF WAR TO THE SPRING OF 1917.

By direction of the Historical Section of the Committee of Imperial Defence.

Compiled by CAPTAIN CYRIL FALLS. Maps compiled by MAJOR A. F. BECKE.

(Published by H.M. Stationery Office, 1933. Price 12s. 6d. Case of Maps, 5s. 6d. extra.)

This volume, as in the case of all the official accounts of the Great War, is a clear and concise account of the operations in the theatre dealt with during the period under review, and is accompanied as usual by first-rate maps and sketches. The photographs and panorama sketches are also excellent.

The diplomatic situations which lead to the dispatch of an Allied Expedition to the

Balkans and which continued to vary greatly during the operations are admirably described and clear up many of the enigmas which puzzled those whose fate it was to serve in the Force.

The descriptions of the various actions are possibly overloaded with an amount of detail, which will be of little interest generally when the survivors have " gone the way of all flesh." The detail has, however, this value—that it may emphasize to the unlearned that confusion is inevitable at times in all battles.

The description of the attacks of 24th April and 8th May, 1917, on the " Pip " Ridge, overlooking Lake Doiran, is clear and accurate, but it leaves unsolved the question why the attack on 8th May was made in the same way and at the same time of day as its disastrous predecessor.

To those who served in these actions it was fairly clear that there was not enough gun power on the British side to make success reasonably possible without co-operation from elsewhere, and that the attacks were made at the wrong time, namely, in the dark and not by daylight. This last point is referred to in the text, but briefly only. At a conference preceding the formulation of the plan of attack, an Engineer officer strongly emphasized the necessity for attacking either at dusk or dawn, owing to the broken nature of the ground and the consequent danger of the troops going astray, and he was supported by his colleague in the Royal Artillery, so that the point was raised in time. Taking into consideration the character of the ground, the paucity of communication trenches and the length of those existing, the confusion that ensued in the dark is not surprising.

It was stated at the time that Colonel Howard's troops, who reached the Petite Courronnée, owed their success among other things to the fact that they were led forward over the open ground and clear of the crowded communication trenches.

In writing of the " Working of the Machine," too little is said of the lessons learned as regards communications in such a country and nothing about the most important part the survey officers played in the campaign. There were no maps of the country of any military value ; there was no port fit, without much organization, for the base of a large expeditionary force ; and there were no roads in the sense in which we understand the word. Yet no preparations seem to have been made to deal with these difficulties until the troops had actually landed and discovered the situation.

Disease is mentioned and the final and efficient arrangements to combat it are described, but little is said of the lack of forethought to which the incidence of disease was largely due. One square yard of mosquito net was issued to each officer and man, with the result that few, if any, of the survivors of that army will be free from malaria for the rest of their days.

It seems to one who had the honour to command a unit in the army, that less than justice is done to the troops. Military histories may be deadly accurate, and they may even be deadly dull, but they are never sentimental. It never seems to be recognized that the MEN are just as human as the scribes. The MEN in Macedonia suffered much. They suffered from a depressing disease, an evil climate, bad accommodation, poor rations, lack of amenities behind the fighting line, and often a lack of the stimulating excitements of war, and yet, they preserved their discipline, their cheerfulness, and their inherent gallantry, in spite of all. There were no " Blighty " wounds for them ; Hortiach plateau was their Blighty, and they had little or no leave. Something might have been said for them.

G.W.

IMPROVED CONCRETE ROADS.

By CAPTAIN D. G. MCLEA, M.I.MIN.E.

This pamphlet is well worth reading by anyone interested in concrete roads. It is so brief and clear that it can best be left to speak for itself, and it can be had for the asking from the author (68, Victoria Street, S.W.1).

This short note, therefore, is concerned less with the contents of the pamphlet than with the development of the idea of which the methods it describes are a result.

Concrete roads, plain and reinforced, have had a chequered history. With comparatively few exceptions, they have until recently been disappointing, and even at the present time miles of concrete roads are being laid to variations of a design which ought long ago to have been abandoned.

The reasons for the falling short of quality from potentiality are many; but the principal reason, as the present writer sees it, is that concrete roads as we know them are much more the result of evolution than of design. In much the same way as the present motor-cycle and motor-car have grown from the fitting of engines into existing vehicles, so concrete roads have developed from the early efforts of road-makers to incorporate a new material into their ordinary work. That is to say, they were first made, and are still very largely made, by people whose job it is to make roads, because it is their job to make roads, and not because of their knowledge of reinforced concrete. It was natural that these pioneers should have worked at first by the light of their ordinary occupation, and improved in the use of the new material by the further illumination provided by experience. Their diagnoses of the causes of faulty work were often wide of the mark; but this is not the place to examine the full distressing history.

Throughout all the trials and errors the fundamental causes of most of the troubles were, and still are, either unsuspected, ignored, or, in the present writer's view, wrongly treated by the majority of reinforced-concrete roadmakers.

These causes are, primarily, the shrinkage of concrete in setting, which sets up initial stresses (sometimes sufficient to cause rupture), in large areas of concrete such as roads, floors and roofs; and, secondarily, the subsequent shrinkage or swelling of the set concrete due to changes in temperature, drying, or wetting. The setting shrinkage has usually been ignored completely, the less important subsequent shrinkage or swelling having been given most attention.

This attention has usually taken the line of attempts to provide for movement, or to prevent it, and has been only moderately successful in most cases. It seems as certain as anything can be that such attempts to deal with effects rather than with causes can never produce a completely satisfactory result.

Of late a few engineers (notably Mr. J. H. Walker and Captain McLea in England, and Mr. Hogentogler in America) have been tackling the problem from the other end. Recognizing that setting shrinkage is inevitable, they turn this characteristic property of concrete, hitherto a serious stumbling block, into something useful. By various methods they have contrived to make this primary shrinkage provide for the subsequent movement due to temperature and moisture, by causing it to break up large areas of concrete into such definitely limited portions as they desire.

Captain McLea's pamphlet shows how he places strip steel in such a way as to compel the setting shrinkage to split up his pavement into a large number of small areas, interconnected by the steel, but separated from each other by hair cracks. These cracks, whilst wide enough to provide for subsequent movement, are so fine as to be invisible and to exclude water. His method is a welcome recruit to what the present writer considers to be the logically sound system of concrete roadmaking. By this system the road is laid in two layers; the lower layer being designed to take all road stresses, and the upper layer to serve the double purpose of running carpet, and protection of the lower layer from the worst effects of temperature changes.

Captain McLea's method deals essentially with the paving layer. He produces a paving which, although laid continuously, without joints, provides within itself, by a large number of fine hair cracks, all the easement necessary to deal with the movements which take place in set concrete. His pavements can be laid on a sound foundation of any kind, and should find extensive use for repaving well-consolidated macadam roads, as well as for new all-concrete work.

A.M.

ALPHABETS OF FOREIGN LANGUAGES.

R.G.S. Technical Series, No. 2.

(Second Edition.)

By Major-General Lord Edward Gleichen, K.C.V.O., C.B., D.S.O., Chairman, and John H. Reynolds, M.A., Secretary, Permanent Committee on Geographical Names for British Official Use.

(Edward Stanford. Price 7s. 6d.)

This paper is the result of the labours of the chairman and secretary of a committee, formed in 1919 by the Royal Geographical Society, for the purpose of standardizing the spelling in English of foreign place-names. With this object the committee has published, from time to time, lists of the more important places in many foreign countries which usually appear on maps of medium scales. In this work it has been assisted partly by private subscription and partly by certain Government departments interested, though support in this respect is anything but adequate.

It is most important that names on English maps should be spelt in such a way, so that when pronounced they should sound as nearly as possible correct and understandable to the people speaking the language from which they are derived. This applies to all names except a few recognized anglicized versions of certain places.

In order to carry this out effectively the greatest care has been taken by the authors to ascertain the exact pronunciation of the letters of foreign alphabets, so as to render the corresponding sound by an English letter or letters. In doing this the personal assistance of the natives of a large number of countries has been enlisted.

As a result, some 76 languages and dialects, forming eleven groups, have been dealt with. Alphabets are given with the corresponding English sound, letter by letter.

The pamphlet forms a most useful source of reference, whether for transliterating names on maps or for any other purpose. It is strongly recommended.

Great credit is due to the authors, who must have put a great deal of work into it, involving extensive correspondence. It is to be regretted that such useful work does not receive more support.

H.L.C.

THE MECHANISM OF THE CAR.

By Arthur W. Judge.

(Chapman & Hall, Ltd., London. Price, 4s.)

This book forms the third volume of a series of motor manuals for owners and users. It is the second and revised edition, the first having been published in 1925, and recent developments relating to gear-boxes, fluid flywheels, braking systems, suspension, lubrication, etc., have been dealt with as fully as possible, while still retaining a book of reasonable length.

The author's intention is to present to the motor user, engineer, student and others, each branch of a widely-extended subject in a clear, concise and non-technical manner, and his success is largely due to the fact that he realizes the difficulty of dealing in such a limited space with the many different designs, the many variations of the hundreds of makes of cars, and with the constantly-appearing refinements in automobile chassis. He has, therefore, described the standard practices now adopted and has included the principal example of each.

As the other volumes of the series deal with engines, carburation, maintenance and repairs, this one is restricted to the chassis of the car, and describes the frame, transmission, brakes, etc.

Chapter 1 deals with the chassis in general and explains the various parts and how the driving effort is transmitted, giving examples of various popular makes. The influence of the power/weight ratio is emphasized.

Chapter 2 describes the frame, though the now quite common cruciform type is not mentioned. The principles of suspension and shock-absorbers are also described.

Chapter 3 deals with the front axle and steering, though theoretical considerations are very briefly treated.

Chapter 4 deals with clutches and includes descriptions of the Daimler fluid flywheel, various types of free wheel, and types of the Bendix automatic clutch control which is now found on some American makes of cars.

Chapter 5 deals with gear-boxes, and after the ordinary clash type boxes have been treated, the more modern developments, such as the so-called Silent Third, Twin Top, Double Reduction, Synchro-mesh and the Wilson and Maybach pre-selective types, are discussed. A very good diagram is given to explain the Wilson box, but its great advantages of gear-changing simplicity and efficiency and absolute silence on all speeds are not stressed.

Chapter 6 discusses alternative transmission of systems which have either been tried and found wanting or which have never caught the public fancy.

Chapter 7 deals with the propeller shaft, universal joints, differential and back axle.

Chapters 8, 9 and 10 deal with brakes, traction and braking principles, road wheels and tyres. Types of brakes are described, including the hydraulic and pneumatic systems. Servos-Dewandre, Rolls-Royce and Hispano systems, are also discussed.

Chapter 11 contains a discussion of the advantages and disadvantages of front-wheel drive and rear-engined cars.

Chapter 12 describes various other types of automobiles, including steam and electric cars, the Citroën Kegresse half-track and Renault six-wheel cars, though no mention is made of British six-wheelers such as Morris and Crossley.

Chapter 13 deals with chassis lubrication, especially as regards automatic systems.

The book should be interesting and easily understood by the non-technical reader, and yet the more technical will find much information of value to them. It can be thoroughly recommended as an addition to the library of mechanized units where the training of N.C.O's and men in the subject known by the horrible name of " Car Mastership " is carried out. It is profusely illustrated and, though some of the diagrams and sketches are small and rather indistinct, they should present no difficulty to anyone accustomed to our own training manuals.

E.W.L.W.

MAGAZINES.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*January*, 1933.) 1. *Influence du théâtre d'opérations de Belgique au moment de la bataille de la Marne en Septembre* 1914, by Major B. E. M. Herbiet.

The article begins with a general survey of the operations between the 23rd August and the evening of the 4th September. The German plan, to separate the French Army from Paris and drive it back to the south-east, failed, and, on the 5th September, the German G.H.Q. issued orders for a new plan, which was to continue operations against the French right wing with the 4th, 5th, 6th and 7th Armies: the 1st and 2nd Armies warding off a counter-attack from Paris.

The situation in Belgium compelled them to modify their plan by sending two army corps and a cavalry division to Belgium, thus weakening their left flank to that extent. The heavy expenditure of ammunition fired on the Belgian forts hampered the Germans later on in their operations against Verdun.

2. *La défense du fort de Pontisse*, by Lt.-Col. Speesen. An account of the defence of Pontisse Fort, one of the twelve forts forming the defensive position of Liége. The writer was, at the time, a captain in the artillery, and was in command of the fort. The garrison consisted of 300 gunners and 80 rifles.

The Germans opened fire on the 5th August, and subjected the fort to a heavy bombardment for a week. On the 13th, it was so badly damaged that further resistance was impossible, and the garrison surrendered.

3. *Défensive de retraite et action retardatrice.* This is the first of a series of articles by Colonel Van Egroo. In this first chapter he deals with the Prussian Army in the Waterloo campaign of 1815. He describes Zieten's skilful handling of the 1st Corps on the Sambre, in holding back greatly superior French forces, and so enabling Blücher to secure his concentration area.

The writer divides the action of the first Corps into three phases: (1) the operations south of the Sambre, (2) the defence of the Sambre, (3) operations north of the Sambre, including the actions of Gosselies and Gilly.

4. *Les opérations militaires sur le front italien* (1915). Captain Vandaele gives an account—taken from the official Italian history—of the military operations on the Italian front in 1915.

Italy entered the war in May, 1915. Her army, when fully mobilized, was about 1,000,000 strong. The general plan of operations, worked out by General Cadorna, then Chief of the General Staff, was for the main Italian effort to be directed across the plain of Friuli towards Gorizia and Trieste. The Trentino was a secondary objective.

The distribution of the four Italian armies on the 24th May is given in detail. The operations in 1915 are subdivided as follows:—

(A) Preliminary operations, from the 24th May to the 22nd June. The first offensive—on the Julian front—took place between the 28th May and the 16th June.

(B) Midsummer operations. The first battle of the Isonzo lasted from the 23rd June to the 7th July. The second battle of the Isonzo lasted from the 18th July to the 3rd August. It was the culminating effort made by the Italians during the year.

