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MAR 1926

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60TH ANNIVERSARY OF D-DAY

Outline Brief

General. The UK Government has announced that there will be a celebration of the D-Day landings on the beaches of Normandy in June 2004. Concessions for parties travelling on UK ferries are available for organized parties attending the events in France. In addition the Government have agreed to issue free UK passports (valid for one year) to Veterans wishing to travel.

Normandy Veterans Association. The main axis for the celebrations of the 60th Anniversary of the Normandy Landings will revolve around the Normandy Veterans Association. The NVA has Branches throughout the UK and each Branch is responsible for organizing coach trips and other events. Those interested in travelling to Normandy should in the first instance contact their nearest NVA branch and contact details are available form all Royal British Legion Branches. The General Secretary can be contacted on 01472 600867.

The Royal British Legion – Remembrance Travel. For those wishing to travel independently to the International celebrations in France there are package tours available from TRBL that includes battlefields on the French coast (and others in Italy and elsewhere in the world). (TRBL Remembrance Travel Tel No 01622 716729)

Portsmouth. The centre for the UK side of the celebrations will take place at Portsmouth over the weekend 4-6 June. This will include church services, Beating Retreat and a flotilla of small boats celebrating through the harbour and some travelling to Normandy. The contact for the Portsmouth celebrations is Tel No: 023 9259 5367

Chatham. It is proposed (subject to support) to hold a day at Chatham for Royal Engineers Normandy Veterans to celebrate the D-Day Landings. The outline programme will be based on the RE Museum and will include:- an arrival time at Brompton Barracks Chatham of 1000hrs for coffee, a commemorative service in the Chatham Garrison Church at 1100hrs, an informal lunch at 1230hrs, possibly a lecture by a Normandy Veteran at 1400hrs, Beating Retreat (weather permitting) with the RE Corps Band at 1600hrs and then disperse. All timings and events are provisional and will depend on numbers attending. It should be noted that there will be no accommodation available in the barracks and all those attending requiring overnight accommodation should do so through private arrangements in local hotels. It is fully understood that family or carers may have to attend to assist Veterans. Could you please indicate to Regimental Headquarters by the end of February if you would be interested in this event and how many may attend? Contact: details are:01634 822035 or email inst.clerks@inst-royal-engrs.co.uk

THE INSTITUTION OF ROYAL ENGINEERS.

All communications for the Institution should be addressed to:—
The Secretary, The Institution of Royal Engineers, Chatham.

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Secretary: Col. F. E. G. Skey, 1st July, 1919.

2150—1-3-26.

THE CONSTRUCTION OF THE TAL (TOCHI) BRIDGE.

COMPILED FROM THE REPORTS OF OFFICERS WHO TOOK PART IN THE WORK.

1. HISTORY.

A PREVIOUS article* describing the Isha-Razmak Road made mention of the fact that the bridging of the River Tochi was to be considered further when the road had been completed and Razmak occupied. The bridge, in fact, was allowed for in the original grant of 65 lacs of rupees, made for the road, but no work was done on the bridge until it was certain that the funds available were sufficient to complete the road, and until the real necessity for the bridge became clear. By January 1923, there were no doubts on the score of necessity, and funds remained.

Like other Indian frontier rivers which depend for their main flow on melted snow, the Tochi comes down in practically continuous spate from mid-March to mid-April annually. The volume of snow water coming down daily varies with the hours of sunshine, and is never, as a general rule, as heavy as the short, sharp, but very violent spates of a few hours' duration experienced in July and August.

The 700-ft. causeway, which had so far carried traffic over the Tochi River bed, had not failed under either spring or summer spate, but on a width as great as this it was impassable for a week at a time for lorries in the spring, whilst, in either spate season, heavy shoals of silt were deposited on it when the spates subsided.

The causeway, then, had fulfilled its purpose within its limitations whilst the policy regarding Razmak was still plastic, but with the decision to occupy Razmak permanently, and with visions of a new Quetta, a permanent high-level bridge became necessary to ensure that the line of communication should be open continuously.

2. SELECTION OF THE SITE.

At intervals along the length of the Tochi River there are bottle-necks formed by the rock outcropping and damming up the water and silt upstream.

*The Isha-Razmak Road—*R.E. Journal*, September, 1925.

At Boya, and along the Kajuri-Saidgi length, such bottle necks have formed, upstream of themselves, the comparatively fertile "*kach*"* land plains of Mahomed Khel and Kajuri respectively.

In all previous proposed or completed bridging operations over the river it has been possible to find the bridge site at a bottle-neck. In the present instance, however, there was no bottle-neck suitable within five miles east or west, and consequently the selection of the bridge site became a matter of making the best of a broad winding river bed, with stretches of alluvial ground at the inside of every curve. Three sites were found to be worthy of consideration, and they are shown as A, B, and C on the accompanying site plan.

Site A offered an outcrop of rock in mid-stream, and the chance of getting the pier foundations on rock to the south of the outcrop, but it also entailed crossing the Tal Algad. Site C gave a blind north bank approach on to the bridge. Finally, Site B, which had been noted when the road alignment was decided, was selected.

This site had several advantages whilst being far from ideal. The north abutment was on solid rock. The set of the stream appeared to be constantly against the rocky north bank. The approaches were easier and cheaper than elsewhere. A stone quarry was close at hand; and, finally, Tal Fort, already built and occupied, overlooked the site.

The large area of low lying *kach* land which so considerably reduces the river bed width at site B was originally considered so liable to erosion, that it was intended to bridge this up to the old river bank, which is some 15 or 20 feet above bed level. However, fear of erosion was considerably lessened as a result of the construction, in early 1923, of a bell *bund*, which silted up a large area and formed shoals upstream which diverted the water to the north bank and consolidated the *kach* land. The next proposal was to bridge some 100-ft. only of the *kach* land, and to make a training groyne south of, and reinforcing, the bell *bund*. Finally, however, the local opinion was accepted that the bell *bund*, together with the additional protection afforded by the old road embankment from the causeway, would be sufficient to protect a south abutment sited on the river edge of the *kach* land.

This left a gap of some 800-ft. to be bridged.

3. DESIGN.

Since 1915 the railway companies in India have been strengthening all their bridges to meet the demands of heavier locomotives and rolling stock. In consequence, a large number of steel girders of the old, and lighter, design, have become surplus, and the North

* KACH—Cultivated alluvial soil.

Western Railway has been disposing of them, suitably remodelled, for use on frontier roads. The Bridge Engineer of the N.W. Railway supplied six 110-ft. deck spans for this bridge at a price of £5 per ton at Jhelum. He also very kindly agreed to undertake their erection unofficially, which greatly simplified matters. The erecting gang was taken on to the pay sheets of the work, and all stores and plant were charged direct to the work, plant being bought back by the railway company on completion at the price paid less depreciation.

The piers and abutments had to be designed for erection largely by unskilled labour.

The shape of the piers, which is shown in the plate, is that found best for shingle nullahs, and is the result of considerable investigation in the Kohat district. It is found that so shaped, the piers induce a silt deposit at each end. They were also made thicker than usual, to withstand the ever-changing direction of flow of the streams which make up the river, and, since it might not always be possible during their erection to have continuous officer supervision, it was thought that the extra sturdiness of design would conteract the streaks of poor work which creep in.

Each pier was on a foundation of P.C.concrete, 1 : 2 : 4 reinforced with rails; above this, and up to the calculated scour level, a ring of stone in cement mortar enclosed mass concrete of the proportions 1 : 3 : 6, with 30 per cent. "plums." Continuing up to highest flood level was hammer-dressed stone in cement mortar. Economy called for H.D. stone in lime above this level up to the holding-down bolts, above which all work was in cement mortar.

The only certain method of determining the depth of scour in any river bed is to dig down to it. For estimating purposes it is useful to arrive at a basic figure from calculation. The figures given below are from memory, but they are sufficiently accurate to illustrate the method. Three cross sections of the river bed were surveyed and plotted, one on the bridge line and the others respectively a mile up and one mile down stream of the bridge line. By noting the highest flood level at each section the wetted area for each was computed. From a longitudinal section of the two miles of river bed in question, the slope of the river bed was determined.

These surveys gave :—

The mean of the three wetted areas (A), which differed less than 15 per cent. from the centre area	=2800 sq. ft.
The mean hydraulic depth (r)	= 4 ft.
The slope of the river (s)	= 0.02

The velocity of the stream is given by Manning's formula—

$$V=\frac{1.486}{n}\times r\times s^{\frac{1}{2}}$$

(where n varies from 0.02 to 0.05.)

$$V=\frac{1.486}{.035}\times 4\times .02^{\frac{1}{2}}=15.3 \text{ ft. secs.}$$

The discharge of the stream is given by

$$Q=A\times V=42,400 \text{ cu. secs.}$$

Adding 33 per cent. 14,100

Whence Q^1 $=56,500$ cu. secs.

Trying a new value of r to suit Q^1—say $r=4.8$ft.—we have :—

$$V^1=\frac{1.486}{.035}\times 4.8\times .02^{\frac{1}{2}}=17.2 \text{ ft. secs.}$$

A^1 (which is obtained from the cross section)$=3,320$ sq. ft.

So that $Q^1=A^1V^1=3,320\times 17.2$
$=57,000$ cu. secs.

which is sufficiently near to the value of Q^1 found before.

The afflux h is given by :—

$$h=\left\{\frac{(V^1)^2}{58.6}+.05\right\}\left\{\left(\frac{A^1}{a}\right)^2-1\right\}$$

For a allow a 10 per cent. reduction of area on account of the piers. Then $a=.9A$.

$$h=\left\{\frac{17.2^2}{58.6}+.05\right\}\left\{\left(\frac{10}{9}\right)^2-1\right\}=1.18 \text{ ft.}$$

The average depth at the bridge before scour is therefore—

$$d=4.8+1.18=6 \text{ ft.}$$

This figure agreed with the highest flood level found by observation.

The velocity under the bridge is given by:—

$$V_2=1.1\times\frac{A^1}{a}\times V^1$$

$$=1.1\times\frac{10}{9}\times 17.2=21 \text{ ft. secs.}$$

The depth of scour (d^1) is found firstly from Kennedy's formula—

$$V_3=.84\,kd^{.64},$$

which gives V_3, the critical velocity just not sufficient to cause further scour; secondly, by assuming that the discharge after scour is the same as before it, namely that :—

$$dV^2=d^1V_3$$

k varies from 2 to 3. For coarse gravel and boulders, as in this case, say 2.5.

Then

$$d^1 = \frac{dV_2}{V_3} = \frac{6 \times 21}{2.1 \times 6^{.64}} = 19\text{-ft.}$$

The depth of scour is therefore 19-6=13 ft. below bed level.

As a result of excavation the greatest scour depth was found to be 11½-ft. Previous experience on Frontier streams has shown that it is safest to double this figure for the depth of the foundations, since these bridges are subjected to conditions for which the formulae make no allowance whatsoever.

The estimate, which was completed by the end of February 1923, totalled 7.98 lacs of rupees, or £53,210 nominal.

4. PRELIMINARY WORK.

A somewhat premature start on the actual construction was ordered in mid-April, 1923. Although on the Kabul River, October is probably the best time to start such a project, in order to complete the work in 12 months, it was very advantageous on the Tochi to make use of the three-and-a-half months between the spring and summer spates, since during these months work is possible throughout the whole 24 hours. After October it is too cold for more than a short day's work, and no night work is possible.

When work commenced on May 14th there were a bare ten weeks available before the summer spates, and consequently the original programme of three piers and one abutment, commencing from the north bank, all built up to mean bed level, had to be reduced to two piers and one abutment. Preliminary work consisted in:—

(*a*) Putting out the work on contract.

(*b*) Collecting materials.

(*c*) Collecting tools and plant.

(*d*) Laying out the work.

(*e*) The construction of protective and guide dams upstream.

A few notes on each will explain these.

(*a*) The work was taken by the best of the Isha-Razmak Road contractors at 5 per cent. below Razmak rates, with a special rate of Rs. 250 per 1,000 cu. ft. for excavation below 6 ft. depth, and an allowance for "protection." The cost of bringing up labour and rations was borne by the contractor. This contractor was a real backwoodsman, and conservative to the last degree, which is exemplified by his refusal to touch the work if a specially procured mechanical grab was used.

As is customary on such jobs, much money was saved by refusing the high tenders and superior organization and methods of the down country contractors, and a corresponding amount of *dikh*, obstinacy, mulishness, and claims was incurred when the local tender was accepted.

(*b*) The collection of materials commenced in April, 1923.

An excellent quarry of flat-bedded limestone, only a mile from the site, furnished masonry stones of almost any size required.

Shingle for aggregate up to $1\frac{1}{2}$-in. was in the river bed in unlimited quantity. This, although comparatively clean, was all washed by being shovelled on iron sheets through a shallow stream of the river.

Lime was obtained from river boulders, burnt near by, and proved slightly hydraulic.

Mortar, of proportions 1 brick dust, 2 sand, 5 lime, was ground by a stone in a circular stone trough, and was stored under water.

Cement of Indian manufacture was used throughout.

At first a grading machine was used for the shingle, but it was found that the natural mixture of the river bed could not be improved upon.

(*c*) The estimate allowed Rs. 20,000 for tools and plant. This sum was quite inadequate to provide plant to enable the work to be completed at the rate at which it was intended, and commitments under this head at one time amounted to one lac. Consequently it became necessary to use this sum to cover the cost of depreciation of the plant only, and to arrange concurrently for the disposal of the plant immediately it was no longer required on the work.

Previous experience on similar work had shown the necessity for one 8 to 9-in. centrifugal pump per pier excavation. The requirements were, therefore, four 9-in. centrifrugals, allowing one spare, three portable engines, three concrete mixers, tackles and derricks for moving pumps, timber for shoring, and the usual digging tools and appliances.

These were collected from far and near, Kohat, Peshawar, Pindi, the Engineer Park at Lahore, and the N.W. Railway all assisting.

(*d*) The work was laid out as described below, and marked with small masonry pillars, cement rendered. The north bank abutment was in this case first located, and the centre line of the bridge marked by two pillars erected beyond each end of the bridge.

Further pillars were then built on this line, one at the actual centre point of each pier. Two pillars were erected respectively sixty feet on the up and down stream side of each pier centre pillar, so that the line joining them passed through the centre pillar and was at right angles to the centre line of the bridge.

This allowed of the quick replacement of any pillar destroyed or removed by any cause.

Finally, when excavation commenced, two subsidiary pillars per pier were erected, respectively 30 ft. short and beyond the pier centre pillar, and on the centre line of the bridge.

The pier centre pillar was then removed. These pillars were all laid out with the theodolite and their levels, referred to a bench mark on the north bank, accurately determined.

(*e*) Temporary dams had been necessary to complete the causeway, and these had all directed the flow of water towards the north bank.

During the spring spate of 1923 the driver of a new M.E.S. 4-ton Packard lorry tried to drive across the causeway when some 2 ft. of water was flowing over it. Unfortunately, instead of watching the opposite bank, he became mesmerised by the flow of the stream across his front, until finally he could resist it no longer and proceeded to follow the direction of flow with his lorry. This occurred close to the north bank, and in order to retrieve the lorry all the dams had to be altered round to divert water to the south bank, and the plan of operations was therefore changed, so that construction was carried out from north to south.

The dams were originally in three lines across the river bed.

The first line, furthest from the bridge site and some three-quarters of a mile upstream, was designed to withstand and divert the spates. It consisted of shingle banked 8 ft. high and 15 ft. wide at the base, faced upstream with boulders in wire crates 18 in. thick, and with a toe wall, 4 ft. wide, in the same construction. At points liable to special exposure the dam was built entirely of boulders in crates.

The two lower lines were intended to deal with surface water, but the upper one was faced with boulders in crates. Owing to a spate, the direction of which was inclined at 45° to the normal line of flow of the river, a fourth dam was necessitated running down the centre line of the river from the uppermost dam to a point on the causeway.

Pier excavations Nos. 1 and 2 were ringed round with walls of shingle in sandbags as an additional precaution.

5. Excavation for Piers and Abutments.

It has been explained that, owing to the antipathy of the contractor to modern methods, the whole of the excavated spoil on each pier was removed by a swarm of coolies using iron baskets.

Work proceeded on these lines comparatively quickly down to a depth of 6 ft., or so long as the coolies could run out of the excavation. Below this depth, and after the shoring had been commenced, the soul-shattering spectacle was witnessed of coolies sitting on struts and ladders handing the baskets up to one another.

Even the thin grass rope and *chattie* and windlass, so dear to the heart of the native well-sinker, was taboo.

The depth of the excavation for No. 1 pier was such that the 8 in. centrifugal pump, which it was intended to use eventually, could not be set in its final position for efficient working until excavation had proceeded down some ten or eleven feet.

Down to this depth the water was dealt with by a 4 in. centrifugal pump driven by a 2-cylinder Aster engine.

The 8 in. centrifugal was located in a wide 6 ft. trench cut off from the main excavation, and it was actually bedded on a sleeper cribwork and connected by belt drive to a portable engine above in the river bed.

Two standing derricks with differential tackles were provided, and so placed that one could take the weight of the cast iron suction pipe and foot valve, whilst the other was available to raise or lower the pump as might be necessary in order to fit in a further length of suction pipe—adjustment being made by altering the amount of crib piering under the pump.

This arrangement gave considerable trouble, owing to the difficulty of maintaining a correct alignment between the pump and the engine to ensure the belt remaining on the pulleys.

Further, the use of heavy cast-iron suction pipe, suspended in the air, resulted in constant air leaks at the joints.

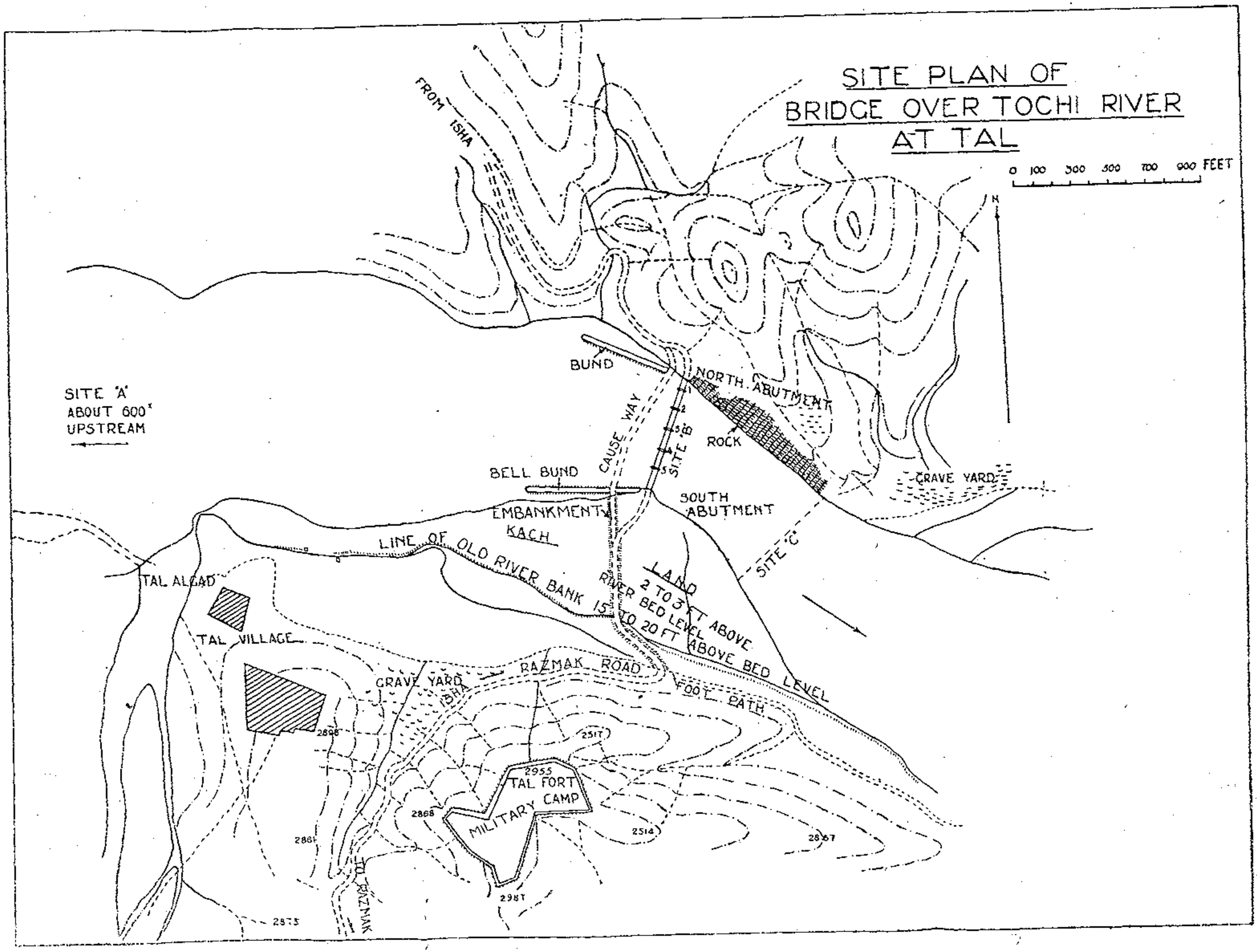
The second of these difficulties was obviated, when the excavation of No. 2 pier was commenced, by the use of light sheet-iron suction piping of local (railway) manufacture, and by placing the pump directly over the sump, supported on two baulks, the ends of which were carried, on one side in the cut or trench, and on the other on the moveable transom of a 2-legged trestle.

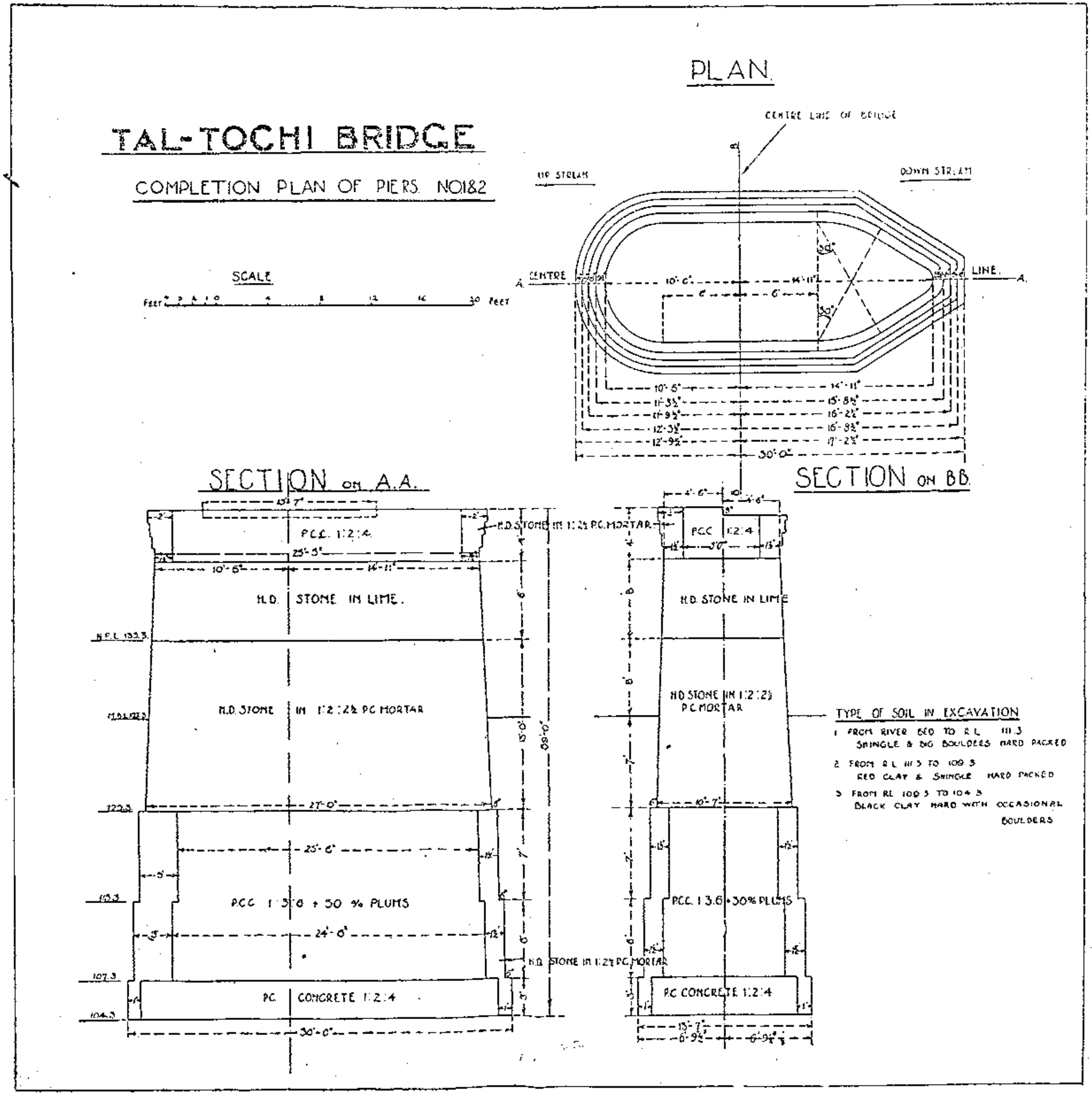
The trouble with belt alignment continued, and no really satisfactory arrangement was devised until electric drive was installed, as will be described later.

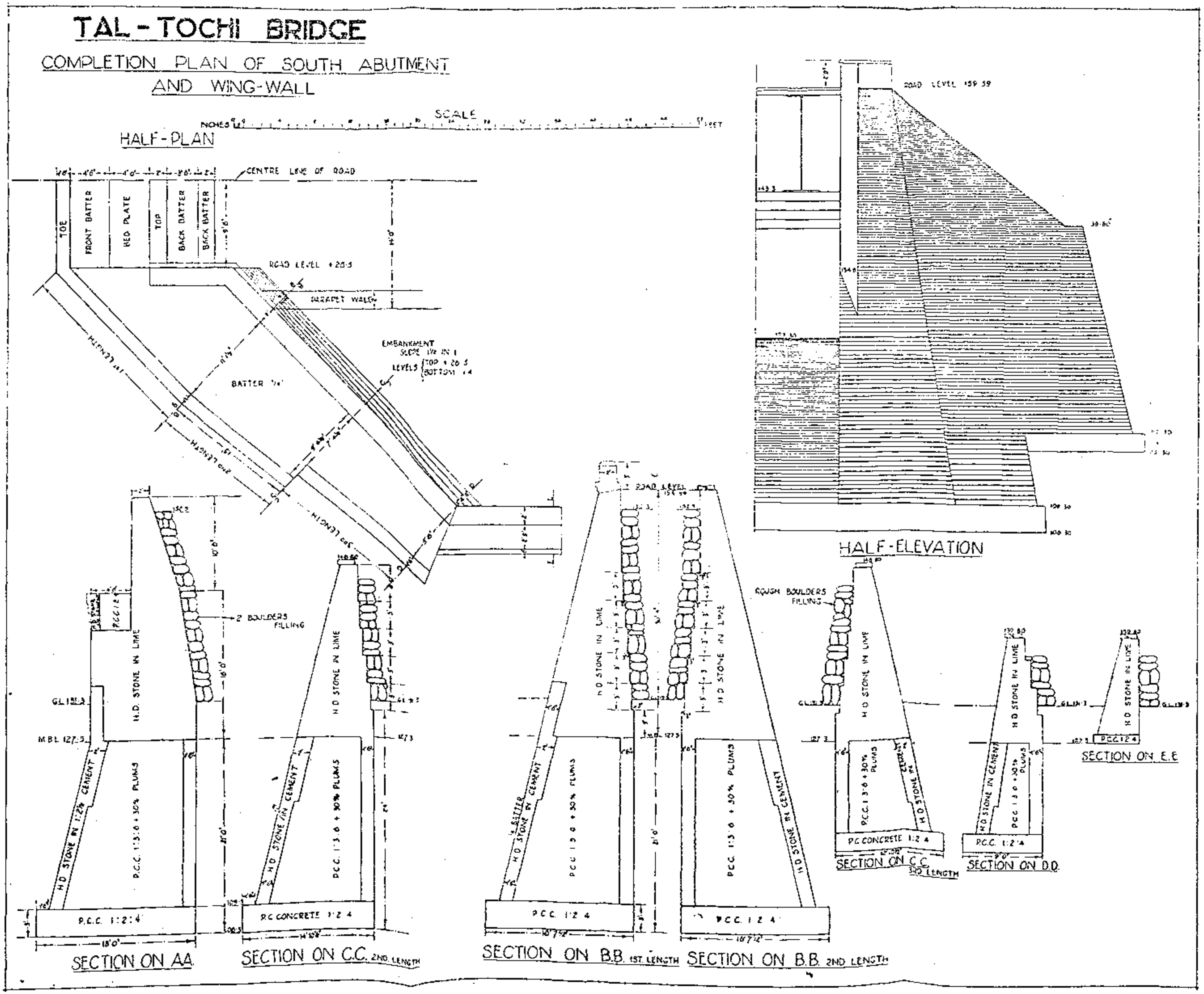
In all the excavations the sumps were arranged at the down stream ends, although, in order to save them, in case of failure of a dam under a sudden spate, the portable engines were on the upstream side. It was found that the inflowing water caused such falls of earth and shingle, that a sump at the upstream end would result in the footvalve being constantly buried.

The work of excavation is all dependent on the water being kept down by the pump, and a most frequent source of temporary stoppage is choking of the footvalve, due to the sump being neglected.

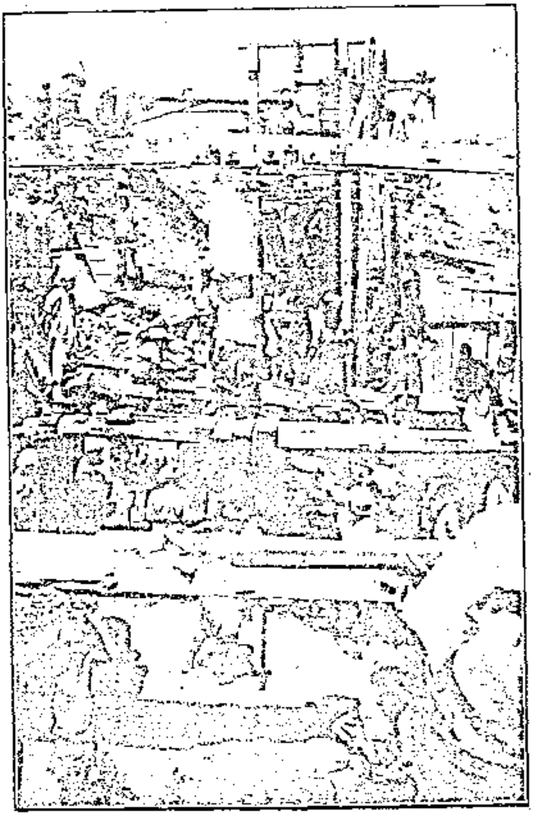
The bottom of the sump must be kept 2 ft. below the level of the main excavation, and the footvalve must not get within 6 in. of the bottom of the sump.