(C) Autumn and winter operations. The objective of the autumn offensive on

the Julian Alps front was the entrenched camp of Gorizia. The offensive began on the 18th October with the third battle of the Isonzo, which lasted till the 4th November. The fourth battle of the Isonzo began on the 10th November, and continued till the 2nd December. Operations were suspended during the winter, no definite success having been achieved.

5. *L'observation de l'A/D.I.* An article by Major Sottiaux on ground observation for divisional artillery.

(*February*, 1933.) 1. *Défensive de retraite et action retardatrice*, by Colonel Van Egroo. The writer quotes further examples of delaying action, all taken from the Great War.

In August, 1914, the Belgian Army had to abandon all hope of common action with the British and French, and was compelled to retire to the north-west, on the 18th. The German Army, following closely on its heels, reached Louvain on the 19th, Brussels on the 20th, and did not cross the French frontier till the 24th August.

Further examples quoted, amongst others, are: the British Army at Mons, the German Army in Lorraine in 1914, and the 5th British Army on the 21st March, 1918.

2. *Histoire de la campagne* 1914–18 *sur le front russe. La bataille de Galicie en août* 1914. By General Golovine. Translated from the Russian by Captain Nannan.

The Franco-Russian Convention of 1892 laid down that, on the outbreak of war with Germany, France should provide an army 1,300,000 strong, and Russia 800,000 men, on the German front, fifteen days after mobilization. This obligation hampered the strategy of Russia, whom it suited far better to concentrate her main effort in Galicia against the Austro-Hungarian monarchy.

The contract was entered in far too lightly: Russia was incapable of putting more than 350,000 men in the field against Germany by the 15th day after mobilization, and only 550,000 men could be made available by the 40th day, instead of 800,000, as promised.

The general idea adopted in the Great War was for the Russian south-west Army Group to engage in a general battle with the Austro-Hungarian forces concentrated in Galicia, in order to effect an enveloping movement, which should cut off the enemy's retreat to the west and south.

A sketch plan is attached to the article, showing the zones of concentration, round Lemberg, of the opposing armies in August, 1914. The Russian armies were grouped in the following order, from right to left: 4th, 5th, 3rd and 8th. The 4th Army, on the right, was the weak spot. The preliminary movements of the campaign are described.

3. *Un régiment d'infanterie à l'attaque d'avant-postes*, by Lt.-Col. Bouha.

4. *L'observation terrestre à l'A/C.A.*, by Lt.-Col. Nonnon.

5. *La méthode actuelle d'emploi de l'artillerie allemande.* An extract from the work, *Artillery in the Offensive in Position Warfare*, by Colonel Bruchmuller, of the German Army. It is mainly based on experience gained in the Great War: some of the ideas are of later date. The work is considered to be of great military value.

(*March*, 1933.) 1. *Pages d'histoire de l'armée belge au cours de la guerre* 1914–18. An account of a successful raid carried out by a Belgian detachment on a German trench on the 28th October, 1927.

2. *Défensive de retraite et action retardatrice* (*concluded*), by Colonel Van Egroo. Chapter IV contains some general remarks on the conduct of a retirement.

Chapter V contains a *précis* of the German regulations for a retarding action (*hinhaltendes Gefecht*). The article concludes with the duties of the various arms. The work allotted to the engineers must be selected with great care. It will consist mainly of demolition work, but, owing to the large area covered, it must be selected judiciously.

3. *Un régiment d'infanterie à l'attaque d'avant-postes*, by Major Sottiaux.

4. *Quelques détails de l'instruction dans une compagnie de fusiliers*, by Captain Leseul.

5. *Histoire de la campagne* 1914-18 *sur le front russe. La bataille de Galicie en août* 1914. By Captain Nannan. (From the Russian.)

This is a further instalment of the battle in Galicia, illustrated by a sketch plan showing the position of the opposing forces on the evening of the 25th August.

General Russki, commanding the 3rd Russian Army, making Lemberg his objective, kept in touch with the 8th Army on his left, but allowed a gap to intervene between the 5th Army and his right. The Galician encounter thus developed into two separate battles.

On the north were the 4th and 5th Russian Armies, consisting of 16½ divisions, opposed by 28½ Austro-Hungarian divisions; *i.e.*, the 1st and 4th Armies, supported by the Kummer and Woyrsch Corps. On the south, the 3rd and 8th Russian Armies, consisting of 20 divisions, were opposed by the 2nd and 3rd Austro-Hungarian Armies, consisting of 11 divisions.

Thus, on the 23rd August, both Russians and Austrians met with a strategic surprise on their right wing. The surprise of the Russians had the most influence on the campaign, since the San-Lublin direction was the more important. The Russian left wing was too far away to influence the course of the battle of Lublin.

General Conrad, the Austrian Commander-in-Chief, had an opportunity of inflicting a decisive defeat on the Russian 4th Army, but missed his opportunity by over-caution.

A.S.H

REVUE DU GÉNIE MILITAIRE.

(*December*, 1932.) 1. *Le matériel de franchissement de rivières*, by Colonel Baillis. Nowadays the Sapper is confronted with the problem of increasing the strength of bridges, to meet the constantly-increasing loads caused by the mechanization of modern armies. The writer asks how this problem is to be satisfactorily solved.

French roads are classified under four separate heads, capable of carrying maximum loads of 12, 16 and 44 tons, and loads exceeding 44 tons, respectively. Very few routes can be mapped out entirely on the two highest classes of roads, and it is almost certain that some portion will be limited to 16-ton loads. If the manœuvring power of army corps and divisions is not to be seriously interfered with, their mechanical vehicles must be limited in weight to 16 tons. This is the maximum load for which floating bridges should be designed.

The weight of a pontoon in the 1901 equipment is, roughly, 800 kg., which represents the maximum weight that can be conveniently manhandled. The writer is prepared to increase the permissible weight to 1,000 kg. A raft, made up of four 800-kg. pontoons, will just carry two Renault armoured cars, of a combined weight of 14 tons. With bridging equipment consisting of 1,000-kg. boats, and suitable superstructure, a raft of four boats ought to be capable of carrying a 16-ton load.

After discussing various alternatives, the writer suggests the adoption of the following equipment:—

For divisional infantry: Light portable folding rubber rafts, with oars, and portable material for footbridges.

For divisional engineers: Folding rubber rafts of a larger pattern than those carried by the infantry, and material for a trestle bridge capable of carrying 9-ton loads.

For corps engineers: Material for a floating bridge capable of carrying 16-ton loads.

2. *Travaux d'irrigation du Niger.* Colonel Doizelet here continues his description

of the irrigation works carried out on the Niger. In this chapter he describes the construction of the distributaries of the Sotuba Canal, the Sansanding Barrage, various minor canals, and a dam restricting the flow of the river. He deals with the character of the natives, both as labourers and agriculturists, and gives an account of the work and life of the European supervising staff.

3. *Passage de véhicules automobiles à chenilles sur un pont de gabions*, by Lieut.-Colonel Poirier. An account of an experiment made to take motor vehicles with caterpillar tracks across a stream over a bridge made of gabions.

4. *Tentative de sauvetage d'un puisatier enséveli.* A report of an attempt, by Lieut. Granon and a detachment of sappers, to save the life of a well-sinker, who had been buried under debris while working at the bottom of a well. The rescue party was, unfortunately, too late to save the man's life.

5. *Note sur l'imperméabilisation du béton*, by Chef-de-bataillon Chambon. A note, based on American experiments, on waterproofing concrete. Reference is made to an article in *Engineering* of the 28th May, 1915, and to another in the *Journal of Research* of December, 1931.

When no waterproofing composition has been added to concrete, its permeability decreases with age, and increases (within limits) with the amount of cement added, and with the amount of watering after laying. The composition and the method of mixing also affect the result very considerably.

With regard to waterproofing materials mixed, in the mass, with concrete, such as chloride of calcium, hydrated lime, soap, etc., some are of slight value, others are definitely harmful. Of waterproofing materials applied to the surface of concrete, the best results were obtained by an emulsion consisting of: asbestos 45%, asphalt 50%, petroleum ether 5%. Coatings of the following materials gave satisfactory results at the end of a year: (*a*) butyl stearate; (*b*) butyl oleate; (*c*) a mixture of petroleum and fat oils. Oil paints are useless, but two coatings of spirit varnish gave good results at the end of a year.

(*January–February*, 1933.) 1. *Les derniers jours de l'école d'application de l'artillerie et du génie de Metz*, by General Goetschy. The *école d'application* at Metz was the training school for young officers of the artillery and engineers from 1802 to 1870. The writer describes the life of the last batches of young officers who joined in 1869. The school was broken up by the German invasion of Alsace in August, 1870. The officer students got away by the last train to leave Metz, on the 12th August. On the 7th December, 1932, Generals Maurin and Belhague, Inspectors-General of Artillery and Engineers respectively, unveiled a tablet recording the fact that the building had been used as a school of instruction for artillery and engineers between 1802 and 1870.

2. *Le domaine défensif*, by Lieut.-Colonel Thouenon. A discussion of the laws and regulations in force relating to fortified places. These laws are being checked and revised. The cession of Alsace and Lorraine to France affects the question to a considerable extent.

3. *Quel matériel est necessaire pour forcer le passage des cours d'eau.* A translation of articles that appeared in *Wehr und Waffen* for October and November, 1932. These have been reviewed in *The R.E. Journal* for March, 1933.

4. *Note sur les travaux de dragages effectués en Haute-Casamance en* 1907, by Chef-de-bataillon Jamet. A description of dredging operations carried out in Upper Casamanca (French Senegal) in 1907, in order to make the river navigable for trading barges. The natural deep channel of the river was kept to, and straightened out in places. It was widened to a uniform width of 10 metres and deepened to 0·60 metres. The work was all done by hand with local labour.

In order to increase the scouring effect in the main channel, and to induce silting near the banks, a series of groynes was thrown up from both banks, the groynes being aligned at an acute angle with the axis of the channel. They consisted of two rows

of wooden pickets, interlaced with bamboos, the intervening space being filled with brushwood. The results proved quite satisfactory.

5. *L'outil portatif universel*, by General Grandcourt. A description of a universal tool, designed by the writer, and made up in the Soueida workshops in Tunis.

The tool consists of two parts, an iron cutter and a wooden handle. There is also a leather guard for the cutting edge. The iron cutter is somewhat similar to the regulation entrenching tool: it has a pick point at one end; the other end consists of a rectangular plate, of which one edge forms the cutting edge of a shovel, another the cutting edge of an axe, the third is a saw. The iron has two eyes, at right angles to one another, into which the helve fits: one or other eye can be used according to the use that is intended to be made of the tool. The helve is also fitted with a wire-cutter, the lever of which is countersunk in the wood when not in use. The uses to which the tool can be put are numerous.

A.S.H.

RIVISTA DI ARTIGLIERIA E GENIO.

(*January*, 1933.) 1. *Recenti progressi nel secondo problema balistico*, by Prof. F. Burzio.

2. *Tiro e impiego dell' artiglieria*, by Colonel Geloso.

3. *Tecnicismo e guerra futura.* Major B. Cappuccini, of the Engineers, writes at some length on the question of the mechanization of the army of the future. He uses the word *tecnicismo*, which he defines as the contribution that science offers to the military art by the study and supply of all means of warfare that increase the offensive capacity of combatants and reduce their vulnerability.

In the first chapter he deals with the questions of personnel and material. A brief reference is made to the views held in France prior to 1870 and, again, prior to 1914. As regards future wars, everyone is agreed that it is not so much a question of equipment of armies as of the preparation of entire populations for war. But from this point onward, students are divided into two schools: (1) the technicians, who attach a primary importance to the preparation of material; (2) the psychologists, to whom the training and organization of men come before everything else. In the writer's own opinion, the methods employed in a future war will not differ, to a great extent, from those employed in the world war.

In the second chapter the writer deals with the evolution of "technicism" (to use his own expression) during the world war. Considering Italy first, he refers to the increase of personnel and material during the war, and gives details of the increase, during its progress, in the number of rifles, machine-guns, guns, aeroplanes, etc. He deals more briefly with the prodigious increase of war material with other belligerents.

In the third chapter, the writer deals with the post-war state of affairs. He has prepared three tables, giving particulars relating to fourteen of the leading nations of the world. The object of these tables is to show an all-round increase in war material, out of proportion to the increase in personnel.

In the fourth chapter the future of technicism is discussed. The writer is of opinion that future wars will be fought between enormous masses of men, but that no increase is possible beyond the numbers engaged in the Great War. A higher proportion of technical troops will be required, but "technicism" is now a quality demanded of all branches of the army; the infantry man is a technician as much as the gunner or the sapper.

4. *Sul collegamento goniometrico parallelo*, by Colonel Baldassare.

5. *Il genio ferrovieri*, by Brig.-General Bellusci. An article on the duties and the work carried out in war-time by the railway units of the engineers.

The importance of having troops trained for railway work was first realized by the Prussians in 1870. After the war, regular engineer units were formed, specially

trained for this purpose and for the construction of temporary bridges. Other nations were not long in following suit, and now all have a proportion of railway troops—Russia taking the lead with 15 regiments, totalling 180 companies.

The article contains some photos, illustrating damage done to girder bridges and their subsequent repair, also a plan of the war area in North Italy, showing the damage done by the Austrians to the Italian railway system, between the battle of Caporetto and that of Vittorio Veneto.

(*February*, 1933.) 1. *Impiego di un reggimento d'artiglieria pesante campale nell' avvicinamento*, by Colonel Laviano. A scheme, worked out with the aid of two maps, to illustrate the duties of a regiment of heavy field artillery consisting of six groups—three of 105/28 guns and three of 149/12 Sk. howitzers.

2. *La radiotelemeccanica*, by Lieut.-Colonel F. Gatta. The writer begins by describing some of the latest developments in radio-telemechanics, and then goes on to discuss the ways in which they can be adopted for military purposes.

Some of the uses of which radio-telemechanics can be made in military work are:—A motor-boat, an aeroplane or an armoured car can be controlled in such a way as to drop an explosive charge on a particular point. Aeroplanes can be made to drop bombs, or take photographs, of a given area, and then return to their starting-point. A number of mines can be fired at a considerable distance without any wire connection with the person controlling the firing.

In connection with the control of ships by wireless, the writer instances the case in America of the obsolete battleship *Iowa* being controlled by wireless from the battleship *Ohio* and being bombed by aeroplanes similarly controlled. He does not think, however, that much progress has been made in this direction since 1927, possibly because of the high cost of the apparatus required.

The control of aeroplanes by wireless has been more or less successfully solved by the use of the Sperry stabilizer. The radius of action is, however, limited by the range of vision.

The writer thinks that the prospect of control of tanks or armoured cars is very promising, although British experiments over distances of only two miles have not proved satisfactory.

3. *Il secondo e terzo periodo dell' aggiustamento in alzo in base al senso esaminati col calcolo delle probabilità*. A technical article on gunnery.

4. *Attività del genio militare nella Cirenaica*, by Lieut.-Colonel Policardi. An account of the work done by the Engineers in the Italian colony of Cyrenaica between 1911 and 1931. The work embraced every kind of work that falls to the lot of military engineers, and included the construction of landing-stages, roads of all kinds, hutments, water supplies, aeroplane hangars, redoubts, light railways, wireless installations, etc. The work had to be carried out in an almost waterless desert, and in the most terrific heat, while the troops and workmen were liable to attack by hostile tribesmen.

5. *Concezioni tattiche straniere sull' impiego dei carri armati*. The writer refers to the progress made up to date in the design of tanks, dwelling chiefly on their armament and their anti-tank weapons. He deals with the tactical employment of tanks, quoting from articles in various foreign journals.

The main anti-tank weapons are the gun and the machine-gun of heavy calibre. A German military writer suggests that infantry should be armed with a shot-gun of large bore (30 to 40 mm.), which, fired at short range, would damage the exposed parts of the optical apparatus and injure the personnel through the loopholes.

6. *Note sui servizi in guerra*, by Brig.-General Cardona.

(*Technical Supplement, March*, 1933.) 1. *I problemi del massimo nella balistica interna e la loro soluzione grafica*, by Lieut.-Colonel Mainardi. 2. *Calcoli rapidi per archi delle traiettorie del fascio subverticale*, by Captain di San Secondo. 3. *Dighe a gravità e dighe ad archi multipli*, by Major del Bello. Calculations, with diagrams,

of gravity dams and multiple-arch dams. 4. *Soluzioni Sperimentali del secondo problema balistico*, by Prof. Burzio. 5. *Consiglio nazionale delle ricerche. Problemi risolti dall' istituto centrale di calcolo.* Prof. Picone. 6. *Sull' analisi microscopica delle sostanze esplosive*, by Prof. Giua and Dr. della Piana. 7. *Travi di ferro saldate ad ali larghe*, by Colonel Perroni. A note on the advantages of using welded trusses with broad flanges in preference to riveted ones.

A.S.H.

REVUE MILITAIRE SUISSE.

(*January*, 1933.) 1. *L'aviation, arme unique*, by Lieut.-Colonel Mayer. The writer criticizes an article that appeared in the October, 1932, number, by General Rouquerol, in which the latter stated that, though aviation will take a greater part than ever in future wars, it is a mistake to suppose that it can become the only arm.

Lieut.-Colonel Mayer has held the view, during the last fourteen years, that a country possessing a powerful air force, but having no land forces, is in a position to reduce to impotence a country that has maintained an army of the old pattern, modified to meet modern requirements. It would take days or weeks for the army to take the field, whereas an air force would act at once, and civil aviation could be militarized in a few hours.

2. *La bataille du Dobropolié*, by Colonel Verrey. The writer draws a parallel between the battle of Caporetto and the final battle of the campaign in Macedonia. A sketch shows the position of the allied armies in Macedonia in September, 1918, stretching across the Balkan peninsula from the Adriatic to the Gulf of Orfano. The left was held by the French Army of the Orient (which included Italian and Greek troops), the centre by French and Serbs, and the right by the Anglo-Hellenic Army.

General Franchet d'Esperey, the Commander-in-Chief of the allied armies, selected as his main objective the Dobropolié–Koziak *massif*, in front of the Franco-Serbian Army. After six weeks of preparation, mostly carried out by night, the artillery bombardment of the enemy's infantry position was begun on the 14th September. The Serbian Army made a vigorous attack on the 15th. The Koziak was captured on the 16th, and additional progress was made on the 17th. The Anglo-Greek Army attacked in the valley of the Vardar on the 18th; the attack was resumed on the 19th. On the 20th, the Serbians, supported by the French, gained the heights between Cerna and Prilep. On the 20th, the Bulgars commenced their retirement, which continued during the subsequent days. On the 30th September, the Bulgarian Army, 77,000 strong, with 400 guns, capitulated.

3. *Le réarmement de notre artillerie*, by Lieut.-Colonel Anderegg. The writer sums up the conclusions he has arrived at in his previous articles on the rearmament of the Swiss artillery. He divides his programme into four phases, of which the creation of anti-aircraft artillery comes first. The process of reorganization would be spread over fifteen years, and would cost 90 million francs.

(*February*, 1933.) 1. *Où en est la conférence du désarmement*, by the Editor. It is approximately a year since the opening of the Disarmament Conference at Geneva, on the 2nd February, 1932. The results obtained after a year of deliberation are not remarkable. Some twenty-odd states proposed projects of reduction or limitation of armaments during the general discussion. Two documents stand out amongst the rest as being important: the Hoover proposals of the 22nd June, and the memorandum of the French delegation of the 14th November. Most nations have expressed sympathy with the Hoover proposals, with reservations on certain points. The French proposal is that of a short service army for all countries, restricted in its capacity for taking the offensive. In addition, each country will have certain specialized units, with armaments forbidden to national armies, acting as a portion

of an international police force. All countries are more or less in agreement on the banning of aerial bombing.

Some of the proposals put forward are quaint, such as that of the Dominican Republic forbidding the manufacture of lead soldiers !

2. *Le tir contre avions à la mitrailleuse*, by Major Perret. The writer lays down seven general rules for anti-aircraft defence. They relate to the location of guns, the necessity for constant readiness, the direction of aim, the time for firing, etc. It is necessary to have several machine-guns trained on the same aeroplane to have a chance of hitting it. The arrangement that the writer recommends is that of three machine-guns, placed at the angles of an equilateral triangle having a side of 750 metres.

3. *Où il est encore question du pas cadencé et de quelques jugements sur lui portés par des sages*, by R.M. The writer dilates on the futility of teaching soldiers the goose-step.

(*March*, 1933.) 1. *Quelques thèmes tactiques illustrés par des cas concrets*, by Colonel Schibler. Some tactical exercises to be carried out with the help of the 1/100,000 ordnance map of Lausanne.

2. *Quelques réflexions sur la réorganisation de l'armée.* A *résumé* of an article by Colonel Sonderegger, by Colonel Lecomte.

The writer considers the three fronts on which the Swiss Army might be called upon to fight: in each case on the defensive, in its own country, against an enemy greatly superior to it in numbers. What he considers a weak point about the army is that its senior officers get no opportunities of handling the larger units.

Owing to the weakness of the artillery, the infantry should be self-sufficient. Each battalion should have 16 machine-guns, as well as light guns or machine-guns of big calibre, and light mortars. All infantry should have mountain transport. The mountain artillery should be increased, and more 15-cm. howitzers are required.

The fighting unit would be the regiment of four battalions, to which would be added a group of four batteries and a proportion of cavalry, sappers, medical units, supply and transport. The army, of 108 battalions, would comprise 27 regiments, forming 9 divisions.

3. *Suggestions défensives*, by Colonel Moccetti. The writer deals, in a general way, with the importance of field fortification in warfare, and shows what part sappers are required to take in it.

A.S.H.

THE INDIAN FORESTER.

(*January, February and March*, 1933.)

The Indian Forester, described as a "journal of forestry, agriculture, *shikar* and travel," now in its fifty-ninth volume, is a well got-up monthly paper, each number containing above 60 pages of eminently readable matter. Naturally, parts of the contents are of a technical nature, but there is much in them which a sapper, especially one who has served in India, will find of interest. The first impression given by the perusal of these three numbers is the vast ignorance of the average engineer as regards the production of one of his most valuable raw materials; the second is the large number of points of contact between the engineer and the forester.

The numbers under review contain, for example, a brief article on reinforced brick-work, notes on the use of plywood panelling (from the *Timber Trades Journal*), a description of the partial afforestation of a military manœuvre area in France, a reference to the use of laminated wood culverts, and a translation from Sanskrit of a poem on the use of certain trees, usually in conjunction with ant-hills, for locating water. Those who know the almost uncanny skill of Indian well-diggers in finding water, will be far from setting down the last-named as rubbish. A review of the

Burma Forest Report for 1931–32 is of special interest, in view of the fact that the rebellion was at that time taking place largely in the official forest areas.

Shikar, as the sub-title informs us, is a great feature of the journal. Colonel Cunningham's recent book comes in for a very favourable review. There are articles on game preservation in the U.P. and on trout culture in Kashmir. Forest officers are sometimes accused of keeping the best *shikar* grounds for themselves; but it is seldom adequately recognized that they are the official game wardens of the areas they control, that certain blocks are permanently closed as game sanctuaries, and that in most others game has to be preserved by limiting the annual number of kills. The March number contains an exciting account of a crocodile shoot at night, during which a half-grown crocodile sprang from the river's bank into the boat of the author, who, after a grim struggle, succeeded in cutting the beast's throat with his hunting-knife!

Special attention must be given to two articles: one, in the January number, deals with the air survey of some forest areas in Burma and Oudh, chiefly the latter. The survey there was of an experimental nature, as advantage was taken of the presence of the Indian Air Survey and Transport Company (London and Rangoon), who were aerially surveying for cadastral purposes the adjoining non-forest areas; for this reason, the cost, Rs. 55 per square mile, was exceptionally small. The author is enthusiastic in his praise of the results, and as regards its capabilities. The error claimed at a scale of 16 inches to the mile is less than 1/200, while, as regards speed, photos of 80 square miles of forest area were taken in four hours' actual flying, as against an estimate, which one must, however, regard as rather unfavourable to the survey of India, of a whole season for ground methods. The author is doubtful as regards the value of air survey in hill areas and for mixed forests, and concludes with hints to the Forest Officer regarding the preparation of his area for aerial survey, *e.g.*, by whitening areas round boundary pillars and cutting branches overhanging bridle-paths.

In the February number is an account, written in a style reminiscent of Kipling, of the eradication of *lantana* from a large forest area by means of elephants. *Lantana*, familiar to all who have served in India, is an aromatic shrub, with vivid orange, pink, or maroon flowers. Few, except forest officers, know what a pest it can become. In the case in question, it was introduced, some 50 years ago, into Chikalda, in Berar, as an ornamental hedge shrub. Now, having grown to a height of 15 feet, it threatens the very existence of Chikalda, and has become "a major problem of forest management in valuable teak forests" over an area of 600 square miles. The author, having an elephant at his disposal, taught her by judicious presents of sugar to uproot and stack the *lantana*; this elephant, once instructed, imparted the knowledge to five others, and the section of six, working through a wet season, eradicated the pest at a rate of 1 acre per 6 elephant-hours, normally the work of 27 to 40 men. There are some fascinating photos of the herd at work with trunk and foot, but, as the author says, their movements should have been recorded by the cinema. The re-growth of *lantana* from seeds was effectually prevented by sowing hemp, a paying crop which required no fencing.

The magazine deserves a place in R.E. and S. and M. messes in India, and might be usefully included among the engineering journals circulated by the M.E.S. in India. The rate of subscription is only Rs. 15 p.a.

F.C.M.

WEHR UND WAFFEN.

(*January*, 1933.)—*The Austrian Tank, 1911 Pattern.* Major-General Kerchnawe relates a tale of lost opportunity, the history of the tank invented by Lieut. Burstyn of the Railway Regiment, and called by its inventor the motor-gun. The tank was to be quite small, about 4 tons in weight, carrying, besides the driver, a 4-cm. Q.F.

gun and two gunners. Across country it ran on two sprung caterpillar tracks, while on the road it ran on wheels. It had a 50 to 60 h.p. petrol engine of the then lorry type. Its armour was 8 mm. of special steel in front, 4 mm. sides and rear, 3 mm. on top. A characteristic feature was the provision of two arms carrying rollers in front and two similar arms behind, the whole being an arrangement to increase the small base (only 3·5 metres × 1·9 metres) so as to improve the tank's power of getting over very rough ground. These arms had various possible positions, being raised or lowered by the engine by means of adjustable metal stays, the T-heads of which ran in guides.

Photographs show the tank climbing over a parapet, when its shape and the arms front and rear, being inclined at different angles to the tank, give it a strangely life-like appearance.

The short description given will be sufficient to show that there were immense possibilities about Lieut. Burstyn's invention. The writer laments that "here Fate presented the all too happily peaceful Central Powers, who with their heads buried in the sand could not see the fate that threatened them, with a trump which they did not recognize." The invention was placed before the Austrian War Office, which turned it down on December 22nd, 1911, owing to an adverse report by the Director of Mechanical Transport. The letter of rejection can be seen alongside the model in one of the technical museums either in Vienna or at Kloster Neuburg.

General Kerchnawe takes it as particularly unfortunate that Lieut. Burstyn's tank, although intended to serve a tactical purpose, was never even referred to the General Staff for report—a remark which is obviously sincere.

The Case of Artillery Shelling Their Own Infantry. Colonel Blümner first rules out the case when oblique or enfilade hostile fire is mistaken by the infantry for the fire of their own artillery. The real instances he classifies as those due to undue dispersion caused by worn barrels, those due to the undue dispersion of inferior ammunition of war-time manufacture, those due to gunnery mistakes—an inconsiderable portion of the whole—and those arising from the artillery's lack of information as to the position of the foremost infantry.