SITE PLAN OF
BRIDGE OVER TOCHI RIVER
AT TAL
0 100 300 500 700 900 FEET
N
FROM ISHA
BUND
NORTH ABUTMENT
CAUSE WAY
SITE 'B'
ROCK
GRAVE YARD
SITE 'A'
ABOUT 600'
UPSTREAM
BELL BUND
SOUTH
ABUTMENT
EMBANKMENT
KACH
LINE OF OLD RIVER BANK 15 TO 20 FT ABOVE BED LEVEL
LAND
2 TO 3 FT ABOVE
RIVER BED LEVEL
SITE 'C'
TAL ALGAD
TAL VILLAGE
GRAVE YARD
ISHA
RAZMAK ROAD
FOOT PATH
2896
2517
2955
TAL FORT
MILITARY CAMP
2868
2861
2514
2867
2987
2873
TO RAZMAK


TAL-TOCHI BRIDGE
COMPLETION PLAN OF PIERS NO1&2
SCALE
PLAN.
CENTRE LINE OF BRIDGE
UP STREAM
DOWN STREAM
CENTRE LINE
SECTION ON A.A.
SECTION ON BB.
P.C.C. 1:2:4
H.D. STONE IN 1:2½ P.C. MORTAR
H.D. STONE IN LIME.
H.D. STONE IN 1:2:2½ P.C. MORTAR
P.C.C. 1:3:6 + 30 % PLUMS
P.C. CONCRETE 1:2:4
TYPE OF SOIL IN EXCAVATION
1 FROM RIVER BED TO R.L. 111.3 SHINGLE & BIG BOULDERS HARD PACKED
2 FROM R.L. 111.3 TO 109.3 RED CLAY & SHINGLE HARD PACKED
3 FROM R.L. 109.3 TO 104.3 BLACK CLAY HARD WITH OCCASIONAL BOULDERS

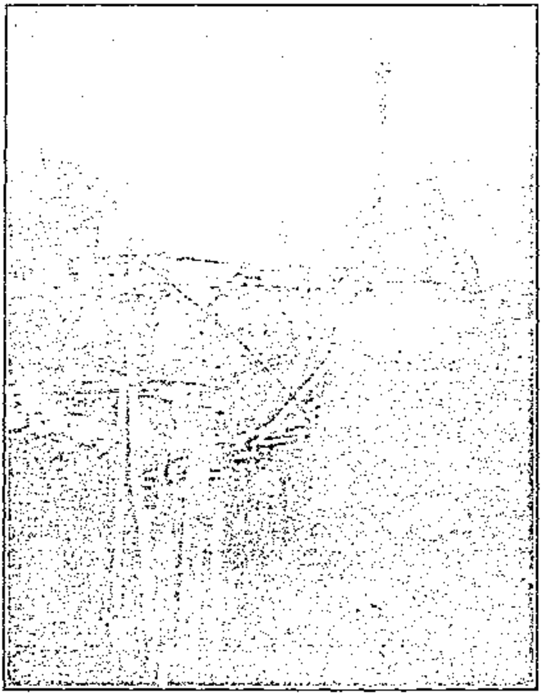

TAL - TOCHI BRIDGE
COMPLETION PLAN OF SOUTH ABUTMENT AND WING-WALL
SCALE
HALF-PLAN
CENTRE LINE OF ROAD
TOE
FRONT BATTER
BED PLATE
TOP
BACK BATTER
ROAD LEVEL
PARAPET WALL
EMBANKMENT
BATTER
1ST LENGTH
2ND LENGTH
3RD LENGTH
HALF-ELEVATION
ROAD LEVEL 159.59
BOULDERS FILLING
ROUGH BOULDERS FILLING
H.D. STONE IN LIME
H.D. STONE IN CEMENT
P.C.C. 1:3:6 + 30% PLUMS
P.C.C. 1:2:4
P.C. CONCRETE 1:2:4
GL 151.3
M.B.L. 127.5
SECTION ON A.A
SECTION ON C.C. 2ND LENGTH
SECTION ON B.B. 1ST LENGTH
SECTION ON B.B. 2ND LENGTH
SECTION ON C.C. 3RD LENGTH
SECTION ON D.D.
SECTION ON E.E

1. Early work on No. 2 Pier excavation.

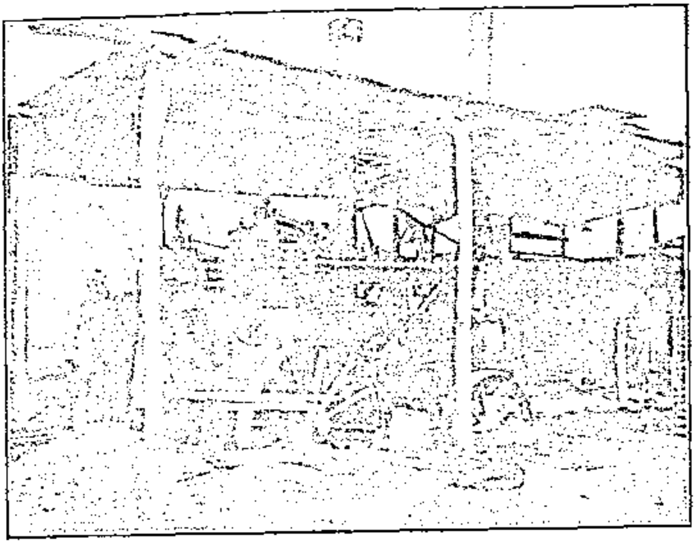


2. No. 2 Pier showing shoring and over bridge.

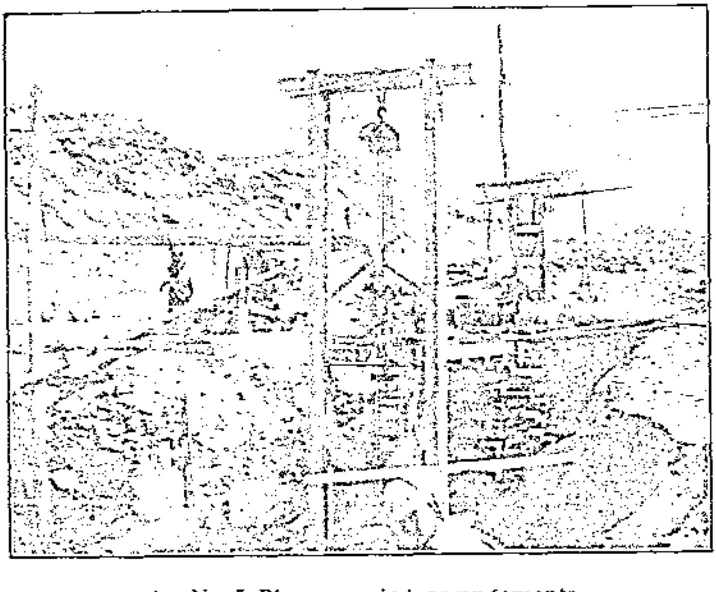
3. No 2. Pier built up to mean bed level.



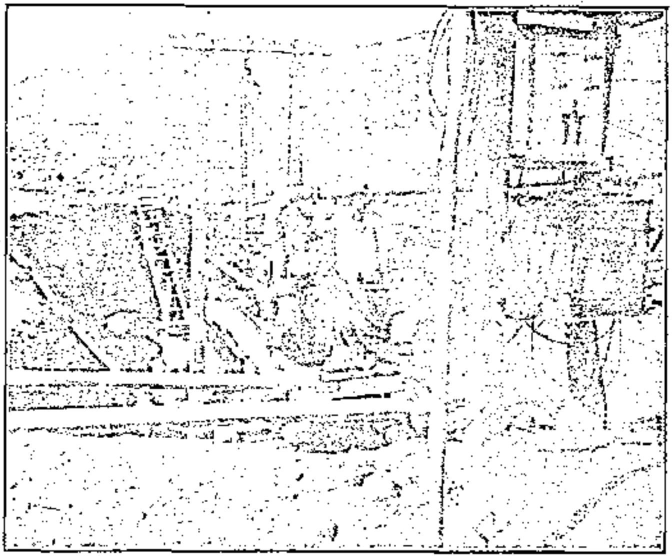
4. Pumping arrangements on South Bank abutment.



5. The Power House.



6. No. 5 Pier pumping arrangements.



7. No. 5 Pier showin electric drive to pump.

8. The Tal Bridge complete, seen from the West.

In such work, the footvalve requires additional protection, and is best enclosed in a bag of wire gauze, tied tightly round the strainer.

A small portable petrol-driven pump, mounted on one bedplate, was kept by, as an emergency measure, for use when a temporary stoppage occurred on the main pump. A set of this nature was found to be invaluable, since it could deal with all water met with up to 18 ft. depth, and was also of great use in starting excavations.

Shoring was found necessary at a depth of 6 ft., when the excavation began to fall in badly, and it was carried down to a depth of 12 to 15 ft., when solid clay, with large boulders embedded in it, was met.

The shoring consisted of 2 in. planks driven down outside a horizontal frame supported by cross struts; the frame and struts being of 12 in. by 6 in. timber, all dogged together.

As the excavation progressed the planks were slightly undercut, and the whole structure of frame and planking was easily driven down. The excavations for the north bank abutment and Nos. 1 and 2 piers took some five weeks, which included all the time lost in failures of the plant, and a whole week on account of a spate. Work was speeded up by working night shifts, and by the provision of bridges over the excavation, which provided additional roads for the removal of spoil.

The night shifts were originally lit by Kitson lamps, which proved expensive owing to the frequent breakage of the glasses. The two Pelapone electric light sets, which eventually replaced them, were very much better and cheaper.

Throughout this work there was the customary continual strife with the contractor, mainly over the standard of unwatering. He was, therefore, made to agree to no claim for stoppages under half-an-hour, due to a depth of water of over 6 ins., or cases of major breakdowns, where he had been given due warning and could switch his labour on to approach roads. A log was kept on the job which showed all stoppages, and was signed by the contractor daily.

The completed excavation, which was made 2 ft. larger all round than the masonry work, was checked for size, alignment, and level, and was then dried out before the concrete foundation was put in. The only satisfactory method of stopping all the small springs, by which the water leaks in from the sides and bottom, was found to be to build a 3 ft.-high wall of dry concrete mixture in sandbags, outside the area for the foundation, and to excavate over the floor an additional 6 ins., and carefully lay this with bags of the same mixture.

6. Pier Construction.

The foundation was laid out, and the work checked as it proceeded by a theodolite mounted on the over-bridges mentioned previously.

The piers were checked at every offset up to bed level.

All concrete was mixed in a mechanical mixer at bed level, and was shot on to the work down a wooden trough, and laid in 6-in. layers.

For a brief spell a petrol driven mixer did most efficient work, but, like so many other mechanical contrivances, it had not been designed for work in the East. It was not long before the cry of "*Sahib phutgaya*" announced that it had passed on, like many another unsuspecting piece of mechanism.

The work of concrete laying proceeded rapidly. The outer stone ring was given a very rough finish on its inner side and was built up in 3 ft. stages, as the concrete laying progressed. During the laying of the concrete, the masons worked on the laying and proper bedding in of the stone "plums." Above the level of calculated scour, where the pier was of solid masonry, the method for each course was first to lay the outer ring, next to lay, in cement, two transverse, and one longitudinal, lines of flat stones, hammer-dressed on four sides. In each succeeding course these lines were staggered.

In any one course the spaces between these three lines were filled with what may be termed "horizontal random ashlar work," that is, very irregular, un-dressed stone, carefully keyed, so as to leave no gap greater than 2 ins. These gaps were first filled with mortar, after which stone spawls were driven tightly into them.

As in other forms of masonry, the great difficulty was to get the masons to lay each stone with mortar, their preference being to lay several stones and then merely to grout around.

The commencement of the summer spate season saw the masonry of the north bank abutment and Nos. 1 and 2 piers completed up to mean bed level, and during the ensuing two months work was confined to building these up, and to work on the north bank approach road.

7. Employment of Electrically Driven Pumps.

Had the work on piers 1 and 2 been further advanced it would have been politic to change round the dams just before the summer spates began, about August 1st, and commence work on the south bank abutment then. But, owing to the large amount of stone collected around these two northern piers, which would have been washed away, the dams could not be altered until the end of August, by which time the spates had carved deep channels in the river bed, making the work more difficult.

It was found possible to commence the excavation of the south bank abutment at the beginning of September, but the remaining piers could not be safely tackled until the end of that month, by which date it was expected that the spates would be over for the year.

In view of the trouble experienced on the first two piers, Simpson, the E. and M. Officer, got out a scheme for driving the pumps on the remaining four excavations by electric motors supplied by current from a temporary central power station to be put up on the bank.

The advantages were several, chief amongst them being:—

1. Reduction in working costs as a result of using fewer prime movers—in this case portable engines—and a reduction in the personnel required;
2. Improved efficiency as a result of having spare engines—allowing for proper cleaning out—and improved control;
3. Saving in time, since with pump and motor on the same bedplate there was no difficulty over belt alignment;
4. Increased safety of prime movers, since the portable engines could be kept on the bank, and not in the river bed where a sudden spate might damage them.

The scheme was sanctioned and it was first put into operation on September 15th, two 15 k.w. generators and three 10 h.p. motors having been collected from Idak, Dardoni, Rawalpindi and Lahore.

The work on the south bank abutment was completed by the old method of a portable engine driving the pump, as the motor ordered for the new scheme did not arrive in time.

The power house, which was a rough shed of poles and corrugated iron, contained two portable engines dug down, each driving a 15 k.w. direct current generator on a concrete bed. A separate switch board, with overload circuit breakers, was erected for each generator. The current was carried from the power house to the distributing station by 37/16 insulated cable.

The distribution board carried a main D.P. switch and 200 amp. fuzes, and D.P. switches and fuzes for each of the three circuits supplied. Close to each of the three excavations—piers 3, 4 and 5—were the main switch, fuzes and starting rheostat for each motor.

An 8 in. centrifugal pump was assembled on an adjustable bedplate with a 10 h.p. motor, and pulleys were made up locally of wood, plated with $\frac{1}{4}$ in. mild steel plate, to give the correct driving ratio.

A similar set was provided for each of these three excavations.

Six-in. flexible suction hose had been ordered to obviate the necessity of adding lengths of suction pipe as the excavation progressed; as, however, only one length had arrived when work commenced, it was only used on No. 5 pier.

Flexible suction hose saves much time on a construction job like this so long as it is new, but once it becomes damaged and leaky, it is a snare and a delusion, and should be scrapped at once.

At the beginning of October, Pier No. 4 was commenced with the portable petrol pump, followed soon after by Pier No. 3, with an extemporised set consisting of a 3-in. centrifugal driven by a Pelapone engine. When both these excavations had been taken down sufficiently deep, the portable sets were replaced by the larger 10 h.p. motor-driven sets already prepared for them. The scheme proved most successful in operation, and when all three excavations were fixed up together, it was found that, by pumping from them in rotation, one portable engine could deal with the work, the second engine having steam up in case of a breakdown.

By December 10th, Piers 3, 4 and 5, and the south bank abutment, were all excavated and built up to mean bed level.

The number of days worked on these was approximately the same as those spent on the two piers and one abutment before the summer spates, but the number of hours worked only averaged 8½ per day as compared with the continuous shifts which were possible earlier in the year.

It is only fair to say, however, that much time was lost earlier in the year in breakdowns, while, in the second period, breakdowns were eliminated, as a result of the thorough overhaul of the plant during the summer spate season.

By December 27th, all masonry was complete up to the top belt of 1 : 2 : 4 P.C. concrete, which was laid by direct labour, and the contractor was diverted on to the approach roads on either bank, which work had hitherto been used only as a stop gap for his labour during spates or breakdowns.

8. ERECTION OF THE GIRDERS.

The railway gang, which had rendered excellent service in shifting and adjusting heavy weights, besides semi-skilled work on shoring and sumps, commenced the erection of the girders on December 20th.

Each span arrived in five sections, each weighing five tons, for convenience in handling and haulage by road from the railhead at Bannu, some 35 miles distant. These pieces were riveted up in the river bed by a trained gang and hoisted on to the piers by a derrick at each end of the span, after which the holding down bolts were put in and grouted. The cross-bracing and corrugated mild steel troughing were completed in the intervals between the arrival of the girder sections.

The sections were hauled up the road from Bannu by six steam-rollers and a steam tractor, no other haulage being available.

Notwithstanding a certain amount of delay in the arrival of the girder sections, the erecting gang had all the steel work completed by mid-April, 1924, when the supervisor, as a reward for this, and many other road bridges erected by him on Frontier M.T. roads since 1916, was very deservedly rewarded by the grant of the title of Khan Sahib.

9. Conclusion.

The approach roads had been completed in February, when the contractor was finally paid up, much to the relief of the staff, who were always busy keeping him up to his work and combating his innumerable fancied claims for losses. His achievement of five piers and two abutments completed in nine months must constitute a record for Frontier bridge work, and no small share is due to the S.D.O., Khan Sahib Miram Baksh, who worked splendidly throughout.

When the cement concrete roadway over the corrugated troughing had been laid, the bridge was opened to traffic in June, 1924, just over a year from the commencement of the work.

In spite of a good deal of unforeseen expenditure, much of which was due to breakdowns in the earlier period, the work was completed without an excess over the estimate.

The officers employed on the job, all of whom had a hard time, were Major L. C. B. Deed, D.S.O., in charge, Ross (on the early investigation and estimate), Stillingfleet (on construction up to the end of July, 1923), Fox (during August, 1923, and at the close of the work), Martin (during most of the autumn and winter), and, above all, Simpson, who was in charge of the E. and M. arrangements throughout.

In conclusion, it may be said that electric drive was clearly proved to be preferable from every point of view to portable engines with belt-driven pumps, and although oil engines would have been handier and more cheaply maintained for driving the generators, the capital expenditure entailed in their purchase was hardly justified with so many portable steam engines already available.

A small and efficient workshop was found to be essential to keep the plant in running order, whilst the advantage of the small, highly skilled railway gang, capable of dealing with heavy weights, was very great.

THE ENGINEERS IN THE AUSTRALIAN MILITARY FORCES.

By C. H. F.

BEFORE commencing a description of the Engineers' organisation in this Commonwealth it must be explained that, as in Britain, there exist two distinct categories of troops—the Permanent Forces, and the Citizen Forces.

PERSONNEL.