As regards the natural dispersion the French regulations for infantry training guard against it by laying down that the attacking infantry must rely upon their own weapons in a zone 450 to 500 metres deep before the enemy's position. It is not easy to see how this system can work, since the cessation of the attacker's artillery fire will be a sign that his infantry are coming, hence a warning to the defender to get busy. Against these French views, the author cites *F.S. Regs.*, 1920, to the effect that, in a planned attack, the infantry must be prepared to reckon with shorts from their own artillery. The German regulations agree on this point, while the Austrians lay down that the infantry behind the creeping barrage are to follow up their artillery fire "unfearful of losses."

Colonel Blümner gives two good tips. The first is the vital importance of good communication between the artillery liaison officer and the guns. The second is that infantry will stand a great deal more from the gunners of their own division, whom they know and can trust, than from any unknown batteries supporting them.

The Clockwork Fuse and its Development. Major Weidinger writes in honour of Heinrich Thiel, a partner in a firm of watchmakers, who spent many years of his life in making the clockwork fuse a working proposition. A Berlin watchmaker, called Bäker, took out the first patent in 1903, and sold it to Krupps, who, not having the necessary plant, entrusted the work to Thiel Brothers. In less than three years the first shooting trials took place, and three years later the clockwork fuse became a vocabulary store. Under mass production there was a serious setback, and the fuse had to be re-designed. In 1916, this new fuse was adopted, and by the end of the war was being turned out at the rate of 6,000 a day. The plant, broken up under the Treaty of Versailles, was replaced at the end of 1924, since when there has been production on the limited scale permitted.

The Machine-gun S2—200. Major Dänicker, the Swiss machine-gun and small arms expert, describes fully with photographs and sketches this product of the Solothurn Company. The S2—200 is a light machine-gun for use by the foremost infantry. In this case it fires from the usual fork-rest. It can also be used on a light tripod mounting, when it is able to undertake at least some of the tasks of heavy machine-guns. By the difference of mounting only, it thus combines the light m.g. with the medium heavy m.g. and becomes a universal machine-gun for infantry.

A Combined Railway and Road Vehicle. The motor-lorry as railway engine was the subject of an article, reviewed in *The R.E. Journal*, September, 1929, p. 508 wherein the solution was to mount the fore part of the lorry on an eight-wheeled bogie while the driving wheels ran on the metal outside the rails. A new solution is here presented. It was arrived at by the London, Midland & Scottish Railway, and is called by them the " Road-Railer." On the axles of the vehicle selected—say, an autobus for 26 people—ordinary railway wheels are fixed inside the road wheels. As the railway wheels are smaller in diameter they are clear of the road. When the vehicle changes over from the road to the rails, instead of being concentred with the railway wheels, the road wheels are placed eccentrically to them. This can be done by one man as soon as the bus, by being driven along the line to where there is a suitable difference of level, has made the railway wheels first engage and then take the weight. The importance of an invention of this sort in these days of increased mobility, when troops must be hurried to the front by railway, only to be detrained at a railhead so far from the enemy as to make embussing necessary for the next advance, has been felt sufficiently for world-wide efforts at producing the combined railway and road vehicle.

The writer of the article considers the L.M.S. Railway's solution of the problem deserving of such attention that he then describes the " Road-Railer " in detail, with drawings and photographs.

The Automatic-Call Telephone and the Army. The army needs the public telephone service for the efficiency of its daily work in peace, to take the place of long-distance military circuits on manœuvres, and most of all in war for the multifarious war services in the home country. From the standpoint of the soldier a recent complication has arisen in the use of the public telephone network, owing to the progressive automatization of the telephone. Major von Dufais proposes to examine these difficulties for the troops and to show how they are to be overcome. As a preliminary, he enumerates the advantages of the new system by means of which the caller-up puts himself through to any desired number, which is disengaged, using the exchange for that purpose, but without needing the services of the exchange operator.—(*To be continued.*)

Signals in Various Countries. The author tries to clear up for us some of the diversity which exists in the various armies, both in nomenclature and in the functions of the signal service. From a comparative table of leading terms in ten European languages, it appears that what we call signals would be called by the Germans the Service of Transmission. What the Germans call their own Signals is the Intelligence (and Liaison) Service. A sidelight on the general diversity is thrown by a quotation from a Swiss military paper: " Intelligence, Liaison and Message Transmission are three different things, each by itself a means in the hand of the commander, by which he forms, ripens and imposes his will as leader. They must, therefore, co-operate most closely, but each must maintain its own position, and must not forget in the service of another its own main object—always and first of all to serve the commander." This quotation also illuminates the admirable simplicity of the British system, which made the sole duty of Signals the transmission of messages, working directly under G (operations), but serving all branches, including Intelligence and Liaison, as G (operations) directs.

(*February*, 1933.)—*Tactical Views on Artillery Employment in the Red Army*, by Lieut. Freytag, 1st Artillery Regt. When the Red Army first came into being

party politics decided that all ideas and arrangements that reminded one of the old Imperial Army should be rejected. This included, of course, all the teachings of the Great War. Since then, however, there has been a steady improvement. First the Civil War, and then the war with Poland, showed that artillery in battle could not be run on the lines of party politics, and provisional combat regulations were issued more in accordance with the actual circumstances and possibilities of war. There appeared in 1927/28 *Artillery Combat Regulations*, and in 1930 an *Artillery Training Manual*, based upon German ideas. In 1931, a revised Part II of the *Artillery Combat Regulations* was issued. In these works there has been a progressive simplification. The confusion of engaging targets has been got rid of, and a diminution in the methods of fighting has resulted. The author makes a few illustrative extracts. The Russians, it appears, do not know the higher artillery commander in the German sense. The artillery commander of the division or corps is found among the brigadiers of the light or heavy artillery brigades in that formation.

In battle the artillery is divided, according to its employment, into two categories, DD (or longe-range) and PP (or infantry-supporting). DD is normally the corps artillery, but if the disposition is such that corps artillery cannot well be run centralized, DD groups may be allotted to divisions, which may supplement them from the divisional artillery. DD groups, in any case keep in touch with both the nearest PP group and the nearest infantry commander. "The employment of artillery under one artillery commander guarantees in most cases the best employment of all artillery material; but on no account must it be used to the detriment of the actual support of and closest co-operation with the infantry. Hence, artillery is only to be centralized in one artillery command in those cases in which there is a certainty of arranging, in the time available, and of maintaining unbroken communication with the infantry."—(*To be concluded.*)

The Automatic-Call Telephone and the Army. Having shown us the advantages of the automatic system over that of the hand-operated switchboard, Major von Dufais with the aid of diagrams now explains how the new system works. He describes in turn the simple relay; the principle of the selector; shows how the selector at the exchange replaces the switchboard attendant by responding to the numbered call as given by the successive motions of the caller-up's finger; describes the different kinds of selector; the method of multiplication; and explains what happens as a result of lifting the hand-set from the fork.—(*To be concluded.*)

The British Military Railway at Longmoor. A short and interesting account is given of Longmoor and its activities, illustrated by a sketch-map at 1 in 10,000. The account is signed with the single initial "W," and abstains from all comment.

The French War Survey Department in N.E. France, 1914–18. Dr. Meyer starts by pointing out that the work of the French Survey Department in the war, although covering 550 km. of front, is hardly known in Germany beyond a limited circle, while the work of the British Survey, covering a front of 150 km., has been widely discussed. Dr. Max Eckert, in Vol. II of his *Die Kartenwissenschaft*, says that the dearth of information from the French side is intentional. As regards the British work, the Germans have been kept posted by articles in the *Geographical Journal*, 1919, and especially by the Prussian Land Survey's translation of one of General Winterbotham's articles, "British Survey on the Western Front," and by a German review of General Jack's "Survey in France during the War," which appeared in *The R.E. Journal*.

As regards French war survey, Professor Eckert, in his work mentioned, gives as his principal sources of information the *Documents parlementaires* for 5.9.20, and a series of articles by a Dane, F. B. Münter, in the *Militaert Tidskrift*, 1921. Since then, however, plenty of material has appeared, though it is not all easy of access. Thus *Service Géographique de l'Armée*, a report of 400 pages, on the work done between August 1st, 1914, and the end of 1919, which was published in Paris in 1924, is now

out of print. The same fate has befallen *The Ordnance Survey and the War*, 1914–18, believed to have been compiled from the O.S. annual reports and the Report of the O.S. Overseas Branch, under Lieut.-Colonel W. J. Johnston.

Dr. Meyer gives a general view of the state of the maps of N.E. France in 1914, illustrated by three sketches showing the divisions of the 1 in 80,000 with date of last revision on each sheet; the state of the 1 in 10,000, showing by shading the revisions up to date and new surveys since 1900; and the state of the 1 in 50,000, showing the special sheets of Paris and surroundings (9), of La Fère and Soissons (2), and of the Alsace-Lorraine frontier (20).

He also gives a slight historical sketch which, by means of instances at the commencement of different wars, brings out the importance of removing to safety copper plates and reliefs before the arrival of the enemy.

Signals in Various Countries. This instalment deals with visual signalling in war, and opens with a fine quotation from Prince Eitel Friedrich of Prussia on the occasion of the 25th anniversary of the formation of Signal troops in the German Army (1st October, 1924), which paints a vivid picture of the deficiencies in signals in 1914, and their subsequent rise to efficiency. The reference is to all means of signal communication, and not to visual only.

The various means finally arrived at in the German Army were the same as used by the British. Two differences of degree, however, stand out—the enormous use the Germans made of the signalling-lamp, and the far greater use than we did, of the messenger-dog. In mountainous country, where the lamp gets long, clear shots, and can easily be concealed, it is often invaluable, as the Austrians found it, who did much of their fighting in mountains. The Germans, on the other hand, fought often and much in the plains, and yet they went to war with all arms equipped with signalling-lamps on the same scale as telephones. In 1917 alone, 75,000 signalling-lamps were sent to the front. Having troops set apart for visual signalling, they were able to cover their divisional areas in the line with a network of lamp stations, carefully sited and concealed, which carried on with their messages when the cables were useless owing to the shelling.

Of other forms of visual signalling, Major Werner, of the Austrian Federal Army, is quoted as giving the highest praise to the heliograph for war work in sunny lands like Afghanistan, Morocco, the Transvaal, etc., for its use between distant columns, and between a relieving force and a besieged garrison. He mentions the case of Roberts' force, on its way to relieve Kandahar, receiving, while still 47 miles away, a situation report of over 200 words in 4 hours. Actually the news of the disastrous sortie, made by the Kandahar garrison, reached Sir Frederick Roberts by helio, through relays at Robat and Khelat-i-Ghilzai, on August 21st, when he was still over 100 miles away.

On the historical side, the writer says of the semaphores used by the Romans along their military roads that messages could be passed with surprising speed. Napoleon's chain of semaphore stations from Strasburg to Paris, 450 km. distance, in 1813, passed a certain signal from end to end in less than six minutes.

(*March*, 1933.)—*Tactical Views on the Employment of Artillery in the Red Army.* The Russians lay down that the fundamental condition for victory is maintaining the closest communication between the infantry and the infantry-supporting artillery (or PP groups). For this purpose the batteries are provided with signal sections for infantry liaison only, known as O.S.P. That a battalion in the attack may be allotted its own supporting artillery, it will often be necessary to subdivide the artillery groups. In any case the Russians have already proceeded as far as to have artillery as a component part of the infantry brigade.

Except for a note regarding additional support required to be given by the artillery when an infantry division is attacking with tanks, the remainder of the article deals at some length with the co-operation of horse artillery with cavalry. The Russians

would presumably attach more importance to this subject than other nations, owing to the great preponderance of cavalry in the Soviet Army (*vide R.E. Journal*, December, 1926, p. 709).

The Russian regulations lay down that when tanks attack with infantry, in addition to the artillery groups (PP) supporting the infantry, a special artillery group, called PTD, must be allotted for counter-battery work, to assist the tanks by keeping down the fire of the hostile anti-tank guns.

Anti-tank Defence. Technical progress, ever producing improved weapon effect, renders necessary an alteration, or an adaptation, of the method of fighting. This latter again, in its turn, generally opens up new questions for weapon technics. Battle tactics and weapon technics are thus intimately related. In order, hence, to gain a clear picture of the tactics of anti-tank defence, it is necessary first to examine the technical power of performance of the defence. For this purpose it is easiest to deal with active defence and passive defence separately.

As regards the former, this is principally an artillery matter. In defeating a tank attack the task of the mass of the artillery falls into two parts: (1) smothering the attack at the very start by concentrated fire upon recognized or supposed ways of approach and collecting-places; (2) defeating the attack itself by the observed fire of all guns, *i.e.*, by a sort of barrage on the advancing tanks.

In order not to be at the mercy of the tanks when it comes to fighting at close range, it is necessary to equip all infantry batteries and field artillery with split trails or light, revolving pivots. The split trail, giving a 60° field of fire, was created on account of the increased mobility of modern tanks, and Major Heigl, in his *Tank Handbook*, 1927 (*vide R.E. Journal*, March, 1928, p. 154), considered that it would be necessary for all guns up to and including the 6". The U.S.A., Great Britain and Italy, in the order named, thus converted their field guns for A.T. defence, while Greece, and, it is believed, France and the U.S.A., have split trail field howitzers.

Besides these conversions must be mentioned the anti-tank gun proper, the infantry gun, and the attempt to satisfy the conflicting requirements of these two, an infantry gun with exchangeable barrels, like the Skoda 70/32 mm. and the Dutch 75/47 mm.—(*To be continued.*)

Shooting from a Moving Platform. This question, introduced into land warfare as a product of mechanization, has there many complications unknown to naval gunnery. It concerns small guns, from 3·7 to 7·5-cm. calibre, carried in tanks and armoured-cars; and limitations of space, nature of mounting, target measurement and difficulty of observation, go to make up a particular case.

The article consists of purely theoretical considerations, with simple diagrams, regarding aiming-off as affected by relative speeds of gun and target, also directions of movement, effect of wind, inclination of course to line of fire, etc., *i.e.*, some of those factors which are necessary to arrive at a numerical evaluation, defining the limits within which useful hits can be obtained. The author recognizes that such an evaluation must, however, be dependent on numerous data which the Germans have not been permitted to find out for themselves, and which are not published by the nations who have carried out the necessary tests and trials.

The Krupp 2-tonner with Air-cooled Engine. Air-cooled engines are nothing completely new. Their development has been going on since the commencement of automobile construction, parallel with that of water-cooled. Phänomen has sold a small air-cooled engine for years, while the air-cooled engines of Franklin in America, and of the British Army cross-country car, have long since proved their utility and reliability.

Since, for the construction of air-cooled engines, greater demands upon metal were to be reckoned with, new materials had to be found. The development of the light metals has been of special importance for this. Bronzes had also to be discovered, and produced, with properties resembling those of aluminium. Air-conduction, too,

had to be studied, and the best shape for ribs, whereby aeroplane and motor-cycle experience were of assistance. Practical trials, based for the time being upon theoretical principles, were conducted with blasts, and opened up new ways for forming with a minimum of power the largest possible masses of air and air velocities. Extended metallurgical research to find the most suitable materials and successes obtained in cold air supply and the subtraction of heat have led recently to the decision to equip lorries widely with air-cooled engines in place of the present complicated water-cooling, which is also heavy and expensive in repairs.

The writer makes of the air-cooled engine of the Krupp 2-ton and 2½-ton lorries, here described, the astonishing statement that the Krupp system of air-cooling, combined with a special improvement of the mixing chamber, have made so great an increase in the performance per litre, that petrol consumption could be reduced 20% to 30% below that of water-cooled engines doing the same work.

The French War Survey Department in N.E. France, 1914–18, gives a sketch of the activities of the Department on mobilization and of its director, Major-General Bourgeois, "a happy combination of high military rank with thorough technical knowledge"; the application to position warfare of the artillery fire instructions laid down for siege warfare; the origin and development of sound-ranging.

The International Automobile Exhibition, Berlin, 1933. Dr. Stadie regards this exhibition, which took place in February, as marking a turning-point in automobile construction. He consequently shows only photographs of, and confines his remarks to, different firms' methods of axle-suspension and springing for small and medium-sized cars.

Robert von Lieben. A pleasing feature of the respect for science, and for learning generally, which is typical of Germans, is that it is their custom to revive the memory of their scientific benefactors by anniversary notices. *Wehr und Waffen* honours itself in thus remembering Robert von Lieben, an Austrian and a pupil of Nernst's, who devoted years of labour to inventing a relay which should make "a whisper into the microphone become a roar at the receiver." It was Lieben's gas-filled triode, brought out with his partner Reisz, which, by amplification, made it possible for conversations of the German General Staff to take place between Spa, Kreuznach or Charleville, in the west, and Pless, nearly 700 miles away near the Russian frontier.

F.A.I.

MILITAERWISSENSCHAFTLICHE MITTEILUNGEN.

The change in editorship is followed closely by an alteration in the magazine itself. Owing to the change of attitude of France towards the question of Germany's right to re-arm, the new editor, General Ratzenhofer, foresees imminent changes in the military systems of all the nations, Germany, Austria, Hungary and Bulgaria, hitherto restricted by the Treaty of Versailles in their military development. He has decided, therefore, that, in order to keep in closer touch with its readers, and thus to keep them more up to date, *M.M.* shall appear monthly in future, instead of as at present every second month.

The magazine may safely be congratulated on this improvement in its position as a purveyor of news, military, political and technical, and on the consequent increase in value of its comments on passing events.

(*January*, 1933.)—*A Study of the Disposition of the Austro-Hungarian Forces at the Outbreak of Hostilities.* Colonel von Dragoni has already given us an article on the organization of the Austro-Hungarian forces during the years immediately preceding the Great War, in which he showed that through faulty organization the full military strength of the nation was not utilized. He now makes similar investigations for the period subsequent to the first order to mobilize.

The mobilization assembly problems tackled by the Austro-Hungarian General Staff may be simply designated as:—Case A, war with the Balkan States alone; Case B, war with Russia alone; Case C, war with the Balkan States and Russia at the same time. What they appear not to have envisaged was what occurred, viz.:—Case D, war with the Balkan States, followed at an interval of some days by war with Russia; in fact, Case A turning into Case C. Incredible as it may seem that Case D was not provided for, the proof of this appears to lie in the fact that the 2nd Army received its orders on July 27th, mobilized and took the field against Serbia, only to be pulled out again and transferred to Galicia, as part of the field army under Case C—a fine example of a large-scale "box-up."

Colonel von Dragoni points out that the whole of the troops required for the offensive against Serbia should have been ear-marked for that purpose, and not included in any other scheme: and that, if they had been so, large economies could have been effected by specializing them for mountain warfare.

Against Russia the Austrians advanced on August 15th, eleven days before the 2nd Army started to arrive from the Serbian front, and twenty-four days before its last units detrained. The absence of the 2nd Army, the author thinks, made all the difference to Conrad's main piece, the blow to the north, between the Vistula and the Bug. Had the 2nd Army been present, he would have been able to start this offensive from two to five days earlier, and with an increased strength of 33%. In this case the German 8th Army, after the victory of Tannenberg, might have been induced to strike S.E. on Siedlice and pinch out Warsaw, a favourite plan of Conrad's, which would have affected the whole war.

Brussilow and his Cavalry in June, 1916. To one tale of an opportunity on the grand scale lost succeeds another. On the 4th June, General Brussilow, with four Russian armies, started his tremendous drive against the Austrians on a front of 350 km., the distance of London from Westmorland. The greatest success was obtained on the northern portion of the line, where opposite Luck the Russians broke through on a front of 130 km., and penetrated to a depth of 90 km., driving the Austrian 4th Army to the north and their 1st and 2nd Armies to the south. There thus arose a gap 30 km. broad between the Austrian 4th and 1st Armies. This breach was not closed for fifteen days.

The failure of General Brussilow to utilize his great masses of cavalry, 60,000 sabres (51 cavalry brigades in 15 cavalry divisions), for reaping a victory in Napoleonic style saved the Austro-Hungarian eastern front. It is the more incomprehensible, when one considers the records and reputations of the commander-in-chief himself, and of his only independent cavalry commander, General Gillenschmidt. Further, the commanders of the two Russian armies that broke through at Luck, Kaledin and Sacharow, were both cavalrymen.

In order to elucidate the mystery, the writer of the article, Lieut.-Colonel Diakow, has made a thorough search of the Russian sources of information on the subject, and comes to the conclusion that there is only one explanation, viz., that Brussilow himself had not believed that the success of the offensive would be so great, while his army commanders had not believed that it would succeed at all. Nothing else in his opinion can explain why, when the great moment arrived, the cavalry were found to be split up and in the trenches, or even in swampy and wooded country where they could not be used as cavalry.

The Development of the Austro-Hungarian Forces in the First Two Years of War. In his first article, Major Franck deals with man-power, its provision, wastage and replacement. Out of this welter of statistics it is possible to draw many ideas. For instance, as regards the greatness of Austro-Hungary's effort, the figures show that, during the period mentioned, just under seven million men were engaged in war service, or 62% of the whole male population between the ages of 18 and 50. As regards the fate of these nearly seven millions, one million were already dead or

permanently lost to military service, one million had been taken prisoner, and less than five million remained to carry on. As regards the fate of the officers during these two years, out of every ten, one was dead, one was a prisoner, two had been wounded at least once, four had been evacuated sick at least once, and two were carrying on the good work nominally and undamaged at their posts. This was the picture when the war had still over two years to run.

The Fight for Manchuria. With an introductory note on the political history of China, taken principally from Dr. Kreitner's *Behind China stands Moscow*, General Wiesinger picks up his narrative where it broke off (*vide R.E. Journal*, September, 1932, p. 570) with the undertaking against Shanghai. As regards the Japanese action in forming out of Manchuria a Manchu state, he quotes the same author as saying, "The undisturbed exploitation of Manchuria and unhindered trade with China are thus a vital necessity for the Japan of to-day," an opinion carrying the more weight as being that of a European resident in China, and described as a warm friend of that country and of its inhabitants. The action of China itself, and of the powers who raised protests against the change in Manchuria, can only make Japan's task more difficult and delay the most desirable reconciliation between the two Eastern powers. That Japan should recede from its position and the policy it has adopted is less likely than that it will extend its hold to include Jehol. As this was written in the middle of December, 1932, the subsequent happenings in that province bear testimony to the author's judgment.

Meanwhile, in spite of all disturbing elements, Manchuria is settling down. One of the factors in the pacification of the country is the establishment of colonies of army reservists with their families from Japan. Simultaneously, the next great step in the Japanese programme is becoming more apparent through the building of a railway to connect Mongolia with the Sea of Japan. This line will run from Soluen, in N. Mongolia, to Taonan, where the line from Jehol in the south will come in, and thence *via* Changchun, Kirin, Tunhwa and Kainei to Seishin on the coast. Of the 1,000 km. of line required, 400 km. have already been completed.

The author then deals with the League of Nations' Commission and with the Lytton Report, which has produced no permanent solution, but only a proposal for a solution which is valueless unless China and Japan can be induced to co-operate. If that should succeed the "honourable effort" of the Commission, and with it the League of Nations, will have been successful. If it fails, then the Lytton Report will lead only to fresh quarrels, complaints and debates at Geneva, all of which will lead to rejoicing at Moscow.

The article concludes by touching on Japan's great rival, Russia, which is still Imperialist in its Far Eastern policy and aims, but from lack of power to enforce its will by arms, must be content to play a waiting game.

Farther ahead, General Wiesinger foresees Japan's expansion as menacing Great Britain and the United States. Events in China have a bearing on the great problem of the Pacific, which will decide the future of those powers. "Before all, England will have to show that it is still a master of diplomacy, otherwise it may hear applied to itself the echo of a term it once applied to another country—the ramshackle empire."

Review of International Military Policy (up to 8.12.32). Major-General Paschek has changed the style of his annual review this year to accord with the new role of keeping its readers up to date, which *M.M.* has adopted as appropriate to its new guise as a monthly magazine. Thus, instead of, as in former reviews, dealing shortly with the principal events of the year, country by country, he mentions only such as are necessary to explain the present position of each country, its policy and tendencies.

The ground covered in an article of twelve magazine pages, even though the greater part of them is in brevier, is astonishing.

In these days, when there is so much to read, and so much to keep abreast of, and

so little time for thinking, a review of this nature performs a real service in marshalling the facts we have read of (or may have missed) in the newspapers, and piecing them together, as we may not have been able to do for ourselves.

Germany's Fate. Major-General Kerchnawe cannot subscribe to Dr. Hartmeyer's view of the guiltlessness of the German people, viz., that they suffer for no fault under the Caudine yoke of Versailles and St. Germain. Such a thought would be a consolation to the patriot. On the contrary, the German peoples in Germany, as in Austria, were not guiltless. Their guilt lies therein that in the happy pre-war days, under the influence of the leading daily Press, they showed a lack of the will to self-defence and of the will to self-assertion. Thus they fell under the wheels of an inexorable, but not of an unjust, fate.

The British Way in Warfare. Captain Liddell Hart and his latest book are here highly praised. The wicked joke about this author's works that they should be read by generals, but not by junior officers, as being too disrespectful to the higher commanders, appears to have found no echo abroad. The Austrian reviewer even breaks a lance on behalf of this work by pointing out that Continental readers will find that the points upon which they disagree with the author will dwindle away to a great extent, if they will bear in mind that the book is written from a specifically British point of view, and that the axioms of Continental armies do not coincide with British war experience and British successful conduct of war during the last three centuries.

(*February*, 1933.)—*Count Schlieffen*, on the hundredth anniversary of his birth, 28.2.33, by Lieut.-General von Cochenhausen.

There are but few modern German soldiers so well remembered in the German Army of to-day as Count Schlieffen. This is the more remarkable, since, in his time as C.G.S., 1891–1906, he was comparatively little known in the army, while his many writings, published after retirement, did not reach a circle much wider than that of his former subordinates. Hunting for the causes why a decisive success was not granted to the German arms in September, 1914, always leads us back into the circle of ideas of the man who gave the last twenty years of his life to the problem of a war on two fronts against superior numbers.

Schlieffen, through many years' study of military history, through occupying himself intensively with the political and military questions of the day, acquired a rare knowledge of things as they are, a clear sense of reality, which was the exact opposite of that unreal optimism, that attitude of "everything in the garden is lovely," sustained by catchwords, which had become the fashion in Germany before the war. He saw the frightful danger to Germany of the Franco-Russian alliance. In vain he gave warning that against the ever-increasing armament of these two mighty allies, the nation's full military strength must be utilized. In vain, in 1909, in *Present-day Warfare*, did he paint without disguise the situation into which Germany had fallen owing to England's *rapprochement* to the Franco-Russian alliance. He drew upon himself the disapproval of Germany, and of almost the whole German Press.

His well-known plan for a central power, attacked on two fronts by strong allies, was to attack one and destroy him, while doing no more than hold the other back for the time being. In order to carry this out it was necessary to be of overwhelming strength, and to strike at flank and rear, so as to get the quick decision which was imperative. The violation of Belgian neutrality thus became, not a casual disregard of political considerations, but a necessary act of self-defence, the only way out of a desperate situation.

Amongst Count Schlieffen's great services, all of which stamp him as a scientific soldier ahead of his times, are that he foresaw as inevitable the modern armies of millions, and he therefore trained himself and others for the problems of their leadership; he created the telegraph troops; he created the heavy artillery in the field; he greatly increased the carrying capacity of the railways.

Schlieffen was all for order and leadership. He demanded personality in the commander-in-chief, and he believed in genius, " that superhuman, or supernatural, something which permeates the leader so that he is victorious over odds."

The author has picked out two quotations : " Only with great means and by great efforts can great things be done, can great ideas be realized." " Amongst all the commanders who have ever lived not one ever complained of having too many troops."