The Permanent Forces are a small body, officered by Staff Corps Officers, and comprising the Australian Instructional Corps, Royal Australian Field Artillery, Royal Australian Garrison Artillery, Royal Australian Engineers, A.A.S.C., A.A.V.C. and A.A.M.C.

Enlistment in these Units is voluntary, the first period of enlistment being for five years, with subsequent terms of re-engagement for three-year periods.

The training is on lines similar to that of the corresponding units of the Regular Army in Britain.

The Citizen Forces are raised under Part XII of "The Defence Act, 1903-1918," which imposes the liability for military training on all male inhabitants of Australia between the ages of 12 and 26 years (excepting those exempted by the Act) who have resided there for six months and are British subjects.

Financial considerations have led to various modifications in the application of this liability, with the result that at present the service must be given for one year in the Senior Cadets and three in the Citizen Forces. The trainee therefore commences his Citizen Force service on the 1st July in the year in which he reaches the age of 18, the previous twelve months having been spent in the Senior Cadets.

Voluntary enlistment, within certain prescribed limits, is also permitted.

The training in the Senior Cadets is elementary, and includes no technical Engineering or Artillery subjects; it comprises merely musketry, marching, and physical training.

At the beginning of each financial year, i.e., on the 1st July, a "quota" becomes due for transfer from the Cadets to the Citizen Forces; on 1st July, 1926, for example, the "1908 Quota," composed of trainees born in the year 1908, will become due, while the "1905 Quota" will become due for transfer to the Unit Non-Effective List, and the "1909 Quota" will be mustered into the Senior Cadets.

In so far as the technical arms—e.g., Artillery and Engineers—are concerned, Commanding Officers of Technical Units are authorised to select from the incoming Quota those who, by reason of their trade or other qualifications, are suitable for the unit.

For the Engineer Units, naturally, Commanding Officers select apprentices or young tradesmen of suitable trades, with the addition sometimes of a few clerks and one or two who are in the cooking trade or are willing to be trained as cooks.

ESTABLISHMENTS.

ROYAL AUSTRALIAN ENGINEERS.

The Establishment of Royal Australian Engineers is, necessarily, not large. It comprises merely sufficient Warrant and Non-Commissioned Officers and Sappers to maintain the Coast Defence Lights, and communications, and to form a nucleus manning detail thereof, to run the launches employed in the larger Coast Fortresses, and to provide technical storemen for Citizen Force Units.

From the R.A.E. also are found the Warrant Officer Instructors for Citizen Force Engineer Units, both Field and Fortress, and in a large degree those for Signal Units also. These, on promotion to Warrant Rank, are transferred to Australian Instructional Corps.

The Officers (except a small number in "Works") are members of the Staff Corps.

The Establishment of R.A.E. for the current financial year is :—

Regimental	120	Warrant and N.C.O. and Sappers.
Works Section	19	,, ,, ,, ,, ,,

In addition there are 15 Officers of the Staff Corps doing duty with R.A.E. or as Adjutants, etc., of Citizen Force Engineer and Signal Units, and several Warrant Officers A.I.C. Instructors to such Units.

CITIZEN FORCE ENGINEER UNITS.

The Citizen Forces of the Commonwealth are organized on a Divisional Basis, consisting of :—

2 Cavalry Divisions.
4 Infantry Divisions.
3 Mixed Brigades.
6 District Bases.

The latter comprise, *inter alia*, the Coast Defence Units raised in a District, of which there are six, corresponding, practically, with the six States of Queensland, New South Wales, Victoria, South Australia, West Australia and Tasmania.

The organization of the Divisional Formations follows that of the British Army; the three Mixed Brigades together are equal to a complete Division, less a few details.

On the Divisional and Cavalry Divisional Organization, therefore, there are:—

5 H.Q. Divisional Engineers.
2 Field Squadrons.
4 Field Park Companies.
15 Field Companies.

It will be noted that no portion of a Fifth Field Park is raised in connection with any of the Mixed Brigades, each of which has merely the one Field Company allotted to it.

The Coast Defence Engineer Units comprise six Fortress Companies, one in each District, except 4th (South Australia), in which none exists, and 2nd (New South Wales) in which there are two.

The Training Establishment of Units is as follows:—

H.Q. Divisional Engineers:—

1 Commanding Officer.
1 Adjutant and Quartermaster (Staff Corps Officer).
1 Sergeant Major (Australian Instructional Corps).
1 Orderly Room Sergeant.
1 Farrier Sergeant.
3 Drivers.
1 Storeman (R.A.E.)

Each Field Company has an Establishment of 4 Officers and 80 other ranks, being composed of a Headquarters and 3 Platoons. The allotted transport consists of a Maltese cart and two water carts for each H.Q. with three carts, tool, three wagons, L.G.S., and three wagons G.S. per Company.

The two Field Squadrons with the Cavalry Divisions are each composed of a Headquarters and Headquarters Troop with three Brigade Troops, the total Establishment of a Squadron being six Officers and 53 other ranks. The allotted transport consists of three tool carts, a water cart, on G.S. wagon, and three L.G.S. wagons per Squadron.

The Training Establishment of each Field Park Company is 3 officers and 27 other ranks, with a small transport echelon sufficient for the conveyance of Bridging stores for training purposes.

The Fortress Companies are of divers establishments, according to the extent of the Fortress to which each is detailed, varying from an establishment of 1 officer, 10 other ranks, to one of 4 officers and 80 others; the total establishment for the six Companies is 15 officers and 200 other ranks.

The Establishments given above are those for 1924-25; it is probable that these will be considerably increased for the financial year 1925-26.

TRAINING.

The Training of the Permanent Forces, as far as the Royal Australian Engineers are concerned, is similar in many respects to that of the Royal Engineers except that there is no training in "Trades."

The small size of some of the detachments, however, means that in some stations the R.A.E. are employed throughout the year (except when the Citizen Force Units are in camp) on the maintenance of the E.L. plants.

On the larger stations it is practicable to carry out training in all phases of E.L. work, and in addition to give a certain amount of training in field works.

Schools and Courses of Instruction are carried out periodically for the instruction of Warrant and Non-Commissioned Officers and Senior Sappers of the R.A.E.

It should be mentioned that, in the Permanent Forces, Certificates of Education must be possessed by all ranks before promotion —i.e., 3rd Class for promotion to Corporal, 2nd Class for Sergeants, and 1st Class for Warrant rank.

The training of the Citizen Forces is made up, under the Regulations, of two natures:—

(*a*) Home Training.
(*b*) Camp Training.

Under present conditions, for the Engineers, Home Training must consist of four days, and Camp Training of eight days. The Home Training may be made up of "full days," "half days" or "night drills," in any proportions laid down by the Divisional Commander.

Camp Training must consist of Training in a Continuous Camp for the whole period of eight days.

These Camps are usually Brigade Camps; in the two larger Districts the Infantry Brigades of a Division follow one another on the same Camp site, with intervals of three or four days between Camps. The whole of the Divisional Engineers, as a rule, attend one of these Camps. In the other Districts a joint Engineer Camp may be held for both Field Companies and Field Troops.

The Fortress Engineers, of course, go to camp at their stations, at the same time as the Garrison Artillery Companies of the Citizen Forces.

In addition to the "Statutory" Camps and Home Training drills, all Engineer Units hold voluntary "week-end" Camps.

These sometimes take the form of a march, with transport, to some convenient place, a bivouac for two nights, and the performance of some work, such as bridging, water supply, reconnaissance, etc. Fortress Companies run the lights at their Station.

Perhaps it should be explained that, in Australia, almost all "Statutory" holidays are held on the Monday next after the actual date; for example, last year the King's Birthday Holiday was held on the 8th of June, although the Salutes were fired on the actual date.

This makes for several long "week-ends" from Saturday to Tuesday morning.

The actual instruction in Camps is carried out by the Officers and N.C.O. of the Units, the Permanent (A.I.C.) Instructor merely supervising or advising as a rule, except when some special work, or new work or drill requiring detail, is done.

Since practically all ranks of the Engineers are tradesmen of some kind, their instruction is not difficult. The Sappers are all very keen, and one never sees any symptoms of boredom or mental weariness among them. The writer speaks from some twenty-five years' association with the Corps when he says that to instruct them is a pleasure.

It is laid down in *Instructions for Training, Australian Military Forces*, 1925, that all practical work in the field will be based on a definite tactical scheme, and, furthermore, that "an endeavour must be made to carry out complete schemes . . . . and the work will be arranged and materials provided to ensure this being done. If schemes are uncompleted Units do not see the result of their labours, and the training loses much of its value."

Near all the Camp sites in Australia there is ample ground for all classes of Engineer training. In Victoria, near the Seymour Camp (60 miles from Melbourne) runs the Goulburn River, a stream of diverse characteristics in every mile of its course. Within a mile or two of the Camp are broad lagoons, a wide river with a slow current, or a steep-banked stream running five knots.

On the George's River at Liverpool in New South Wales, there are good facilities for bridging, while around Brisbane (Queensland) there are many rivers—broad, narrow, swift, or sluggish, as desired.

For materials, additional to the Service gear, there is no lack of bush timber which may be had for the felling.

Field works can be carried out anywhere, and the bugbear of having to "fill-in" afterwards need not be feared—the Infantry love to use them next year in "attack" practice.

In conclusion, it may safely be said that the Field Troops and Companies in Australia have ample opportunity for thorough practical training, and that they have made good use of them.

THE EARLY YEARS OF THE ORDNANCE SURVEY.

(Continued.)

IX. Progress of the Survey of Ireland from 1826 to 1839.

Portlock, Reid, Larcom, O'Donovan.

Colby's System.—Colby often refers in his letters to his "system" of surveying, and as this system is the origin of the distinctive methods of the Ordnance Survey, it will be as well to describe it briefly. The main principle of Colby's system was that of division of labour; the all-round subordinate was not wanted in this system. Each man had a definite job to do and was kept at that. The surveyor who carried out the chaining did not plot his work; the plotting was given to other men. The man who plotted the main lines of the survey did not plot the detail. Afterwards, by an extension of the system, the surveyor who examined the work on the ground and inserted names and descriptions had nothing to do with the drawing or tracing. In the trigonometrical branch, in later years, the observers never computed their observations, but worked quite blindly as to the results of their work. There is much to be said for such a system; each man becomes very expert at his own particular speciality. It sounds, perhaps, a little dull for the surveyors; and, indeed, some men spent their working lives in doing the same thing over and over again. But it is less dull than it sounds, and if a surveyor in the field became incapacitated by illness, or from other causes, he could be brought into the office and trained up in another routine. The method is well suited to the large-scale survey of a civilized country; it would be quite unsuited to the topographical surveying of a tropical dependency.

Some copies have come down to us of the *Instructions for the Interior Survey of Ireland*, a small pamphlet of some 30 pages, "lithographed at the Ordnance Survey Office, Phœnix Park, Dublin," in 1827. The *Instructions* begin with the statement that, "The Interior Survey of Ireland is to be performed on a Scale of Six Inches to one English Mile; and the Plans are to be drawn with all the Accuracy and Minuteness of detail which that Scale admits." The whole work was, of course, based on the Great Triangulation, which depended, after November, 1828, on the length of the Lough Foyle Base. A certain number of points were intersected from the principal stations, and we may suppose that the officers who were responsible for the "interior survey" were given the bearings and distances of points some ten miles, or so, apart. "The subsidiary Triangulation for determining the Interior Points for regulating the Survey being to be performed by the District Officers, who will combine with that operation the determination of a good series of altitudes." In 1833 all trigonometrical work was placed under a special division. The detail was surveyed almost entirely by chaining; traversing was not generally allowed. From trig.-point to trig.-point the chain was dragged; the interior of the triangles being also split up by chained lines. Every boundary line was chained and all important features. Traversing, though not absolutely forbidden, was discouraged. Even in the towns the detail survey was carried out by simple chaining. An exception appears to have been made in the case of the survey of winding streams in deep valleys, and, generally, traverses became allowable in uncultivated and wooded districts and in the mountains. But, for towns, the probibition appears to have remained in force until 1897; and much ingenuity used to be displayed by the surveyors in carrying out the survey of close towns by right lines.

"The plotting is to be performed on sheets capable of containing at least ten or twelve square miles. . . . The Trigonometrical Points are to be pricked off on the paper before the plot is commenced. . . The Plans are to be co-extensive with the Parishes, each Plan containing a single Parish, except in cases where Parishes are so small that two or more may conveniently be put together. . . ."

Since the areas of Baronies and Parishes were required as well as those of the Townlands, instructions were given that the chain lines should be laid out chiefly with reference to the larger divisions. Hence long lines were not uncommon; in the example given in the pamphlet there is a chain line over three miles long, and many were longer.

The areas were calculated, and not measured from the plan as they are in modern Ordnance Survey practice. A later article reads, "In the first article of these Instructions it is directed that the survey shall be performed on a scale of six inches to a mile and with all the accuracy of detail which that scale admits. It is not, however, intended to put in the Fields generally, but with this exception everything attached to the ground is to be inserted on the Plans."

In accordance with the instructions of the Select Committee, the early six inch sheets did not show the field boundaries, except where they coincided with the townland or other administrative boundaries. Larcom, writing in later years, says:

"At this time (1843) another circumstance had arisen; the early Northern Counties had not been surveyed with the degree of detail which had been attained in the South, when the men and officers had attained greater experience and skill. The tenement valuation, now introduced, for the Poor Law, required this detail accordingly on the Memorials of the Northern Counties; the Government allowed the Maps of them to be revised."

"The persons employed on the survey" were to endeavour to obtain the correct orthography of the names of places by diligently consulting the best authorities within their reach; the various modes of spelling a name were to be given and the authorities quoted.

"The boundaries of the several legal and ecclesiastical divisions of Ireland" were to be pointed out to the officers, "by persons authorized and directed to shew them by His Excellency the Lord Lieutenant: and the District Officer is to send to notify the times and places" where these persons' services were required. Precise instructions are given that no boundary is to be surveyed unless it is completely marked and pointed out on the ground.

The Committee of Enquiry of 1828.—In its early days the Ordnance Survey of Ireland was by no means universally popular. Local surveyors naturally felt that their bread and butter was being taken away from them. There were those who looked upon the whole undertaking as a piece of State interference. It is probable also that the Boundary Department would have liked to carry out the work itself; certainly the two departments did not get on well together. And many looked doubtfully upon the employment of soldiers. Captain Waters writes to Colby from Londonderry, on 28th March, 1828 :—

"I do believe that the greater Part of the Civil Engineers of Ireland are hostile to Our having the Survey; that from the intercourse they have with the Gentlemen of the Country an Opportunity is afforded of poisoning their minds as to its accuracy, and that the idea of employing Soldiers to execute what they alone imagined themselves qualified to undertake is a disparagement which they cannot well brook."

Then Colby introduced a new system, and even some of his officers failed to give him the support which he needed, and advocated systems of their own. It was inevitable that complaints should arise from many different quarters. Misrepresentations appeared in the press. Accusations of extravagance and inefficiency were made to the Board of Ordnance. As early as February, 1826, only a few months after the survey was started, Sir Henry Hardinge wrote from the Board of Ordnance to Colby :—

"I have received a letter in which it is stated that 'the whole of the Survey in Ireland has failed.' I do not attach, of course, much importance to this Statement, but I beg to remind you of my recent request to be furnished with an account of the progress made in the Survey. . ."

Colby was indignant at the rumours, and wrote to the Board of Ordnance. Hardinge gave Colby some very sensible advice in a letter dated 22nd April (probably 1828). He says :—

"I consider . . . . that every Dept$^{t.}$ in employing its officers ought to give them its support, most especially in the case of rumours and reports not proved. But, on the other hand, when the rumours admit of clear demonstration, the Person attacked ought to be most forward in courting enquiry and challenging proof. In short, the doubtful must be satisfied, and where the *exact sciences* are the subject of dispute, the only way of dispelling prejudice and unfairness is to come to the proof. Now the rumour that the Survey of Ireland is not properly conducted gains ground—persons high in office have received impressions that yr. *system* is wrong and liable to error. This is a point that I would grapple with. Officers of your own Corps as well as Civil Surveyors give it against you. This surely is capable of Demonstration. Secondly, it is stated that Errors to a large extent do exist owing to this Defective System of calculation (not to the Boundaries), and again, I say, call for one, two, or more instances to be specified—calculate the contents in different ways (the boundaries remaining the same), and ascertain whether the attack be just or unjust. . . If you are supine or passive, you will in a short time longer have such a mass of prejudice to contend with that yr. position will be uncomfortable: by challenging and seeking Enquiry, and making it yr. own act, you get rid of that awkwardness."

The upshot was that, on the 14th July, 1828, the Board of Ordnance wrote this letter to Colby:—

SIR,—In consequence of the continued reports of which you are aware respecting the Survey in Ireland, the Master General has given directions to Major-General Sir James Carmichael Smyth, assisted by Lieut.-Colonel Sir George Hoste, to proceed there immediately, for the purpose of enquiring into the state and progress of the Survey, with instructions to ascertain whether any better mode can be devised for the future conduct of it.

And I am commanded by His Lordship, in acquainting you therewith, to desire that you will attend to such communications and directions as you may receive from Sir James Carmichael Smyth in fulfilment of the Mission with which he is charged. I have the honour, etc.—DOWNES.

Sir James Carmichael Smyth was a distinguished Royal Engineer Officer, who was born in 1779, and was thus 49 years old when this duty was thrust upon him. He had served with Sir John Moore at Corunna, and had been on Wellington's staff at Quatre Bras and Waterloo. He became Governor of Bahamas, and, later, of British Guiana, and died at Demerara in 1838. He was a good soldier, capable and popular, but it was not likely that he could teach Colby anything about surveying, though, being an R.E. officer, he probably thought that he could.

Portlock, always a friend, writes to Colby on 26th July:—

"I should not intrude upon you at this moment did I not conceive that the expression of undiminished attachment and fidelity to your cause cannot be unwelcome. Alarming as this crisis is, I do not despond. Your cause must triumph over the efforts of a despicable cabal. All I trust is that you will not allow such petty and repeated vexations to tempt you to resign. That is, I doubt not, their hope. . ."

Well, the Committee went over to Ireland and made their report, in which the principal recommendations were that the areas should be measured from plots on the 12-inch scale and that a sytem of traversing round the boundaries should be adopted. Colby resented the method of enquiry by which the Committee usually examined his officers, as it were secretly, and not in his presence. He writes to Sir James Smyth on the 3rd September, 1828, as follows :—

"Instructions as to the mode of carrying on the Survey coming with the Master General's authority relieve me from a heavy responsibility, and must, therefore, be highly acceptable. But in those you read privately to me yesterday, there is no direction to provide the additional number of theodolites required for traversing boundaries, and the checks which I am to direct to ensure the accuracy of that mode of surveying were not enumerated. In the direction to compute the areas of the townlands from paper solely, the number of independent plots from which the computation is to be made and the scale of the content plot . . . were not mentioned. The Boundary remark Books are not directed to be preserved or sent to Mountjoy, and thus the check on the boundary department is done away without any apparent saving of time or money. . . ."

Portlock says that during the progress of the enquiry he was camped upon Cuilcagh, engaged upon the triangulation. Cuilcagh is a mountain 2,180 ft. high, 12 miles S.W. of Enniskillen. It commands "a vast number of churches and other points connected with the district triangulation, and thereby assisting to furnish bases for the surveys of about 20 counties." Colby took the two commissioners up this mountain in order that they might see for themselves the trigonometrical methods in use and might question Portlock. The latter writes :—

"If, as they certainly did, they toiled, panted, and blowed upon their ascent, envying, no doubt, the elastic and never-faltering step of their more experienced comrade [Colby], they appeared, on arriving at the summit, to forget their fatigue and to be repaid for their exertions. . . Both Sir James . . . and Lieut.-Colonel Hoste expressed the highest admiration of what they saw : but alas ! whilst they praised the executive officer, they overlooked or failed to appreciate the merit of the man who had planned the work which the other executed, and thus fell into that error which has been only too common in estimating the services and talents of General Colby."

Colby's views on the report are expressed in a letter to an unknown correspondent :—

"You are well aware of the vehement prejudice which exists against me at the present moment : and that any representation coming from me for the purpose of relieving the Irish Survey from the deadly wound it has received from Sir James Smyth, would merely be treated as an emanation from my wishes to have my own way. . . . To a superficial observer the changes effected by the Master General's orders may appear only a sacrifice of a certain portion of accuracy and completeness of information to an increase of celerity. But where upwards of 700 persons have been cautiously trained to a system, with a view to give the division of labour its most beneficial effect, the slightest change, which would pass almost unnoticed by a single executive officer, operates as a powerful check on the aggregate."

In another letter from Portlock to Colby of the 24th October, we find:—

"Larcom has told me the result of the investigation, and whilst I deeply feel for those parts which must be unpleasant to you, I see in the whole enough to support you against the whole cabal. They have not dared to impugn the System, they have given an admirable testimony to its merits."

But Colby was by no means happy about the business. In January, 1829, he says that the Survey

"is languishing under the baneful effects of the late investigation. . . The two main difficulties to be overcome in the Irish Survey were: the vague and careless manner in which the Boundaries were laid out by the Boundary Department under the Irish Government, and the vehement desire of the Engineers to make apparent progress without due regard to the character and quality of the work. My task in compelling all parties to do their duty was most irksome and invidious."

He goes on to say that he always felt sure of support as long as the Duke of Wellington remained Master General. And he points out that the new instructions have had a marked effect in reducing output.

But things settled down. The order about traversing seems to have been withdrawn; and, as to measuring areas on paper, that is Ordnance Survey practice to this day, though the 12-inch scale is not used. In November, 1829, Sir Henry Hardinge writes to Colby, "I was happy to hear you are getting on prosperously with the Irish Survey." And there we can leave the Committee of Enquiry, which did less harm than might have been expected, but left behind it in the Ordnance Survey a departmental dislike of traversing, as of some slack and irregular method, which no decent surveyor would make use of if he could possibly employ another.

The Triangulation of Ireland.—There are thirty-four stations in the great triangulation of Ireland, rather more than one per county; they are all hill stations and the height of most of them is considerable. The highest is Brandon, in County Kerry, which is 3,119 feet above the sea. Next in height is Galtimore, 3,007 feet. Then there are Baurtregaum, 2,788 feet; Slieve Donard, the same height; Mount Leinster, 2,602; Knockmealdown, 2,601; Knockanaffrin, 2,470; Kippure, 2,465, and so on. The average height of these 34 hill stations being about 1,850 feet above sea level.

Two rays, Slieve Donard-Cuilcagh-Tawnaghmore, are sufficient to cross Ireland from the Irish Sea to the Atlantic. Three rays, Slieve Snaght-Cuilcagh-Keeper-Baurtregaum, cover the length of Ireland from the north to the south-west. The longest ray in Ireland is that from Cuilcagh to Keeper, which is 102 miles long; the next longest is that from Keeper to Nephin, which is over 98 miles long. From Cuilcagh about half of the country—that is, the centre and north—can be seen; and from Keeper the centre and the greater part of the south. So that from these two stations almost the whole of Ireland is visible. In the *Account of the Principal Triangulation* it is stated that the station of Slieve League, a mountain nearly 2,000-ft. high, in the extreme south-west of Donegal, was marked by a pile of stones, which "indicates the spot where the great instrument was once in position on the wildest headland probably in Great Britain or Ireland."

Practically all the angles of this triangulation were observed by Captain (afterwards Major-General) J. E. Portlock, R.E., with the 3-ft. theodolite B.O. (Board of Ordnance); the instrument, that is, that was made to the order of the Honourable Board and was first used in 1791. All this work was finished by Portlock by 1832, and the triangulation was then looked upon as completed, though, in the forties, two stations were revisited and three more were added to Portlock's. The probable error of a single angle was about two seconds.

And here, perhaps, a note as to what purpose the triangulation of Ireland was meant to serve may not be out of place. It was never seriously attempted to use the work in the determination of the figure of the Earth. The best proof of this is that, in the whole of Ireland only four latitudes were observed, and these not until 1843. The object of the triangulation of Ireland was the purely practical one of providing an accurate basis for the 6-inch maps.

The County Meridians.—There is a technical matter with regard to which we can say definitely that our predecessors were unnecessarily strict. In Ireland it was arranged that each series of 6-inch sheets for any one county should be plotted, independently of those of other counties, on a meridian chosen for that county. The method of plotting, that is, "the projection," was the following:—A central meridian was selected and this was represented on paper as a straight line; some point on this meridian was chosen as the origin. Then the position of any other point was fixed by the length of the great circle on the earth's surface, from the point in question, perpendicular to the chosen meridian; and the other co-ordinate was the distance along the meridian from the foot of the perpendicular to the origin. The great circles mentioned were plotted as straight lines at right angles to the central meridian. In this projection, which is an excellent one for the purpose, there is very little error in an east-west direction. But the error in a north-south direction increases approximately as the square of the distance from the central meridian, owing to the fact that, in nature, the great circles converge, whilst on paper they are plotted as parallel straight lines.

Our predecessors were well aware of the existence of this error, but seem to have been unnecessarily afraid of it. By limiting the area plotted to a single county they certainly reduced the resulting error to an altogether negligible quantity; but they might have been much bolder. The multiplication of meridians has the great disadvantage that there is discontinuity at every county boundary. The maps were, therefore, published county by county, and there is no detail shown beyond the county boundary, so that there is much waste paper.

If we take the meridian 8° W as a central meridian for the whole of Ireland, and measure from this meridian, we shall find that the greatest extension of land eastward is less than 105 miles, and the greatest extension westward is less than 115 miles. If the whole of Ireland were plotted on this one meridian, the greatest error of scale due to the projection would be less than 1 : 2300; and this error, by a device which need not be described here, could be reduced to less than 1 : 4600, and in computing areas this small error could be allowed for. The six-inch maps of Ireland might, therefore, have been plotted on one single meridian, instead of on 32 meridians—one for each county; and time, money, and inconvenience might have been saved. But to say this is not to undervalue that remarkable work, Colby's six-inch survey of Ireland, but only to point out that, in one particular, it suffered from what appears to us, nowadays, as an unnecessary scrupulosity.

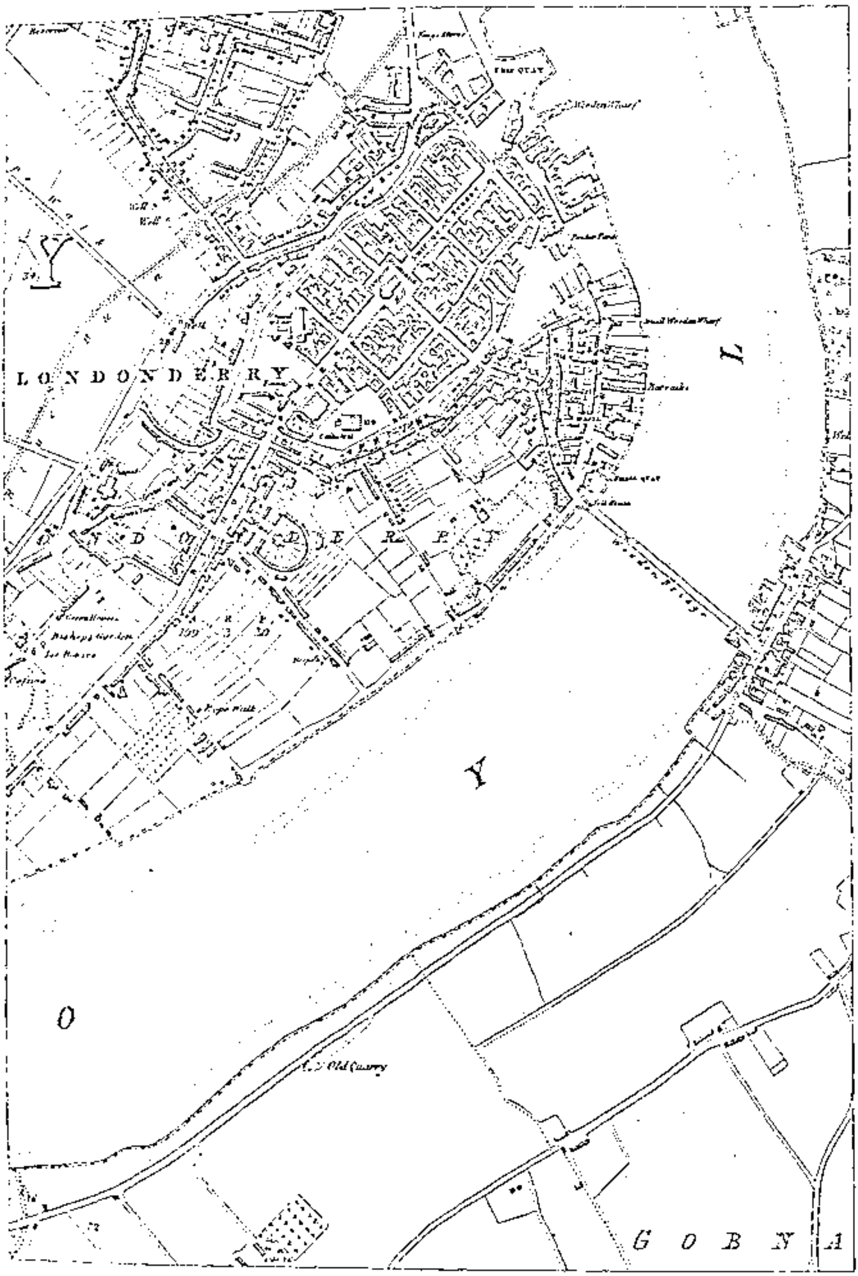
Progress of the Six-inch Map, 1829-1839.—Although the Smyth enquiry caused some delay, the field work of the six-inch map seems to have recovered in the course of a few years; but the rate of execution was not as rapid as Colby had originally hoped for. However, by the end of 1839, the work was very well advanced, and this was its state:—About three-quarters of Ireland, from the extreme north down to a line including Galway, King's County, Queen's County, Carlow and Wicklow, had been surveyed in the field. The six-inch sheets of the northern half of the country had been engraved and published. Only two counties had not been taken up, namely, Cork and Kerry. It would not now be many years before the whole undertaking was finished.

The maps were beautifully engraved; indeed, the engraving is so fine that it is difficult to reproduce it. During the greater

A PORTION OF THE FIRST 6-INCH ORDNANCE MAP.
LONDONDERRY SHEET 20.

Surveyed in 1830. Engraved in 1831, at the Ordnance Survey Office, Phœnix Park.

(Lieut.-Colonel Colby, F.R.S., &c., Superintendent).



MAJOR-GENERAL J. E. PORTLOCK, R.E.,
LL.D., F.R.S., F.G.S., &c.
1794–1864.

Reproduced, by permission, from a photograph in possession of the Geological Society of London.

part of this period the headquarter office at Mountjoy was under the charge of Lieut. T. Larcom, an officer of exceptional capacity. The engravers were: McCoy, Sandys, Macaulay, Duncan, Fraser, Chisholm, Aikman, Oldham, Darling, Sergeant West and Corporal Keville. The first county to be engraved, Londonderry, with an area of over five hundred thousand acres, was finished in 1832; and, as we have seen, the sheets of this county were submitted by Colby to King William IV, in May, 1833.

These early six-inch sheets show no contours; occasional heights are marked in feet, reckoned from low water; but the Irish datum was not exactly fixed until 1837. The various county, barony, parish and townland boundaries are very clearly shown, as, of course, was necessary, for the determination of these boundaries was the original main purpose of the map. The sheets have a very characteristic appearance, not only from the fineness of the engraving, but from the abrupt endings of the minor roads, and the number of circular, pre-historic "forts" which are scattered over the surface of the countryside. These interesting relics of the past average about fifty yards in diameter, and one may say that there is a "fort" in every two or three square miles. There are probably at least ten thousand of them in Ireland.

Portlock.—Nearly all the observations on the mountain tops of Ireland, for the Great Triangulation of that country, were taken by Portlock. His career is an interesting one to study, for it combines, to a remarkable degree, soldiering, surveying and more abstract science. He was born at Gosport in 1794, and was the son of Captain N. Portlock, R.N., who was one of the loyal colonists of America. The elder Portlock had entered the Navy as a midshipman under Captain Cook and was with him at his death. The son, Joseph Ellison Portlock, the subject of this notice, was educated at Tiverton and thence went to the Royal Military Academy and obtained his commission in 1813. The next year he took part in the siege of Fort Erie, in Canada, and for the greater part of the time was the only engineer officer in the trenches.