The Strategic Break-through. Lieut.-Colonel Kiszling thinks that if, in the war of the future, the offensive power of the air squadrons and of the motorized troops is exhausted before a decision has been reached, so that operations come to such a dead stop as was often the case in the Great War, the higher command will have to take measures to resume a war of movement. Such a measure is the strategic break-through, the leading idea of which is to gain an open field of operations, in order to arrive at the enemy's encirclement : since rapid successes capable of deciding a campaign can be obtained only by action against flank and rear.

The writer then examines shortly, but with clear sketches, seven great break-through battles of the Great War in order to deduce principles therefrom. These are :—(1) Gorlice, where, in May, 1915, in order to relieve the pressure on the Carpathian front, Mackensen broke through the Russians on a 45-km. front. With the adjoining Austrian armies co-operating, a total advance was made in the centre of 90 km. in 14 days. The new front, the chord of the arc of the old front, was 450 km. long. " By the numbers engaged, this was the greatest offensive in the history of war." (2) The offensive from the Tyrol, in May, 1916. This was a pet plan of Conrad's, falling in with what appears to have been in Bismarck's mind after the War of 1866, when he allotted Italian South Tyrol to his Austrian enemies, " a dagger thrust at Italy's heart," instead of giving it to his Italian allies. This thrust was a tactical success, but failed strategically, as the Italians could not be driven off the mountains. (3) The Brussilow offensive in June, 1916. This was intended by the Russians to relieve the pressure on the British and French, and especially on the Italians. Strategically a success in this respect, it was in the local theatre a strategic failure, for the Russians failed to utilize the large breach they made between two Austrian armies, and by pouring troops through it to finish the campaign in Galicia. (4) The Schyl valley break-through, November, 1916. Although a small-scale tactical operation, only four divisions and a cavalry corps against three divisions, this break-through gains a place amongst the seven greatest through its enormous strategic result. After the Rumanians had been driven out of Hungary, Falkenhayn had to fight his way over the mountains into Wallachia. He decided to do this by way of the Schyl valley. After a preliminary repulse the pass was carried on November 11th. The Rumanians rallied, but were defeated again on the 16th and 17th, at Tirgul Jiu ; after which the cavalry were put through, reaching Crajova, 120 km. farther on, by the 21st. This blow from the north-west combined with a timely effort from the south ; Mackensen crossing the Danube, at Svistov, on the 23rd. The fall of Bucharest, the occupation of the oil-fields, and of the whole of Rumania followed quickly, so that by Christmas the Austro-Hungarian front ran from the line of the Carpathians through Galatz to the Black Sea. (5) Zalosce, July, 1917. Although the Russian revolution had broken out in March, it was not until December that an armistice was signed. Meanwhile, Kerensky, who was at the head of Russian affairs, desired a military success, and an offensive was carefully prepared in E. Galicia and started on the 1st of July. This met with some success, especially south of the Dniester, near Stanislau, where the Austrian 3rd Army was driven back 30 km. On the 19th July, the counter-stroke followed, eleven German divisions attacking on a narrow front of only 20 km., near Zalosce, east of Lemberg. Two days later this advance had got forward 35 km. to Tarnopol. From there the whole Russian position to the south could be outflanked, and the strategic value of the break-through was

here brilliantly shown by the way the Russian line was rolled up from north to south, retiring 130 km. to the frontier. The battle of Zalosce might also serve as a splendid example of the value of the counterstroke by fresh troops, set apart for that purpose, acting against a successful attacker in his moment of disadvantage, and seizing from him the initiative. (6) Caporetto, and (7) St. Quentin, which close the series of examples of strategic break-through, are both too well known to need any description. The author thinks that the former should have taken place, not on the Isonzo, but in the Seven Communes. It would then have put Italy out of the war once and for all.

As regards the March, 1918, great push, Lieut.-Colonel Kiszling thinks that, in return for the loan of the 14th German Army for the Isonzo offensive, German G.H.Q. might well have asked for Austrian help, which could hardly have been refused, and that as many as even ten divisions might have been sent. The neglect to ask for this assistance, and a wrong distribution of their strength, in that the 2nd Army, opposite Amiens, was not reinforced to the same extent as the 18th and 17th Armies, were the main causes contributing to the Germans' failure.

The principles deduced from these seven examples are:—(1) Tactics must govern, *i.e.*, a place must be chosen where a tactical break-through is possible. (2) The place of tactical break-through must be so situated that from it a maximum of strategic effect can be obtained, and (3) army reserves must be immediately available for exploitation of success.

The Development of the Austro-Hungarian Forces in the First Two Years of War. Major Franck continues to give us the results of his statistical researches. This instalment deals with the methods of provision of man-power (reinforcements and new units) for the various arms: also with the production of artillery material in detail. In rather less than two years, 3,275 guns of sorts were manufactured, from 3" mountain-guns up to 16·5" howitzers, nearly one-half of which were the 1914 pattern 4" field howitzers.

The Uncertainty of Success in the Fight. Lieut.-Colonel Rendulic quotes two authorities, Clausewitz and Wellington, as to the existence of this element in war, and then, setting aside chance "invisible and everywhere at work," he investigates its remaining causes. He has little difficulty in tracing these to insufficient knowledge of the enemy, his strength, situation and intentions, the possibilities of surprise, the difficulties of gauging the effects, moral as well as material, of our own fire, and the morale of both sides. It is safe, therefore, to say that the causes of the uncertainty of success in the fight will never be removed. They can, however, be diminished by superior leadership, a high degree of training, increased morale, numerical and weapon superiority.

Scientific Aids to Military Education. In this article Major Franck deals first with ordinary civil broadcasting. He advocates the introduction of a "Soldiers' Hour," not necessarily for the instruction or entertainment of soldiers, but for the education of the general public in what it should know and understand of military matters, war economics, disarmament problems, etc. He admits that such an innovation would probably meet with a very mixed reception. Other items suggested for civil broadcasting are popular accounts of manœuvres, expert comment on current warlike events, and occasionally simple narratives of war experiences. So much for existing civil stations. The author further advocates the introduction of military broadcasting stations using service equipment, the only extra cost being that of extra power. This broadcasting would be for the army only, and purely educational, consisting of various kinds of lectures, to officers, to other ranks, and to the different arms. All such lecturing would be done by lecturers having so much authority in their own subject as to be worth listening to in all commands.

Major Franck thinks it would be worth trying whether a war game could not be conducted by wireless. This would give good practice to the officers taking part,

as well as to wireless personnel. The couching of all messages, their enciphering and deciphering, would make a war game played in this manner more realistic.

Another suggestion (*vide R.E. Journal*, September, 1931, p. 559) is to utilize the "wandering" microphone of special broadcasts, such as those of sporting events, for the use of the umpire staff on manœuvres.

Finally, a good case is made out for the use of the dictaphone, especially for the training of staff officers. This instrument has long been used in the United States General Staff School, and has been used for military training in England. As an example of its use, an officer receives a question relating to a known scheme, or certain information, and after due time for consideration, is called upon, without having been allowed to put down any notes in writing, to dictate his answer, orders or appreciation to the dictaphone. The value of this instrument, recording faithfully every hesitation, alteration of what has been said, etc., is very great for training in clear thought and clear expression, and also as a means of selecting staff officers possessing desirable qualifications. The not quite "innocent merriment" it often provokes has good educational value.

(*March*, 1933.)—*Count Schlieffen and Austro-Hungary's War Plans.* Lieut.-General von Cochenhausen, having given in the last number some account of von Schlieffen and his works in general, Colonel Kiszling now treats of him with special reference to his effect upon Austro-Hungary's plans in case of a war with Russia, and upon what actually happened in Galicia and Volhynia in August and September, 1914.

The general tenor of the articles, which have appeared lately in Germany about Count Schlieffen, is that the 1914 campaign against France would have ended victoriously for Germany if Schlieffen's plan had only been strictly followed. Whoever is inculpated by this view, the Reichstag or the C.G.S., there is nothing for which to reproach Count Schlieffen. A similar conclusion as regards the Austrian early disasters can hardly fail to be arrived at by reading this article, for the writer makes abundantly clear (1) that Count Schleiffen did not anticipate an Austro-Hungarian advance in force against the Russians, such as took place, *i.e.*, in a northerly direction between the Vistula and the Bug, except in conjunction with a German advance in a south-easterly direction behind Warsaw; in fact the "tongs" effect; (2) that such German advance could not take place until France had been put out of the war; (3) that, before the Austro-Hungarian advance northwards, five to six corps would move north-east to protect its exposed right flank.

This last condition was not fulfilled by the impetuous Conrad because the 2nd Army, an integral part of his scheme, had not yet arrived from the Serbian front; while the condition of co-operation with a German advance was put back as a possibility for six months by the result of the battle of the Marne.

The Baptism of Fire. Major Hesse collects examples from war literature, which show how impossible it is to generalize upon such a subject as what a man feels when first under fire. Some of the pictures he gives, of nerves, false and exaggerated reports, blind firing, coming into action against imaginary foes, do not strictly belong, as they are generally pre-baptism phenomena. They can be paralleled in most armies and in most wars, and are, in fact, easily beaten in the accounts by Major-General Meckel of German panics in 1870–71, quoted in Colonel Maude's *War and the World's Life.*

Motorization and Mechanization. Lieut.-Colonel Regele deals with this subject, in an article rising to pamphlet dimensions, under the following heads:—

Historical: the steam sapper, used in every war from the Crimean to the South African; motor transport, introduced only on a modest scale before August, 1914, makes great progress during the Great War, at the end of which France, Great Britain and the U.S.A. possessed 200,000 motor vehicles in the field; since 1918,

M.T. makes enormous progress in economic life, France alone being now able to turn out over 200,000 automobiles per annum.

Motorization, or the transporting by automobile of troops who then fight on foot; has embraced in turn staffs and signals, then supplies, ambulances, artillery, m.g. detachments, bridging columns, searchlight and cable detachments, and the infantry (first in buses and lorries, then on motor-cycles); Gallieni's division's strategic move to the Ourcq during the battle of the Marne.

Mechanization, or the transporting by armoured automobile of troops who fight without leaving the vehicle; primary object is to overcome position warfare; armoured trains, armoured cars and the tank, the tank's limitations; completely mechanized and motorized forces; whether they are going to replace armies as normally constituted or supplement them; whether by their employment wars must become shorter.

The country of mechanization, Great Britain: the Fuller School; the views of Captain Liddell Hart, Major-General Rowan-Robinson, Lieut.-Colonel Martel, Major B. C. Dening; against them V. W. Germains, Lieut.-Colonel Baird Smith, Major Brownlow; Lord Rawlinson's message in August, 1918, to the Minister for War; the Fuller School and opinions abroad, for, General von Seeckt (Germany), against, General Debeney (France); the question of small professional armies; what Alexander, Napoleon and Radetzky were able to do against odds; the small mechanized army requires a large army of workmen to keep it in the field; the history of mechanization in the British Army; the six-wheeler in all modern armies.

France: the reigning Camon School; for simple motorization, with mechanization as supplementary; the effort to be independent of imported petrol; the Carbone Carburant Congress in Milan; motor-cycle squadrons for reconnaissance, composition of the transformed cavalry division (one-third horsed, two-thirds motor transport).

Italy: attitude influenced by mountain frontiers; the *corpo celere* consisting of cavalry, cyclists and mechanized troops.

U.S.A.: in 1932 the General Staff decided against independent mechanized forces; mechanized troops are considered indispensable, but auxiliary.

The author, summing up, finds that in modern armies generally, there is much the same picture as regards motorization and mechanization. Nearly everywhere the artillery has been motorized, and transport almost completely so. Generally the idea of independent mechanized forces has been given up, while mechanized troops have obtained a firm holding as auxiliaries. He concludes that doubtless the future belongs widely to the motor, since the progress of technics will in time completely remove the remaining drawbacks to its military use. Nevertheless, the idea of armoured land and air fleets as the exclusive form of future armies is unjustified, since the war of the future will bear the stamp of the levy *en masse* of every kind, and there are various reasons why, within such levies, the motor can only occupy a definite sphere, even though it is certainly a very large one and may often be decisive.

Ensuring the Supply of Motor Spirit for Air Fleets. Under this title, Major Reigel examines the petrol supply of the great powers in turn, after having shown that the maintenance of an adequate supply is a life and death question for all those having either none or no considerable amount of natural oil to be found either in the mother country or in its possessions. Those falling into this category are Great Britain, France, Italy and Japan; and the author deals shortly with the individual efforts of all these powers to obtain what they cannot do without for sea and air fleets, and for transport, military and civil.

The position of the United States is unique, not only as possessing vast oil-fields in California, Texas and Oklahoma, but also as having acquired complete control of the oil-fields of Mexico, and interests in those of Russia, Venezuela, Persia and Rumania. This account leads naturally to a mention of the continual struggle between the largest oil concerns of the world, the Standard Oil Company of America and the Shell Group, which includes the Anglo-Persian Oil Company.

As regards Germany, under the pressure of the blockade oil of many kinds was produced from coal in great quantities, and by more processes than one, but entirely uneconomically and with vast amounts of unmarketable by-products. Germany's present position is that the Bergins hydrogenization process of obtaining petrol, and mixtures to do the work of petrol, from shale-coal, brown coal, in fact all kinds of coal except anthracite, is now being worked on a large scale, and will, when a cheap process of obtaining hydrogen is produced, herald another coal age, restoring coal to the position from which oil has driven it.

A process of obtaining hydrogen cheaply is said to have been already discovered, which will make the synthetic petrol derived from coal only half the price of that obtained from earth oil.

Major Reigel foresees a golden age for Germany, with its coal measures estimated to be sufficient for a thousand years, when it will not only be independent of other countries in the matter of oil fuel, but will also become a world-wide oil-exporter. To the condition of cheap hydrogen he prudently adds another and greater condition—if the all-powerful international oil concerns, who can be relied upon to put up a great fight, can first be defeated.