"He constructed the lines and *tête de pont* of Chippewa, at which Lt.-General Sir Gordon Drummond made his successful stand and saved Upper Canada. For his services on this occasion Portlock was thanked in general orders. He was afterwards employed on numerous exploratory expeditions. Portlock Harbour in Lake Huron was named by Sir Gordon Drummond in memory of Portlock's services."*

In 1824 he was posted to the Ordnance Survey and became Colby's confidential friend and companion, and in 1825 he commenced his work on the triangulation of Ireland, by taking part in the observations on Divis. In 1826 we find him on the very

* *Dictionary of National Biography.*

exposed station of Slieve Donard, in County Down; and in 1828 he remained in camp, on the top of Slieve League, in County Donegal, 2,000 feet above the sea, until the middle of January. The Great Triangulation was practically completed by him in 1832. He then directed the operations for the minor triangulation and organised an elaborate system of vertical observations for altitude. In the same year, 1832, he undertook a survey of geology and productive economy for Ireland. He had many difficulties to contend with; as he said himself, "Geology was permitted not commanded." In 1837, he formed, under Colby, a geological and statistical office as a branch of the Survey. It had been intended to publish elaborate memoirs of all the counties, but after the publication of one volume of the series, this was stopped on financial grounds. The Geological Survey was, later, resumed.

Portlock's memoir of Londonderry was the commencement of the Geological Survey of Ireland.

Sir Roderick Murchison, then President of the Royal Geographical Society, speaks thus of Portlock in his address of May, 1864:—

"This volume of Portlock's on the geology of Londonderry is a perfect model for fidelity of observation and minute attention to phenomena. To the quickness of his eye, and his resolution to surmount difficulties, we also owe the first detection in Ireland (Tyrone) of those trilobites and other organic remains which enabled him to identify these rocks with the Silurian rocks of England and Wales very shortly after my first classification of these older palæozoic rocks. . . . He was, in truth, a geologist quite after my own heart; for in him an acquaintance with rocks, minerals, and fossils was united with the full knowledge and feeling of a true physical philosopher."

Murchison then quotes Sir Thomas Larcom, who was Portlock's friend and contemporary on the survey:—

"The characteristics which shone forth in Portlock during his well-spent life, whether as a soldier, a geographer, or a geologist, were undaunted courage in facing difficulties, Spartan endurance and invincible perseverance in overcoming them. Endowed, when in the zenith of his career, with a frame and nerves of iron, he exhibited such a vast power of continuous labour that he achieved every object he had in view; whilst great ability and a pure love of knowledge were in him guided and governed by the highest sense of honour and moral rectitude."

In 1843 Portlock's work on the Survey of Ireland came to an end. It appears that about this time Colby and Portlock no longer saw eye to eye, and it must be admitted by the truthful historian that Colby had rather a knack of quarrelling with his officers; at least, that was the case with Drummond, Reid and Portlock, all very able men. But, however that may be, in 1843 Portlock, who was then 49, was ordered to Corfu. In 1849, he was C.R.E. at Cork; in 1851, he was appointed Inspector of Studies at the

R.M.A. In 1856 he was C.R.E. at Dover, and in 1857 he was appointed a Member of the Council of Military Education. He retired in that year, but retained his post till 1862.

Whilst he was at Woolwich he wrote the *Memoir of the late Major-General Colby*. Colby died in October, 1852; the first instalment of the memoir appeared in the R.E. *Professional Papers* for 1853, and the memoir was continued in 1855 and '56. This account is more than a biography, and contains a good deal of technical information in addition; but it is, perhaps, most useful now in its main purpose of throwing light upon the life and character of Colby. If it were printed in large print it would make quite a substantial book, for it contains some 90,000 words. Portlock's own character comes out very well in this memoir, which was written in pious memory of his old chief, in spite of the fact that Portlock did not feel that, in later years, he had been very well treated by him. He says at the very end of the memoir, in admirable words:—

"In my early connection with the Irish Survey, I was his chosen assistant and confidential adviser. . . . In the later period of my connection he was estranged in feeling towards me; but as I now look back on the past from a more distant point of view, I cannot doubt that there were faults on both sides . . . and feeling that the early kindnesses and services I received from him far outweigh the later harshness. . . I am proud to have had the opportunity of recording my respect for the memory of a man towards whom, when living, I always felt and expressed affection."

From 1856 to 1858 Portlock was President of the Geological Society of London.

He died at his home near Dublin in 1864, aged 70.

There is a curious letter from Portlock to Larcom, who preserved it amongst a collection of letters now bound together and kept at the Ordnance Survey Office. Larcom was six or seven years younger than Portlock, who writes in 1826 from camp in the north of Ireland, evidently suffering from ague:—

"My dear Youth, I am, of course, better to-day, and must for a time live on hope. I send you Yule's Diagram of Points. [Then follow some technical instructions.] Take care of yourself. I drink hard for security. Not that I recommend Intemperance. Sim ought to have known better than to drive the Pegs too low. Ever, my dear Youth, Your miserable J. E. PORTLOCK."

On October 12th, 1826, he writes to Larcom from Sleibh Donard:

"My dear young Gentleman,—On the opposite whole margin you have the necessary data for Holyhead. Those for Snowdon I shall despatch To-morrow or next day addressed to you at Carnarvon. . . I hope to be off myself in the course of next week. Drummond has made good his footing: he looks very unwell and would have acted more wisely had he remained below."

On the opposite page are instructions for setting the instrument at Holyhead station so as to intersect the light on Sleibh Donard.

There is a bundle of letters from Portlock to Colby, written between 1825 and 1829, almost entirely about the trigonometrical observations. From Newtown, Limavaddy, November 18th, 1825, Night :—

"Wind is now so constant either from one quarter or another that it is impossible to observe without a Tent. . . November 19th, My Tent still standing though almost every Cord has been broken and repaired."

Knocklayd (1,677-ft.), in Antrim, July 15th, 1827 :—

"There is as yet no improvement in the Weather as regards observations. Morning after Morning I have had the mortification of seeing the Horizon shrouded in mist or fog and the Sun rising high before he could break through. . . My only dread is that, deceived by the lovely weather, you may feel a difficulty in fully estimating the extent of haze which surrounds this Hill."

From the same station, August 17th :—

"Yesterday and this morning I have had several takes of Ben Lomond, most, indeed, hazy, but two or three very fair and the whole giving a mean difference only 2" from what it ought to be according to the former angles. Cairnsmuir has not again shown itself sufficiently clear."

From Sawel (2,228-ft.) in County Derry, September 18th, 1827 :—

"I avail myself of some Clouds, which, I hope, will be passing, to write you a few hasty lines. You certainly carried with you the observing weather, as nothing important has been done since. Friday and Saturday, constant Fog. Sunday baffling clouds, a few Donegal Points in the Afternoon. . ."

Slieve Snacht (2,011-ft.), in County Donegal, October 4th, 1827 :—

"I am told that the Weather is free below, and I rejoice for all your sakes that it is so. Here we have an interminable Fog. The Night is likely to be wild, but we are so secured by huge Stone Traverses that we have nothing to fear. . ."

Cuilcagh (2,180-ft.), in Fermanagh and Cavan, June 25th, 1828 :—

"On Friday last we met with a singular accident. It was a stormy, unsettled day, but one, during the intervals of Showers, very favourable for churches, and I was, therefore, fixed to the Observatory. A violent hailstorm came on, and I was just stooping to take up one of the Microscope leaps, my head being near the open side of the Observatory, when I received a smart Slap (as it were) on the top of my head from a passing flash of Lightning, and raising my head, somewhat surprized, I just saw Gunner Phibbs who stood in front (being watch) roll round and tumble to the ground. He rose again, but instantly fell and remained in a kind of torpor, breathing heavily, for about twenty minutes, when he began to recover. He seemed stupefied and quite unconscious of the true cause, feeling as if intoxicated and fancying that he had slept on his Post. As soon as he could walk I sent him down the Hill, when he was bled."

Writing from camp at Croghan, County Wicklow, on 3rd January, 1829, Portlock says:—

"As to Health, I heartily thank you for your kind concern about us all. . . I have little apprehension as to myself, that Bane a Fire not being admitted to my Quarters. The Men, too, are in excellent Health. ."

Kippure (2,465-ft.), in County Wicklow, July 5th, 1829:—

"Yesterday Afternoon, at 5 p.m. I for the first time saw the Precelly Heliostat and took it twice with Lugnaquilla and Bray Head, the only convenient referring Points in sight. Clouds then cut it off, but . . we shall doubtless see it often again. . ."

This ray from Kippure across the Irish Sea to Precelly, in Pembrokeshire, is over 107 miles in length.

The letters are all much in the same strain. They naturally dwell a great deal on the weather. But Portlock evidently enjoyed the work, in spite of fog and storm, on the tops of the Irish hills.

His was an interesting life. Early in his career campaigning and exploring in Canada; then carrying out, almost single-handed, the great triangulation of Ireland; then soldiering in a more humdrum way in Corfu, Cork, Dover and Woolwich; the founder of the Geological Survey of Ireland; President of the Geological Society. Larcom uses the right word when he speaks of Portlock's well-spent life. In later years his name has been almost forgotten on the Ordnance Survey. It is hoped that the foregoing brief account of his career may serve to revive the memory of this fine old officer, who, indeed, deserves to be remembered, with Roy and Mudge, with Colby, Drummond and Larcom.

Sir William Reid.—When the Survey was begun in Ireland, in 1825, Colby placed Major W. Reid in charge of the Mountjoy office, and, in effect, in general charge of the operations in Ireland whenever Colby was called to London, as not infrequently happened. Reid was an officer of outstanding ability, who had served with great distinction in the Peninsula. But he had his own ideas as to how the Survey should be conducted, and as these differed from Colby's, especially at the time of the Enquiry of 1828, he left the Survey at the end of that year. So far as the Survey is concerned, we do not again come across him until 1850, when he did the Department a very good turn by recommending Lt. Alexr. Ross Clarke for employment on it.

Reid became, successively, Governor of Bermuda and Barbados, then Chairman of the Executive Committee of the Great Exhibition of 1851, and finally Governor of Malta. He died in 1858, aged about 67. He was the author of Reid's *Law of Storms*, and was a Fellow of the Royal Society.

Sir Thomas Larcom.—Good men seem to have been common in those days; Colby found to succeed Reid an officer who was in every way fitted for the post, and who, in after years, took a large part in shaping the history of Ireland. Thomas Aiskew Larcom was born in 1801, and after a brilliant course at the R.M. Academy, was commissioned as 2nd Lieutenant in the R.E. in 1820. He was posted to the Ordnance Survey in 1824. When Reid left, Larcom took his place at Mountjoy.

"Here he soon had the work in his own hands. He organised the large body of civilians and soldiers required for the multifarious operations of compiling, engraving and publishing the county maps of Ireland, the beauty of which has never been exceeded; adopted the electrotype process, and introduced the system of contouring. Mountjoy became a centre of scientific education, and the resort of scientific men."*

During his 18 years at Mountjoy he served on many committees and commissions, and made use of every opportunity to increase his knowledge of Ireland. He took immense interest in all that concerned Ireland—history, archæology, language, literature, topography, place-names, folk-lore and what not. He acquired a wonderful fund of information about the country and people, which was afterwards to serve him in good stead.

In 1846, when the original six-inch survey was completed, Larcom left the Survey and became a commissioner of public works. In the Great Famine he was appointed chief director of relief works. In 1853 he was appointed Under-Secretary for Ireland, and he remained in this post until 1868. It is a testimony to Colby's good judgment in the selection of his officers that two of them, Drummond and Larcom, became the virtual rulers of Ireland. "Larcom, adopting the policy of his friend Drummond, undertook to govern all parties alike with even-handed justice, to remove abuses and prevent disorder."

"If he had been Viceroy for those sixteen years, he could not have been more entirely identified during that time with the government of Ireland. Each of those great officers. . . . Whigs and Tories alike, vied with each other in their recognition of his services. Men like Lord Clarendon and Lord Mayo were his enthusiastic friends; splendid gifts of plate, and flattering addresses were presented on his resignation, and, till the infirmities of old age intervened, he was frequently consulted upon Irish affairs by subsequent Governments."†

Besides being a clever man, he was evidently a very industrious and methodical one. It is said that there are hundreds of bound volumes of his notes and memoranda on a great variety of subjects; most of these volumes have passed to various learned societies in Ireland. There are four volumes of letters, with his notes, now in the Ordnance Survey Library at Southampton; three

* *Dictionary of National Biography.*

† *Edinburgh Review*, No. 336. Quoted in Whitworth Porter's *History of the Corps of R.E.* Vol. II.

of these deal with contouring, and one with levelling. The volumes are full of technical interest; one volume, in particular, contains a valuable series of examples of various methods of depicting hill features—experiments which range from 1824 to 1847. Some of these have a curiously modern look.

On his retirement Larcom was created a baronet and an Irish Privy Councillor. He had already been made a K.C.B. He died in 1879.

Here is a letter from William Denison to Larcom. Denison (afterwards Sir William Denison, and some time Acting Governor-General of India) was, when he wrote this letter, the first editor of the *Professional Papers of the R.E.*

Woolwich, March 4th, 1841.

My dear Larcom,

There is some comfort in corresponding with you: one always gets some encouragement or assistance, while from others one too often meets with just the reverse. I must say that with some few exceptions I have met with a very small allowance of support or assistance from my Brother Officers; no one seems ever to think that his comrades may be benefitted by the information he may have in his possession, and consequently everyone waits till a subject is actually suggested to him before he thinks of putting pen to paper, though were he conscious of the benefit it would be to himself in perfecting and extending the knowledge of the subjects he is conversant with, he would make a practice of embodying his knowledge in the shape of a paper. This, however, is a mere expectoration of bile. . . .

I am glad you are pleased with this volume. I hope to get something from Alderson about Acre. I saw a letter from him to Fox giving a very clear account of what was done there, and some very sound remarks about Sea Batteries when exposed to such heavy fire as is now brought to bear against them. . . . I was not aware of what you have been doing about contouring, but I am rejoiced to hear that you have succeeded in introducing it, upon the six-inch scale; it is the only mode of showing the ground. I have long been an advocate for it upon Plans of any size—on a small scale it would be absurd, but on the six-inch it will give you an enormous mass of information at a glance, relative levels, shape of ground, etc. I think it would be well worth a paper and should be very glad if you would take it up. . . . Shall you be able to establish your levels all round Ireland with the necessary degree of accuracy for general Tidal observations? Is there not a dispute as to the Sea Level? What do you take as your datum line? I have not seen the results of Whewell's work at Bristol; he seemed to have taken very great pains in his levelling. . . .

Thanks for your memoir of Hogan. I like the style of the figure of Dr. Doyle, though I dislike the allegorical figure of Ireland. I hope he will do justice to Drummond. I am working away in the Dockyard here. I am rather short for money this year.

Yours very truly,
W. Denison.

Irish Place-Names and John O'Donovan.—In the course of the survey of Ireland it became necessary to ascertain the correct forms of spelling of the Irish place-names. This was no easy task. In every country the lapse of time results in a gradual corruption of place-names; but in Ireland, in addition to this natural cause of error, there was an artificial cause, due to the orders of the English Government in the seventeenth century. Larcom quotes an order of King Charles I, which states that the "barbarous and uncouth names of places" in Ireland much retard the reformation of the country, and directs "the Lord Lieutenant and Council to change such names into others more suitable to the English tongue, annexing the ancient names in every grant so altered." Colby fully appreciated the importance of getting correct forms, and, when Larcom took charge of the Mountjoy office, the latter threw himself heartily into the difficult work of restoring the names. Larcom says, "as for the orthography of the names engraved on the maps of the Ordnance Survey, the different spellings and *alias* names of every townland were collected from all accessible documents, some . . . . of very great antiquity; and, finally, local enquiry and examination were made by an Irish scholar on the spot, to render the name ultimately adopted as nearly as possible consistent with the ancient orthography."* All this information was collected in *Name Books*, which now form a priceless record of Irish place-name study. Again, Larcom says that the full results of this investigation will only be seen in the future; it arose "from the desire to ascertain a correct orthography for the numerous names of places, more especially parishes and townlands, which alone amount to nearly 70,000. . . . These names were commonly of Irish origin, and frequently of great antiquity. Lieut. Larcom first began himself to study the Irish language, and investigate the names as they arose, but this was obviously insufficient."* Many of the names

"were in Latin, many in Irish, contained frequently in M.S. charters and grants. When all had been collected that libraries and records could furnish, an investigation by a qualified Irish scholar was made on the ground, where, by additional inquiries, conversation with the old inhabitants, and examination of the locality, little difficulty was experienced in discovering the meaning of the name, and its correct orthography. . . . the practice was to adopt that one among the modern modes of spelling, which was most consistent with the ancient orthography. The documents thus collected form in themselves a most valuable topographic library, such, perhaps, as no country in Europe possesses in the same condensed form."

The chief of the Irish scholars mentioned above was John O'Donovan. An excellent source of information with regard to

* Portlock's *Memoir of General Colby*.

John O'Donovan, LL.D.
1806–1861.
From a portrait painted in 1838 by C. Gray, R.H.A.
Reproduced by permission.

his life is the account written by Mr. Henry Dixon in *An Leabarlann** for April, 1906. What follows is based, by permission, on this source, which should be referred to by all interested in the subject.

John O'Donovan was one of the five sons of Edmund O'Donovan, who belonged to a family that had settled in Kilkenny early in the seventeenth century. John was born at Atateemore in July, 1806. His father died when John was eleven. It is said that it was from an uncle that he first caught "that love for ancient Irish and Anglo-Irish traditions" which he preserved all the rest of his life. He says himself that he "transcribed Irish pretty well in 1819." Early in 1821 he was sent to school at Waterford; and in 1823 he went to a Latin school in Dublin, where he remained until 1827. In 1830, whilst staying in Queen's County for his health, he made extracts from the *Annals of the Four Masters* and read many books bearing on Irish history.

In this year, 1830, to use his own words, "I applied to Capt. Larcom, then Lieutenant Larcom, for employment. I had known Mr. Larcom since the year 1828, when I taught him some lessons in Irish, and he wrote to me immediately, offering me a situation at a very small stipend, of which I accepted after some hesitation. . ."

O'Donovan was immediately employed upon the investigation of place-names. The various forms of the names were written in *Name Books*, and each authority quoted. This involved much research into the history and topography of the district, in fact, here, as always, history, topography and philology went hand in hand. "To O'Donovan the work was of special import. To this work and to his great application may be attributed the wonderful knowledge of history, archæology, and topography displayed in the innumerable writings associated with his name." He was periodically sent out into the field; and, taking with him the information collected in the *Name Books*, he was able, by an examination of the locality and by questioning the old inhabitants, to fix with some certainty the correct forms of the names. "The system . . . of visiting each place was afterwards not followed out, and O'Donovan was asked to decide on the proper names of places he had never visited, a system which he protested against." His many letters to Larcom giving the results of his investigations are a mine of information on philological, historical, and archæological matters, and are frequently drawn upon.

It had been the intention of Colby and Larcom to publish a series of memoirs of the parishes of Ireland. This magnificent scheme was never carried out; or, rather, only one parish was so dealt with. This parish was Templemore in County Londonderry; and the *Templemore Memoir* was published, with the assistance

*Dublin. Browne & Nolan, Ltd.

of the British Association, in 1837. It gives an account of the topography, geology, botany, and zoology of the parish; a description of the towns and a history of the townlands; a third section deals with statistics, social economy and manufactures. "The preface written by Colonel Colby states that the section relating to history, archæology and antiquities was written by George Petrie and John O'Donovan."

In 1845 O'Donovan published his *Irish Grammar*; in 1851-56 there was published his translation of the *Annals of the Four Masters*, with introduction and notes; in 1849 he was appointed Professor of Celtic Languages in the Queen's College, Belfast; in 1856 O'Donovan was elected a corresponding member of the Royal Academy of Berlin, on the proposition of Jacob Grimm. He died at Dublin on the 9th December, 1861, and was buried in the Prospect Cemetery. Inscriptions on tombstones are usually of too flattering a nature to be regarded as reliable material for history; but the account of O'Donovan's work on his tombstone is accurate and just. It reads:—

By his Irish Grammar, his edition of the Annals of the Four Masters, his labours on the transcription and translation of the Brehon Laws, and his invaluable contributions to our knowledge of the topography and local history of his country made during his connection with the Ordnance Survey, he laid a sure foundation for sound and scientific Celtic Studies and established his position as a master of Irish Philology and Archæology. . .

O'Donovan was helped in his investigations by all classes of his countrymen. He writes, for instance, from Belfast on 15th March, 1834:—" Dr. Crolly, R.C. Bishop of Down and Connor, has given me the following letter to the Priests of the Diocese:—

'The Bearer, Mr. John O'Donovan, is employed by the Ordnance Surveyors to ascertain accurately the old Irish names of townlands, villages, etc., for the purpose of making the general and particular Maps of Ireland, and its different counties, as perfect as possible. In this useful, laudable, and patriotic pursuit I trust that he will obtain from the Catholic clergy every assistance which they can afford in order that Mr. O'Donovan may be enabled to accomplish his interesting and important object.'"

O'Donovan's letters to Larcom at the Mountjoy office are full of interest to this day and are written in a free and natural style, very different from that of most official reports. Thus, on the 23rd April, 1834, he writes from Castlewellan:—

" I have this day made a pilgrimage to Sliabh Domanghairt [Slieve Donard on the maps, 2,800-ft. high]. I have been induced from many motives—1. To endeavour to get the names of the Mourn Mountains from its lofty summit. . . . 2. To gratify a curiosity excited in my mind by the gigantic appearance of the mountain itself from every part of the county, and by the following passage in Colgan's *Acta S.S.*:—' In the territory of Iveagh and Diocese of Dromore, there are two churches dedicated to St. Domangard, one (which is at the foot of a very high mountain overhanging the eastern sea) is called Rath Murbhuidlg by the ancients, but at this date Machaire Ratha; *the other* on the *summit* of that lofty mountain, *far removed from the habitation of every human being*, and which is frequented by great multitudes of pilgrims, etc. Hence this mountain, which was called Sliabh Slainge by the ancients, is at this day commonly called Sliabh Domhangaird from this Saint.' My third reason was, I suppose, to wash off in S. Domangard's well the many sins I have committed by cursing dogs, ganders, over-inquisitive people, and petty country landlords."

Downpatrick, April 29th, 1834:—"Please to desire Lieut. James [afterwards Sir Henry James] to insert into the *Name Books* the names of all the mountains, rocks, streams, valleys, loughs, etc., that are to appear on the maps of the barony of Mourne. . . These mountains bear very curious aboriginal names, and I am very anxious to have a perfect list of them lest I might omit any. . ."

Downpatrick, May 2nd, 1834:—

"In the parish of Tyrella there is a townland called Ballykinler, which Vallency, Beauford, and in all probability O'Reilly, would have explained, the *Town at the Head of the Sea* . . . but as soon as I heard it pronounced by an old Irishman, I said it must mean the *Town of the Candlestick* (horrid name ! !), and silly conjecture for any sensible person ! Be it so, say I—but turn to the fact. Look at Harris's *History of the County of Down*, 1744, and you will find, Ballykinler lower, middle, upper . . . formed the parish of *Ballykinler*, the tithes of which were appropriated to Christ Church, Dublin, for WAX LIGHT. . ."

O'Donovan's letters to Larcom were presented by the Ordnance Survey to the Royal Irish Academy. The three letters above quoted are taken from *An Leabarlann*, for June, 1909, a number which deals with the letters of O'Donovan, written in 1834, from County Down.

(*To be continued.*)

ERRATA, *R.E. Journal*, DECEMBER, 1925.

On page 550, line 26, for "Offaty" read "Offaly."
On page 661, line 45, for "(a-b)/b" read "(a-b)/a."

DEMOLITION OF THE S.S. "CYRENA," WANGANUI, N.Z.

By LIEUT. COL. J. E. DUIGAN, D.S.O., N.Z.S.C.

IN the month of May, 1925, the S.S. "Cyrena," carrying case oil and benzine from the East, while entering the port of Wanganui, N.Z., struck what was thought to be a waterlogged tree trunk on the bar of the River. The dimensions of the "Cyrena" were approximately, length 288 feet, beam 54 feet, draught 26 feet. The freighter had previously called at the port of Auckland and discharged some thousands of cases of cargo from her midship hatches. It is presumed that the back of this ship was broken when she struck the submerged obstacle owing to the fact that the weight was all in the fore and after ends of the vessel. A few hours after the ship struck she was floated off but found to be leaking badly forward of the engine room which took up the whole of the after end of the ship. The pilot in charge of the vessel decided that it would be unwise to proceed into the River entrance and she was beached a quarter of a mile to the north of the mole.

The case oil and benzine was salvaged from the ship, but heavy weather came on, causing the vessel to break in half just abaft the bridge amidships. Further heavy weather caused the fore part of the ship to be driven on to the beach about the half tide mark whilst the after portion was driven on to the north mole (see Photo 1). and threatened to break through it, thus blocking the port. At this juncture the Defence Department was approached by the Wanganui Harbour Board to demolish the wreck. The ship was abandoned by the salvage party who stripped her of everything of value. The wreck was inspected immediately on the request of the Wanganui Harbour Board and a programme of action was adopted which proved to be sound from the results achieved.

The following stores were ordered from Ordnance in Wellington and shipped to Wanganui by a coastal steamer :—

Gun Cotton Wet (old submarine mining)	4,480 lbs.
Primers 1 oz. Field dry	600
Detonators No. 13	300
" 8	300
Fuze, slow	150 fathoms.
Boxes jointing and testing, complete ..	1
Leads, electric	3,500 yards
Exploders, Field Service	2

	.. .. ..	200 fathoms.
Spun Yarn ..	.. .. ..	1 lb.
Twine	.. .. ..	1 coil
Lashings $\frac{1}{4}$ inch ..	.. .. ..	
Water proof bags.	6 to be made locally to hold 50 lbs. weight gun cotton.	

After some considerable delay owing to the equinoctial gales, a party consisting of two Officers, New Zealand Staff Corps and four N.C.O's of the old Royal N.Z. Engineers, now Electric Light Section of the R.N.Z.A., commenced operations.

Calculations.

All calculations in connection with the demolition were based on the formula $\frac{3}{2}$ B t^2 and this formula proved to be absolutely accurate. It would seem unnecessary to give the calculations in detail, but at the end of the demolitions it was found that 100 lbs. of gun cotton was over out of the calculated total amount of 4,480 lbs.

The scheme of operations was divided into two distinct portions :—

A—Forward Portion.

Scheme A was as follows :—

(*a*) To cut the ribs and sides of the wreck in between the forecastle and the bridge on the port side.

(*b*) To cut the deck on the port side and drop this side out to port.

(*c*) To cut the deck between the forecastle and the bridge and to drop it into the hold.

Note.—This deck was supported by 15 6" round steel pillars riveted to the keelson and deck girders. It was decided not to cut the pillars but to leave them standing, in order that the deck when cut would be thrown outwards, leaving room for the starboard side to be dropped flat into the hold.

(*d*) To cut the ribs and hull on the starboard side and let this drop to port, at the same time dropping the bridge portion outwards and aft.

(*e*) To cut the forecastle clean through in two places, up the sides and through the decks, which were three in number, and fore and aft, where it was embedded in the sand and to break the remainder up later by small charges.

Note.—As this portion of the wreck was only 600 yards from the nearest houses large charges could not be used.

B SCHEME. AFTER PORTION.

(*a*) To place four made-up charges of 50 lbs. each in waterproof bags well down inside the hull as follows :—
One on each side of the boiler room between the boilers, two in number, and the hull of the ship,
One in the stokehold, and
One in a cofferdam forward of the stoke hold.
To fire these charges simultaneously.

(*b*) To cut through the engine room sides down to low water mark and along the decks fore and aft and necklace the funnel.

(*c*) To continue the cut across the beam of the ship and thus leave the seas to do the rest forward of the engine room.

(*d*) To cut through the stern aft of the engine room bulkhead.

(*e*) To cut the tween decks ribs, stern post and rudder pillar allowing the whole of the remains to drop down to the level of the mole.

The after portion of the wreck was tackled first owing to the danger of it breaking through the mole, as already explained. A hand trolley was loaned by the Harbour Board Engineer and the stores loaded up for the first day's work in weather that one might expect on the Coast of Biscay but not in New Zealand. It was high water with a heavy flood coming down the River. The mole was slippery and spray was breaking over the wreck. The conditions were so bad that after several attempts to place charges in position a halt had to be cried until the tide dropped. A slip by any member of the party meant injury on the rocks with every chance of being washed out to sea and incidentally into Davy Jones' Locker. As the tide dropped the seas broke outside the wreck and, with new vim and the aid of the Harbour Board Engine and a truck, the party started off again for the wreck. The four charges mentioned in (*a*) were successfully lowered into position and the party retired 800 yards up the mole to watch the effect. These charges were arranged two in series with an earth return and fired simultaneously by lashing the rack handles of two exploders to a piece of 2in. x 1in. timber. The result was as follows :—

1. The sides were blown out for a distance of 10 ft. on each side of the charges.
2. The two boilers in the boiler room were standing on end and the cofferdam bulk heads were blown out, giving the sea a free chance to assist.

NOTE.—These charges had 8' of water over them when fired. Further extensive damage was done by these charges and the sound

THE DEMOLITION OF S.S. "CYRENA."

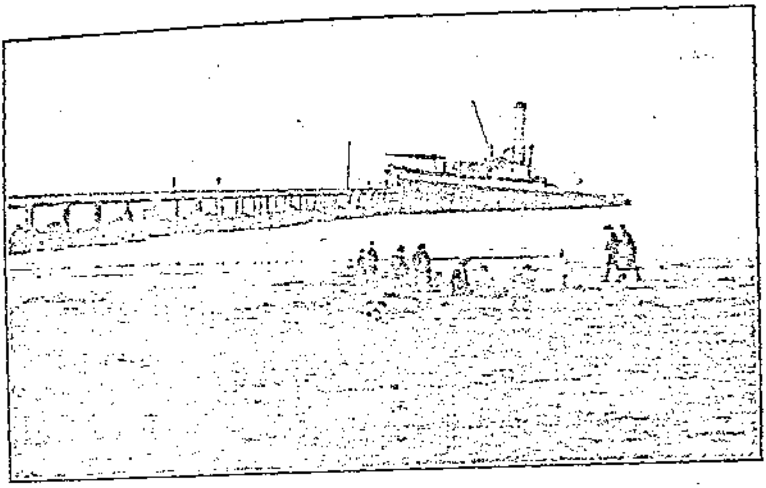


Photo 1. The after portion.

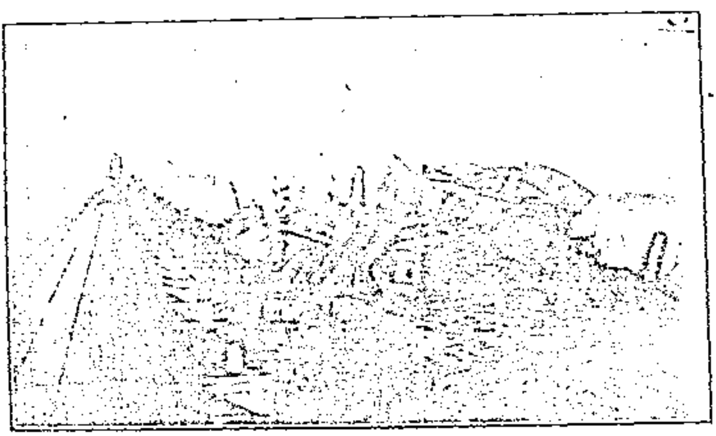


Photo 2. The after portion demolished.

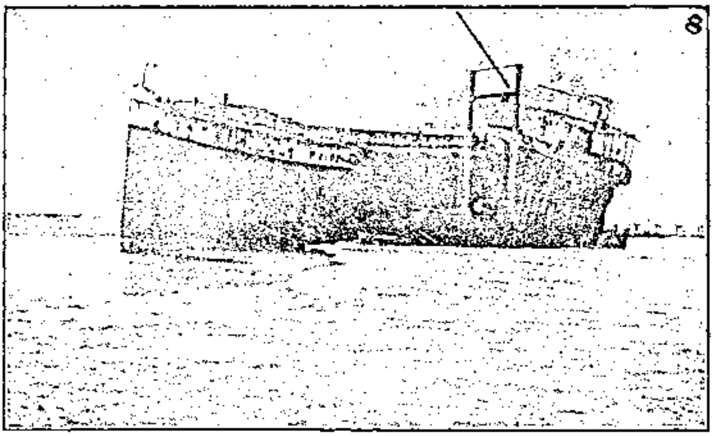


Photo 3. The forward portion.

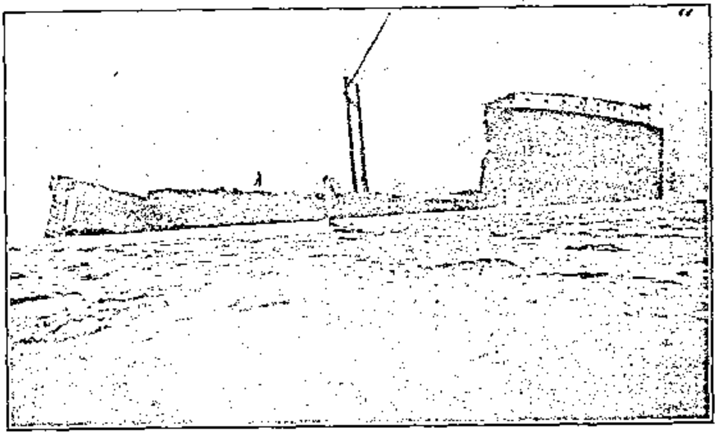


Photo 4. The forward portion demolished.