The New 37/70 Skoda Infantry Gun BA, by Major Dänicker, Swiss Army. Following on their type of infantry gun with two barrels of different calibre, one above the other, the Skoda works went over to the single-barrel type with their 32/70-mm. infantry gun, 1926 pattern. In this type the calibre is convertible by the insertion or removal of a liner. Their new 37/70-mm. gun is in many ways an improvement on its predecessor, in lightness, mobility, adaptability to transport (two-men draught, horse draught with limber, five-men pack or two-mule pack) and especially in its penetration (29 mm. of armour at 500 metres against the 22 mm. of the last model). If, in its way, the gun is one of the best yet produced, it still cannot deal with heavy tanks like the 47/75 Dutch H.I.H.S. Siderius, or the Bofors (*vide R.E. Journal*, September, 1932, p. 570), or the 47/75 Schneider E.L. (*ibid*, March, 1932, p. 192), which for that are all more than twice as heavy.

F.A.I.

REVUE MILITAIRE FRANÇAISE.

(*January*, 1933.)—Général Loizeau has a most interesting instalment of *La manœuvre d'aile*, describing how every commander in the Great War tried to outflank his enemy and how few succeeded. Although the tendency in 1914 was for defence to be stronger than offence, all commanders realized that an efficient outflanking movement would always have a greater success than a frontal attack. General Loizeau gives a long description of Schlieffen's plan and Moltke's execution of it and he clearly sees how Moltke failed to carry out what was a very fine plan. Schlieffen's idea from beginning to end was weight in the right wing; Moltke also thought of an offensive in Lorraine and the protection of Prussia. Napoleon said that only full effort can be given to one part of the operation; Moltke tried to deal with two or three parts and failed accordingly. The writer then deals with Joffre's efforts to outflank the enemy. Here his strategic ideas were sound, but he failed either to produce the necessary speed or the necessary strength. Although the victory of the Marne was of great importance, it had not the decisive effect that was hoped for; actually, it is doubtful whether the French and ourselves could have achieved much more after the long retreat. General Loizeau then shows how each side failed to outflank the other on their race to the sea, and finally, how Foch outflanked the enemy time and again in 1918, though he naturally had to break through first. The instalment closes with a short description of the German outflanking movements on the east; here the slowness of the Russians made outflanking attacks all the easier.

Général Camon finishes *Le système de bataille du Prince de Condé* by describing the battles of Fribourg, Nordlingen and Lens. Napoleon, in writing of Condé, says that he deserved to win on account of his obstinacy, if for no other reason. Condé always led the main blow himself after a violent cavalry attack which surprised the enemy and usually drove back their cavalry. In the 17th century there is no doubt that Condé was ahead of most other commanders, both on account of his tactics and of his obstinacy; in fact, it seems that the latter characteristic is the most important of all. He was only just over twenty when he first found himself in command and he showed himself well fitted for it. Although the French casualties were considerable in all Condé's four battles, particularly at Fribourg which was fought in difficult country, the result was far greater than in a number of battles where the commanders failed to drive home their advantage. Where battles were seldom fought when compared with the length of the campaigns, Condé's determination was of the greatest value.

Capitaine X has *Un aspect du problème mandchou* in this number. This is a very clear description of what has occurred in Manchuria during the last forty years. The article is written, if anything, from the Japanese standpoint, but it does make clear how Japan could not fail to be attracted by Manchuria as a buffer state when she became powerful and saw China and Russia opposite her across the sea. Capitaine X points out how her well-trained army was bound to be successful against the Chinese and why she is now in Jehol, which has always been regarded as a part of Manchuria. While this fighting is still in progress, the state of Manchuko has been proclaimed but only recognized by Japan. The writer mentions the Lytton Commission, but his most interesting remark deserves a quotation, viz., "From the French aspect, we can only rejoice to see form itself, next to Soviet Siberia, a state honest, sensible and strong, which, raising a solid barrier against bolshevik enterprises, will protect our possessions in Indo-China menaced by the Muscovite poison."

Commandant Delbe finishes *Les bibliothèques d'officiers* by describing the great increase in officers' libraries after the Great War, and then by explaining how, in the colonies and at sea, these libraries have been developed at the same time. The article is more for the Frenchman than for the Englishman, but it is interesting to see how the French officer now has access to a big library, whether he is a sailor, a soldier or in the colonies, and has every opportunity to "teach himself." There is no doubt that good library books on every kind of war provide the necessary opportunity for officers who have little money to improve their general knowledge, and so become ready to be efficient commanders or staff officers later in their service.

The second instalment of *La guerre sainte des Senoussya*, by Général Meynier, deals mainly with the war between Italy and Turkey which was fought in Tripoli. Italy, having become a great European power, was beginning to look for colonies in Africa. She therefore continued to press Turkey concerning her nationals who lived in Tripoli and eventually declared war. The writer describes briefly the difficulties Italy found, and how long it was taking her to defeat the Turks, when fortunately the Balkan War broke out. Italy then began to overrun the country but found that the Senussi were now her chief enemies. By this time she had soldiers in the country, who realized the difficulties in a semi-desert state of this sort, and by 1914 she was more or less master of Tripolitania and Cyrenaïca. At the same time the Mussulman inhabitants had risen against the French in Tunis but were crushed. Eventually the outbreak of the Great War found General Meynier, with a French force, in what turned out to be part of Italy's conquest. This incident was regularized without much difficulty, but it showed that a closer system of frontier liaison was required in future.

(*February*, 1933.)—Général Loizeau concludes *La manœuvre d'aile* by considering the action of the present-day army in driving in the flank of the enemy, based on the French 6th Army, of August and September, 1914. The writer points out that

where there is space, as there was in 1914, and will be at the beginning of nearly every war, it is easier to attack the enemy's flank than his centre if the troops and staff are well trained. In 1914, when Joffre formed the French 6th Army, what it required was a general direction of attack *outside* the existing sphere of operations, speed in arriving on the enemy's flank and consequent surprise, protection, means of reconnaissance, and finally, thoroughly efficient troops and staff to carry the manœuvre through. A flank attack is far quicker than a frontal attack, therefore training is essential for the troops involved; on the other hand, the success of a flank attack is usually far greater than that of a frontal attack. There is little doubt that modern conditions do not make flank attacks less frequent; in fact, the introduction of mechanization will probably cause them to become more and more often undertaken.

For those who are interested in statistics, Lieut.-Colonel Larcher's *Données statistiques concernant la guerre* 1914–18 are of value. The first instalment gives the figures by divisions for the German, Austrian and Allied armies and shows how the assumption of the German Command by Hindenburg and Ludendorff caused the partition between east and west to be more obvious than ever according to the front on which the main offensive was taking place. The difficulty in making up one's mind purely by this type of statistics lies in the enormous variation of the different countries. It does not mean that the presence of fifty German opposite fifty Russian divisions causes a likelihood of a drawn battle; the Germans were so superior in equipment, if nothing else, that they were almost bound to win. Although statistics, therefore, are of value they must not be considered as of too great importance compared with other factors in war.

Colonel Blaison begins *Un passage de vive force du Rhin Français en* 1848 in this number. When the French revolution of 1848 began, it had a great effect in Germany, which then consisted of over thirty kings, princes or dukes, ranging from Prussia down to small states like Baden. Each of these provided their portion of the German Army and each was disturbed by the revolution over the Rhine. Special parliaments were held, partly in imitation of the French, and the French tricolour was also produced in parts of Germany. This instalment describes what the situation was in 1848, how the Germans followed the French and how in Baden, across the Rhine which was here the frontier, those intending to revolt in Germany paid particular attention to the French.

L'armée allemande et la révolution russe, by X . . . , describes the action of the 77th reserve German division, situated on the Dwina, in 1917. This division had been on this part of the front for two years and apparently was in very close touch with the crumbling away of the Russian Army during the revolution. To the Englishman the German proclamations are interesting; they are entirely directed at pointing out to the Russians how England had betrayed them, how the revolution is on account of England's betrayal, and so on. There is no word of any other ally: it is always England. What is also of interest is the entire lack of raids by the Germans combined with a complete knowledge of the Russian movements, often before they occurred. It looks as if the Germans had built up such a secret service system within the Russian lines that the crude method of raiding, to find the enemy's dispositions, was quite unnecessary. The article ends with a description of the Russian attack early in the revolution, its failure, and the German proclamation that for every round fired by the Russians in future, Germany would fire three!

The third instalment of *La guerre sainte des Senoussya*, by Général Meynier, describes briefly the rise of Great Britain's power in Egypt and how Napoleon, over a hundred years ago, marked the Suez area, although no canal was then built, as the weak spot of the British Empire. The writer goes on to explain how the canal was built under a Frenchman, with mainly Frenchmen under him, and how Great Britain was successful, however, in obtaining control of the canal. The instalment finishes

by describing the conquest of the Sudan by Kitchener and the agreement between England and France as to the boundary between the two Empires.

(*March*, 1933.)—Lieut.-Colonel Larcher continues *Données statistiques concernant la guerre* 1914–18 in this number. Three main tables are dealt with, the strength of the forces on each side at the end of the war, the German losses and the Austro-Hungarian losses. The first table must be taken with a grain of salt, as a large proportion is not really of much use, particularly in countries like Turkey. The most interesting part of the instalment lies in the comparison of losses in Germany and Austria. The general proportion is much the same according to the population of the two empires, but it is remarkable how far greater were the Austro-Hungarian losses in killed, missing and deserters. In fact, what this empire lost on the Russian front is so large that it seems probable that it would have broken up completely a year earlier if only Russia had not given way first under German pressure. Although statistics are not usually interesting, it is undoubtedly of value to see how much a country can stand in losses from these tables and when she is finally forced to give way.

Colonel Blaison continues *Un passage de vive force du Rhin français en* 1848 with a description of the women's clubs which appeared after the French revolution started, and the formation of the German legion in Paris. The friendship between the French revolutionaries and the Germans, who wished to work in the same way, provides a striking contrast to Franco-German relations after the wars of 1870–71 and 1914–18. A German legion was successfully formed in Paris and greatly acclaimed by the French before it set off for Strasbourg. At the same time the Poles in France were hoping to liberate their country, and there was a great deal of talk of Germans and Poles combining. The instalment ends with a description of how the Polish efforts died very soon, before the German frontier was ever reached. The article is of historical interest, but when the changes in Europe after the war of 1914–18 are considered, the immediate effect of 1848 in Germany and Poland seems feeble in comparison.

Capitaine Mousset begins *De la bataille de la Marne à la course à la Mer*. His reasons for selecting this part of the war are that less is known about it than the actual fighting on the Marne and also that there are books, both French and German, describing what occurred during the race to the sea. It was Falkenhayn's first effort as Chief of the German General Staff, and this instalment describes how Bülow and Klück again failed to agree, followed by the German orders to their 6th Army to achieve a success on the northern flank. The first stages of the move northward consisted of attacks by the German 1st and 2nd Armies south of Laon, but as the commanders failed to work in unison, these attacks were unsuccessful. At the same time certain French troops began to appear farther north and at a conference at German G.H.Q., Falkenhayn finally gave instructions to the German 6th Army to advance in the direction of Amiens with two objectives. One, a subsidiary objective, was to protect the German right flank, the other, the main objective, to drive in the left flank of the French. Thus began the race northwards which only ended at the sea.

Chef de bataillon Morel has an interesting article entitled *Constantes de l'Histoire de l'Afrique du Nord*, in which he describes the stages of French Northern Africa throughout history. The present French domination of a half or one century may seem long to the present-day observer, but it is little to one who reviews history as a whole. The first ruler to our knowledge was Carthage, from about 1000 B.C., and it was several hundred years before she fell out with Rome and the Punic Wars took place. Rome then ruled Northern Africa for about six hundred years, till the Roman Empire crumbled. She was then followed by the Vandals and Byzantium, each for a comparatively short century, before the appearance of Islam. After centuries of fighting between the incoming Mohammedans and the Berbers, Northern

Africa became stabilized again about 1500, and it was not till after 1800 that the French began to stake their claims across the Mediterranean. As the writer says, it is up to the Frenchman of to-day to see that this part of Africa remains French and does not go to any other European nation.

Général Meynier completes *La guerre sainte des Senoussya* in this number, by describing the German efforts to gain control in Northern and Central Africa before and during the Great War. The German Emperor posed as the protector of Islam, and there was more than one incident where Germany failed to get a proper footing on the southern shores of the Mediterranean. She then took to more concealed methods, and France and England did not realize how her representatives were all through Egypt, Tunis, Morocco, etc. When the Great War broke out she made every effort to help the Senussi against the Allies, using her submarines to provide warlike equipment and liaison officers. There is no doubt now that Germany's idea was to bring most of Africa into the German Empire and all her efforts were directed towards this idea. Unfortunately, the war went the wrong way for her and she lost all her possessions in Africa instead of increasing them.

H.A.J.P.

CORRESPONDENCE.

HISTORY OF THE R.E. YACHT CLUB.

To the Editor, *R.E. Journal.*

DEAR SIR,

The letter from "Emeritus" in your March issue is not strictly accurate as regards the 1909 R.E. eight.

Regarding the boat being a "heavy seagoing craft," the facts are that, during the winter of 1908-09 the boat had been stored in one of the old submarine mining sheds at Gillingham. On opening the shed in the spring of 1909 for the purpose of rowing the boat round to the raft, one of the heavy steel doors fell off its rollers and knocked off some five or six feet of the bow of the boat. A new bow was built and fitted by the R.E. boatman (whose name I cannot recollect), but it was slightly "cocked up" and, when in the water, the boat caused a very heavy wash. This was not so noticeable in the Medway, but was very apparent at Henley.

At Henley in 1909, the R.E. entered for the Wyfold, as well as the Thames Cup. The first heat of the latter, against the Thames Club, was rowed about 11 o'clock. Four of the eight then had to row their Wyfold heat about 3 o'clock, while the eight again took the water about 6.30 against B.N.C.

Before going to Henley, the eight had received a lot of assistance from the Vicar of one of the Rochester churches, whose name, also, I

regret, escapes me, but who should certainly receive a " mention " when referring to R.E. rowing that year.

Mention of the 1909 R.E. eight has produced a crop of happy memories :—

(*a*) The coach at Chatham, " faint yet pursuing " the eight in the only, but very slow, motor-boat that could be obtained.

(*b*) Sankey's training diet of beer and port and the taste of the latter obtained from the pub. in the village some six miles out of Henley, where the crew lived. The bright inspiration and the rescue by Gibbon, who obtained some of the Leander Club's port for the last two evenings. The broadcasting by Gibbon through his megaphone of the training diet of the R.E. crew.

(*c*) The " Casualty's " wire to Guy Nickalls on hearing the result of the first race and referring to the latter's forecast in one of the morning papers—" Who slopped who "—the latter's mystification that such a telegram should have been signed by what he understood was a Christian name.

(*d*) The great welcome given to an R.E. blazer at all the College and Club " barges " on the last night of the regatta.

(*e*) Finally, on an entirely different matter, John O'Hara Moore's eyeglass when playing Rugger, removed only when he " scrummed down."

I am afraid my *alias* is not likely to be as impenetrable as that of " Emeritus."

Yours faithfully,
" THE PART AFFECTED."

CONCRETE SLAB ROADS.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

In his extremely interesting article on this subject, in the March issue of *The R.E. Journal*, Captain Bennett hardly makes good all his claims for the advantages of concrete slab roads over those formed from planks.

As regards his (*a*), timber roads certainly do require an enormous amount of material, but so do all roads which depend for their surface

on materials other than those adapted from the ground itself. Aggregate suitable for reinforced concrete is not always to be found, or easily obtained in the field, as witness Mesopotamia and parts of East Africa.

Concrete slabs have to be carried forward from their factory, somewhere in rear, to road site, and are heavier to transport than 3″ or 4″ planks, therefore requiring more lorries.

(*b*) As regards speed of laying, the advantage claimed for the slab road is arguable, particularly when we remember that the Australian Engineers laid two miles of plank road in 1918, during the progress of an attack, so that their armoured cars could operate in the enemy's rear. The speed of laying the slab road must surely depend on the number of derrick-lorries available, and their ability to move over the ground concerned, which in the case quoted they certainly could not have done.

In railway practice, it is generally conceded that 75 lb. is the greatest weight a man can carry over rough ground, whether the weight is in the form of rails—when special slings or tongs are used—or single sleepers. Slings can, of course, be devised for the concrete slabs, but this necessity constitutes a disadvantage as compared with planks.

The sole advantage of the slab road seems, then, to lie in the possibility of finding suitable aggregate nearby, if the " wheel-strip " form of one-way road is considered suitable. The plank road, on the other hand, gives a better distribution of weight on the earth's surface, while its components are far more easily handled, and can be thrown into and out of lorries without fear of breakage.

All forms of military road, however, except in heavily shelled areas, seem to be inferior to " mix-in-place " roads, for which less than a hundred tons of imported material (emulsified bitumen or oil) is required per mile of 20-ft. roadway.

If, for any reason, the " wheel-strip " type of road is deemed to be adequate, a very simple and easily moved form is provided by steel channels or rolled steel joists laid flat. They can be laid over and over again, are unbreakable, lighter per foot run than concrete slabs, can be used as small culverts, and in addition provide a double-wheel guide. Holes drilled in the flanges, to take drag-ropes or slings, largely solve the handling problem. This form of road is sometimes used by municipalities to allow lorries to move about on rubbish tips. It might prove useful in war for bringing up heavy guns whose weight would possibly break up a " mix-in-place " surface.

Yours faithfully,

E. St. G. Kirke, *Colonel.*

A REPLY.

I am extremely pleased to see Colonel Kirke's letter to the *Journal*, as it shows that my short article has, in one case at least, succeeded in one of the objects which I stated was "to invite attention to this problem in the hope that readers may give this matter their thought."

I do not suggest that the concrete slab road is the solution to all our temporary road problems, and entirely agree that an adequate supply of suitable aggregate within convenient distance is an essential consideration. But one may also say that for wooden slab roads an adequate supply of timber is also essential and each type must be considered on its merits.

As regards speed of laying, figures are not yet available for long lengths of concrete slab roads, but when one considers not only the "hours" but also the "man" factors in the "man-hours per (say) hundred yards," I think there is no doubt but that the concrete slab road will show an overwhelming advantage.

I have heard, since the March *Journal* appeared, that there exists with some readers a doubt as to the meaning of the expression "a water ratio of 7%" which I used at the foot of page 134. This, I fear, shows that some people still fail to realize that water is just as important an ingredient of good concrete as either cement or either of the aggregates. There, however, is nothing mysterious about the expression—it simply means the ratio of weight of water to the combined weights of cement and aggregates, expressed as a percentage. It may be added that a 7% ratio is a very good general rule for normal concrete work.

Yours faithfully,
J. H. D. BENNETT, *Capt., R.E.*

"ROAD PROBLEM OF A FORCE OPERATING IN UNDEVELOPED COUNTRY."

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

In his essay on the "Road Problem of a Force Operating in Undeveloped Country," Captain C. M. Singer, R.E., rightly stresses the importance of further research and experiment with oil and bitumen-bound roads. Much work on these lines is in progress in all parts of the world, and it will be of interest to your readers to know that in recent work in India, using local soil and bitumen emulsion, six men, by hand-mixing, produced an output sufficient to complete 30 lineal yards of 10′ road at 3″ consolidated in 8 hours. This work was carried out in hot weather, and it is enlightening to

learn that the material after 4 hours was rolled with a 2½-ton roller, and that after 24 hours final consolidation was carried out with a 10-ton roller. The above rate of progress is equivalent to that mentioned in Table A, under Type iv, without the help of a concrete mixer. Using a concrete mixer, 6 men in the same time will complete 64 lineal yards.

It would seem that Captain Singer has missed a definite feature in his conclusions on Forward Roads, in that Type iv, in Table A, is capable of forming an excellent base for utilization later in constructing Main Lorry Roads. Types iii and v are of rather less assistance, while Types i, ii, vi are completely useless in this respect.

An expedient that might be of use in connection with Main Lorry Roads is the introduction of some gravel or " murrum " into black cotton soil to enable this to be treated by mix-in-place methods to give satisfactory results. By this method, the amount of aggregate which would require to be transported would be far less than that necessary for the construction of a concrete road.

27. 3. 33. Yours faithfully, E. G. WACE.

A REPLY.

General Wace's criticisms and suggestions are most interesting. It is useful to know that bitumen-bound earth roads can be successfully mixed by hand without the use of a concrete mixer, at such a satisfactory pace. This would, of course, enormously increase the value of this type of construction for forward road work, provided that consolidation by roller can be dispensed with. Does General Wace consider that a 3″ thickness of bitumen-bound soil will consolidate rapidly and properly under the pneumatic-tyred traffic to be expected on a forward road, or under a 2½-ton roller only? This seems to be essential for a road in the forward area, where rollers will not usually be available, and where the weakness of the decking on standard bridges of the small box-girder type may seriously interfere with the travelling of rollers to the site.

I agree that any stretches of bitumen-bound earth road laid in the forward area will eventually be of use for incorporation in a Main Lorry Road. This is an additional argument in favour of the replacement of expedients such as wire-weaving by bitumen-bound earth, recommended in my conclusions on Forward Roads (p. 46).

The introduction of gravel into black cotton soil should be tried out early in a campaign, if the results of such an experiment are not already known. Anything that will reduce the weight of aggregate to be transported would be of value.

1st April, 1933. C. M. SINGER.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

With reference to Capt. Singer's article, "The Road Problem of a Force Operating in Undeveloped Country," which appeared in the March, 1933, number of *The R.E. Journal*, I should like to draw attention to two sets of data given in the article which, in the light of information available since Capt. Singer compiled his article, require considerable amendment.

The first occurs in para. (vi), page 45, in which, in discussing the use of wire netting as an expedient for the hasty surfacing of a road, Capt. Singer states :—

> "An average rate of laying would be 50 yards in 30 minutes with a party of 15 men, the rolls of material having been prepared beforehand. In the case of wire netting or weaving, the weight to be transported is only some 5 lb. per foot run of 10-foot road."

Extended experiments with wire netting have been carried out in India, culminating in a full-scale trial on manœuvres in December, 1932. It has been established that, with mixed parties of R.E. and infantry, work starting at several places simultaneously and materials carried to site in tracked vehicles (*i.e.*, under best conditions), approx. 18 yards could be laid by 15 men in 30 minutes. For service conditions I consider 1,000 man-hours per mile to be a reasonable working figure.

The type of wire netting that has now been standardized weighs 6·8 lb. per foot run of roadway. Capt. Singer's figures were apparently based on earlier records, which were unduly optimistic.

The second point I wish to draw attention to is the reference in the article on page 49 to macadam roads. Sub-paras. (i) (*a*) and (*b*) read :—" (*a*) The enormous weight of stone required. Each ½-mile of a 20-foot road contains some 3,000 tons of stone. (*b*) Their slowness in construction. One roller with 32 men will take 27 days to complete a ½-mile, even in peace-time conditions."

The quantity of stone, 3,000 tons per ½-mile, is approximately correct for a first-class road.

In the circumstances under discussion no such standard would be attempted, and for purposes of comparison with wire roadways the quantity of stone works out to roughly 2,000 tons per mile.

As regards the number of days required by one roller upon ½-mile of road, further experience has more recently led to the introduction of revised figures and the number of days given by Capt. Singer should be doubled.

Yours faithfully,

G. H. ADDISON, *Major-General.*
Engineer-in-Chief.

A.H.Q., Simla,
4. 5. 33.

LADY GROVER'S HOSPITAL FUND FOR OFFICERS' FAMILIES.

THIS Fund, instituted in 1911, is intended to assist Regular Officers of the Royal Navy, Royal Marines, Army, Royal Air Force, Royal Indian Marine and Ecclesiastical Establishments, on the active or retired list, by assisting to defray the expense of residence in or attendance at any recognized Nursing Home or Hospital in Great Britain or Ireland, that may be incurred by their wives or children.

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SHIKAR NOTES.

(*By the late* COLONEL A. H. CUNNINGHAM.)

THIS book, written for private circulation, was completed by the late Colonel A. H. Cunningham just before his death. It is a most useful publication for officers who may be going to India and are interested in shooting. It is compiled with the accuracy for which the writer was noted, and is based on his own 30 years' experience in Indian jungles.

Copies can be had at Rs. 2 (or three shillings postage paid) from the Adjutant, K.G.O. Bengal Sappers and Miners, Roorkee, India.

The proceeds, at the writer's request, are to be credited to the "Elles Fund," a charitable fund of the above Corps.

THE MILITARY ENGINEER IN INDIA

VOLUME I

BY

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(Author of *In Kut and Captivity, Tales of Turkey*, etc.)

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more and more aggravated, and the droop of the curve is the signal to him to enquire into the cause and to insist on the remedy. For example, the brickmakers insist that their dispatches of bricks have been to time; the production of the labour density curve should be sufficient answer, since had bricks been available it is unlikely that the building contractor would not have built them in.

Again, in estimating the allowance to be made for bad weather, a glance at the curve shows the daily average for the weeks preceding and succeeding the bad spell, and a truer estimate is more easily obtained of the time lost.

Whilst, therefore, curves produced on these lines are of primary value to the officer supervising the work as it proceeds, it is also held that they form a useful index to the capabilities of the contractor.

Every deviation from the straight line of constant numbers employed requires investigation, and the explanations, whether they be on account of weather, stores, sub-contractors, labour troubles or transport difficulties all combine to make the curve bear a definite relationship to the particular contractor employed.

From the point of view of the War Department it is, therefore, urged that the methodical preparation of such curves for every job put out to contract would form a valuable record for the appraisal not only of the particular jobs but of the contracting firms employed.

In conclusion it is suggested that the analysis of representative jobs on the lines explained, might be used to advantage in the education of Military Foremen of Works, since such a clear idea is obtainable of the relative importance of the building trades employed, of their interdependence, and of the combined effect of labour, materials and transport on the expeditious completion of a major work.

MEMOIRS.

COLONEL LORD SYDENHAM OF COMBE, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., F.R.S.

THE following extracts are reproduced from the obituary notice of Lord Sydenham which appeared in *The Morning Post* of February 8th, 1933 :—

" Lord Sydenham, whose death took place on 7th February, 1933, was not only a great Pro-Consul but a master of Imperial strategy, and the country and the Empire owe much to his initiative and energetic labours.

" It was largely due to his suggestions that the War Office was reconstituted on modern lines after the South African War and a General Staff brought into being.

" As first Chief of the Secretariat of the Committee of Imperial Defence, he did excellent work in co-ordinating naval and military duties and securing recognition of general strategical principles. Subsequently, as Governor of Bombay, he showed a firmness and a strength which produced an excellent effect during difficult times in India.

" George Sydenham Clarke, first Lord Sydenham, was born in Lincolnshire on July 4th, 1848, being the eldest son of the late Rev. W. J. Clarke, vicar of Swinderby, Lincs. He was educated at Haileybury and Wimbledon School, before entering the R.M. Academy, Woolwich, into which and out of which he passed first. He joined the Royal Engineers in 1868, and from 1871 to 1880 was on the staff of the R.I.E. College, Cooper's Hill.

" Promoted Captain, he served in the Egyptian Expedition of 1882, receiving the medal and clasp. In 1885 he served in the Intelligence Department and as Assistant Political Officer under Sir G. Graham at Suakin, and was present at the actions of Hashin and Tofrek, and during the advance to Tamai, being mentioned in dispatches and receiving a clasp. He was then employed for several years in the War Office, and acted as Secretary of the Colonial Defence Committee from 1885 to 1892.

" His duties in connection with that committee brought him closely into touch with the problems of Imperial Defence, at a time when the question was almost for the first time being taken in hand seriously and comprehensively, and his grasp of the subject and the administrative capacity he displayed in dealing with it singled him out as an officer of exceptional capacity. During this time he was sent on a special mission in connection with fortification questions to a number of foreign countries.

" In 1893, on completing his period of service with the Colonial