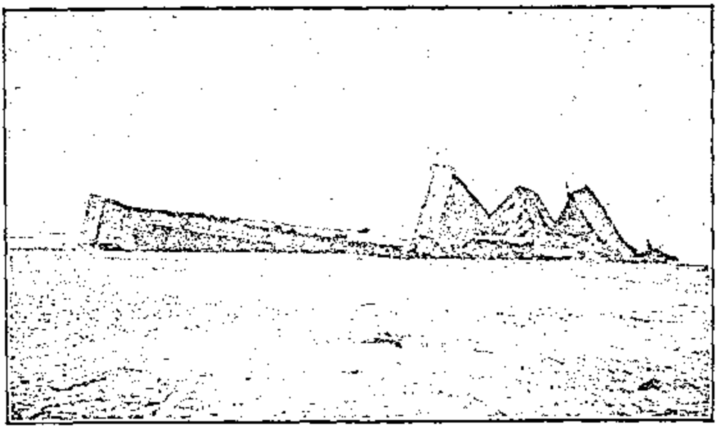


Photo 5. Final condition of the forward portion.

of grinding steel, rivets breaking, and the bulk heads moving about with every sea showed that the underwater damage was very considerable.

On the second day of work it was decided to get rid of the funnel which was necklaced with ½ slabs guncotton and fired electrically with two detonators in series. This funnel was a most tenacious beast, as after cutting it clean through all round it defiantly stood up, held by two ½ in. angle irons, 3 in. wide, opposite each other, and it was not until one of these was cut that it decided to lower itself gently down as if lowered deliberately with a block and tackle. Work progressed slowly but surely and at the end of the six days' operations the wreck was reduced to the mass of debris shown in photograph 2.

During work on the extreme after part of the wreck, a deck cutting charge fired by fuze caught fire due to the dryness of the wet gun cotton and the manner in which the fuze had been allowed to lie along the length of the charge. When this was seen from the locomotive which we were now using for running up and down the mole, the driver put up a world's record over 400 yards. This charge detonated when the fuze reached the detonator. The Sergt. Major was asked later by the Engine Driver if he heard a piece of steel whiz past during the trip up the mole and retorted "Yes, I heard it twice, when it passed us and when we passed it."

The forward portion of the work offered more scope for ingenuity than the after portion. The plan of attack remained as originally designed and it was launched at 9 a.m. on the 7th day. It is not proposed to enter into more details than necessary but we brought two exploders into action from zero hour and commenced cutting the ribs and hull as low down as possible on the port side. An attempt was made to fire four detonators in series off each exploder simultaneously but we found that we could not rely on firing more than two off each. This meant delay and was not due to the exploders which were tested and fired through 100 ohms comfortably. No doubt the resistance of the detonators varied considerably. They had only been tested for continuity.

In cutting the sides of the ship the charges were made up by nailing the guncotton on boards about 12 feet long, as recommended in the *Manual of Mining and Demolitions*. This was found to be very successful but one must watch for close contact between the charge and the objective, otherwise the cutting effect is uncertain. Close contact with the sides was gained by cutting partially through the boards the guncotton was nailed on to, or by placing a weight against the charge, but this is sometimes difficult to arrange. In cases where it is impossible to flag off a large danger area, anything that may fly, such as angle iron, etc., should not be used to keep the charge in close contact with the object to be demolished. In one instance, a piece of steel weighing 10 lbs. flew 300 yards from a 15 lb. charge placed on the side of the wreck. The local press stated that steel was flying at Castlecliff and making a noise like an aeroplane. This piece did, and fell inside the danger zone 30 yards from a seaside cottage.

All the charges that had been fired on the forward portion up to this had been fired from behind a steel tank, but it was considered that discretion was the better part of valour and our place of retreat was moved to a safer place under the after end of the forward part of the wreck.

On the eighth day, cutting of the port side was completed and fell to port. The ribs and hull in the hold of the ship were cut simultaneously. Later in the afternoon, on the same day, the deck was cut out and the stanchions holding it up amidships which had been left intact, threw the deck out to port and into the side of the wreck already dropped (see photo 3.), thus leaving room for the starboard side to fall into the hold as originally projected. (See photo. 4.) It was most surprising to find that the twin masts remained standing and only the wooden topmast had suffered when the deck weighing 80 tons fell. The twin masts were next cut and fell on deck as if placed by hand. On the following day the starboard side was laid flat (see photo 4,) and the bridge portion went at the same time outwards and aft making a clean looking job and one that the demolition party were proud of. The forecastle and forward cofferdam only remained. This was cut into three pieces and left to the mercy of wind and waves, but proved very difficult to dispose of and it would have been a waste of money to cut it into smaller sections. Where possible, charges placed on the forecastle section were tamped. The value of wet sand for tamping cannot be exaggerated.

This ended the operations which I hope will be found interesting to the Corps of Royal Engineers.

BRIEF HISTORY OF THE ROYAL ENGINEERS WITH CAVALRY IN FRANCE DURING THE WAR 1914-1918.

By Colonel W. H. Evans, D.S.O.

The subject is treated under the following heads :—

A. The British Cavalry Corps, formed October 11th, 1914. } Abolished March 25th, 1916.
B. The Indian Cavalry Corps, formed December 2nd, 1914. }
C. The Cavalry Corps, formed September 4th, 1916, and existing until the end of the war.

A. The British Cavalry Corps.
(1st, 2nd and 3rd Cavalry Divisions.)

1. At the outbreak of the war an organisation existed for the formation of a Cavalry Division of 4 Brigades, and a Field Squadron, R.E. (afterwards the 1st), had been formed at Aldershot in March, 1914, from the 1st (Aldershot), 2nd (Chatham), 3rd (Canterbury) and 5th (Aldershot) Field Troops. There was also the 4th Field Troop at the Curragh.

2. The 1st Field Squadron (Major E. S. Sandys, Capt. P. O. L. Jordan, Lieuts. G. E. H. Sim, T. H. Foster, R. R. Egerton and R. G. W. H, Stone) mobilised at Aldershot, with the 1st Cavalry Division, on August 4th, 1914; it landed at Boulogne on August 16th, and concentrated round Maubeuge on August 19th. The Division marched north, and during the battle of Mons, on the 23rd, the Squadron prepared the bridges between Pommerœul and St. Aybert for demolition and put Quievrain in a state of defence. The next day, the commencement of the retreat, the Squadron sent back all their wheels and thenceforth acted as mounted infantry, the only R.E. work done consisting of cutting fences for the passage of Cavalry; they were in the firing line at Audrignies on the 24th, retiring to Jenlain; held Solesmes on the 25th; retiring via Beaumont, Ligny, Ronssoy, Roui Le Grand and reaching Flavy Le Meldeux, near Ham, on the 28th; on the 29th they fought a delaying action with the 2nd Cavalry Brigade round Guiscard and Crisolles, reaching Ourscamp in the evening; on the 30th, with two Squadrons of the 19th Hussars, they covered the retreat of the infantry, reaching La Croix St. Ouen in the evening, via Divisional Head Quarters at Compiègne, where they again picked up their wheels. On August 31st the Squadron prepared the bridge at La Croix St. Ouen for

demolition and held it, retiring with the Carabineers, on September 1st, via Verberie to Mont L'Evêque; on the 2nd, the march was continued via Ermenonville to Villeneuve, where an enemy battery was destroyed and the eastern end of the village defended; the retreat was continued the next day to Gournay on the Marne, near Paris, where the Squadron got a little time to refit. On September 5th the advance commenced and the Squadron moved up via Marmand, Jouy Le Châtel, La Hante to Sablonnière where, on September 8th, the bridges were reconnoitred and the bridge at La Ferté Gauche was strengthened for M.T., the Squadron following in the pursuit to La Voue Le Prêtre; on the next day the Division were ordered to seize the crossings over the Marne at Charly sur Marne and Saulcherry; the Squadron prepared to bridge the river, but the existing bridges were found intact. The advance was continued to the Aisne, via Mont de Bonneil, Grisolles, Cramaille to Braisne, where, on September 12th, preparations were made for bridging, but one bridge was found intact; after severe fighting on the part of the Division, the advance was continued to Vauxcere and Oeuilly, where the Squadron were employed from September 14th to October 2nd on improving and strengthening the bridges over the Aisne; one of these was a girder bridge that had been partially destroyed during the retreat, and considerable difficulties were experienced due largely to the river rising. On October 3rd, the march to Belgium commenced, the Squadron moving via Quincey-Sous-Lemont, Le Plessier Houleu, Crépy en Valois, Moyvillers, Villers Tournelle, Longpré (near Amiens), Bouquemaison, Monchy Bretonne, Guarbecque, reaching, on October 10th, Vieux Berquin, which village they defended, the Division being employed on covering the deployment of the infantry. On October 13th the Squadron moved northwards, via La Flétre, St. Jans Cappel, to Neuve Eglise, on the 16th assisting the 2nd Cavalry Brigade in an attempt to cross the Lys at Ploegstreet and on the 17th reconnoitring the river at Houplines. To the end of October the Squadron were employed on trench work and acting as a Divisional Reserve to the cavalry holding the Messines Ridge; on October 30th, when Messines was lost, the Squadron were holding a farm between Messines and Wytschaete and handed it over to the Carabineers and a battalion of London Scottish half-an-hour before it was taken by the Germans, the Squadron retiring to Wolverghem; Capt. Jordan and Lieut. Stone were wounded during the action. During the early part of November the Squadron moved to Neuve Eglise and later to Dranoutre, being employed as Divisional Reserve and on trenches in front of Wolverghem. On November 11th they moved up to Ypres in support of the 1st Brigade, S.E. of Brielen. On November 13th work was started under the Chief Engineer, First Army, 2 troops being employed on a bridge S.W. of Kruisstraat and 2 troops with the 2nd Cavalry Brigade on trench work; Lieut. Egerton was killed on the 17th. On November 26th the Squadron was withdrawn to Thieshouk for the winter.

3. The 4th Field Troop (Capt. L. C. Trench, Lieuts. T. A. S. Swinburne and K. M. Carnduff) mobilised at the Curragh on August 4th, leaving Queenstown on the 15th, and landed at Havre on the 17th. They joined the 5th Cavalry Brigade at Aulnoy, near Maubeuge, on the 19th, reaching Boussiére on the 20th, and came into action on the 21st at Hargnies, between Binche and Mons. On the 25th the troop had retreated to Taisniéres and marching daily had reached the Oise at Chauny on the 29th, where charges were placed on the bridges and their demolition carried out on the 30th August. The Troop accompanied the Brigade during the retreat and the subsequent advance to the Aisne, where, on September 25th, the 2nd Cavalry Division was formed by detaching the 3rd and 4th Cavalry Brigades from the 1st Cavalry Division; at the same time the 2nd Field Squadron was formed by splitting up the 4th Field Troop into two troops and the addition of a troop (Lieut. Stone) from the 1st Field Squadron. The Squadron accompanied its Division on the march northwards, reaching Taux on October 1st and Caestre (near Hazebrouck) on the 12th October. Here they were joined by a strong detachment (Capt. C. R. Johnson, Squadron Commander, Lieuts. F. Preedy, G. E. Grimsdale and W. F. Pattinson), which had been raised at Aldershot, sailing from Southampton on October 10th, and disembarking at Havre on the 11th; on the 16th the troop from the 1st Field Squadron rejoined its own Squadron. The 2nd Field Squadron then marched via Westoure to Wytschaete, where, from October 16th onwards, it was employed first on strengthening the outpost line between Houthem and Gaspard, held by their Division, and later on a second line between St. Eloi and Wytschaete, to which line the Cavalry retired on October 30th. During the early part of November the Squadron were helping their Division in the line, and later on wiring a line east of Wolverghem, the Headquarters of the Squadron moving from La Clytte to Reninghels and St. Vans Cappel. After a rest of six days at Vieux Berquin, the Squadron were in the line with their Division north of the Kemmel-Wytschaete Road on November 20th and 21st, then withdrawing to Vieux Berquin for the winter.

4. The 3rd Field Squadron (Capt. C. E. P. Sankey, Lieuts. R. D. Pank, J. Kiggell and J. C. Bowles) were ordered to form at Ludgershall on September 16th; men were collected and trained at Aldershot and the squadron embarked at Southampton on October 12th, reaching Boulogne on the 14th, detraining at Hazebrouck on the 18th and joining their Division at Passchendaele on the 19th October. After assisting their Division in the line, the

squadron were employed on second line defences east of Ypres, employing civilian labour, and afterwards worked on communication trenches, etc., for the 1st Corps; Squadron Headquarters moving during this period from Zonnebeke to Dickebusch Farm; Captain Sankey was wounded on October 30th; on the 21st November the squadron was withdrawn to Hazebrouck for the winter.

5. The British Cavalry Corps was formed on October 11th, 1914, at St. Venant, while the 1st and 2nd Cavalry Divisions were advancing in the area round Hazebrouck and covering the detrainment of the infantry sent up from the Aisne, the 3rd Cavalry Division was just arriving from England. The Cavalry advanced to the Lys position between Armentières and Warneton, and held the Messines Ridge till the arrival of the infantry, who took over about November 9th, the cavalry withdrawing then to about Merris. On November 11th the 1st and 3rd Cavalry Divisions went up to Ypres under the 1st Corps, and were withdrawn on the 20th. On November 20th the 2nd Cavalry Division were put into the line east of Kemmel, and were relieved by the 1st Cavalry Division on the 22nd, the infantry taking over shortly afterwards. The Corps then assembled in their winter area round La Motte; 1st Cavalry Division round Liettre (Field Squadron, Thieshouk); 2nd Cavalry Division round Vieux Berquin (Field Squadron, Vieux Berquin); 3rd Cavalry Division round Hondeghem (Field Squadron, Hazebrouck). The winter was spent in training, chiefly for trench warfare; experiments were carried out and instruction given in grenades and trench mortars; the ordinary R.E. services were carried out, including a good deal of road work and the construction of aerodromes at Bailleul. On December 3rd the cavalry were inspected by the King. During January the 2nd Field Squadron were employed supervising civilian labour near Hinges, constructing a 2nd line east and north-east of Bethune, and a 3rd line about the La Bassée Canal, under the Chief Engineer, 1st Corps. On February 1st Capt. Trench (3rd Field Squadron) was wounded, and on February 2nd, Lieut. Scobie (1st Field Squadron) was slightly wounded by a hand grenade. During February, for a period of six weeks, the Corps relieved French infantry (18th Division, IX. Corps) in the trenches north of Hill 60, and also helped the 28th Division; the 3rd Field Squadron were up during the first half of February and again from February 18th to 26th, handing over on the 22nd to the 1st Field Squadron, who were employed on sap heads, mines, etc., and were withdrawn on March 5th, Major Sandys being wounded on February 23rd; the 2nd Field Squadron were in the trenches south-east of Ypres from February 12th to 23rd. From March 9th to 20th the 3rd Field Squadron with dismounted cavalry were employed on trenches west of Steenbecque. The Corps stood by for the battle of Neuve Chapelle on March 10th, the 2nd Cavalry Division going up to the

battle, one brigade being engaged. On March 25th the 1st Field Squadron moved to Hondeghem.

6. On April 21st, 1915, there occurred the first gas attack at Ypres, and the Corps went up in support of the left of the British line from Ypres to the right of the Belgian Army; the 1st Field Squadron, on the 23rd, were helping the 1st and 2nd Cavalry Brigades on the line Woesten-Elverdinge-Brielen, and on the 26th their Division supported an attack by the French on Lizerne and Hetsaas; the 2nd Field Squadron, on the 25th, were assisting the 4th Cavalry Brigade to entrench in front of Boesinghe; the 3rd Field Squadron were at Vlamertinge with their Division in reserve. Subsequently the Field Squadrons were employed on trench work, east of Ypres, under the C.R.E., 28th Division, and continued work in this neighbourhood until the end of May, sometimes working with their Divisions in the line about Hooge and Wieltje and sometimes on the G.H.Q. Line east of Ypres and the Zillebeke Switch. Between May 17th and 28th the squadrons worked together under the C.R.E., Cavalry Force (Major Sandys). During the second gas attack, on May 24th, the 1st Field Squadron had to abandon their dug-outs and man the Menin Gate trenches. The 1st Field Squadron were withdrawn on May 28th to Esquelbecq; the 2nd on May 29th to Ebblinghem; the 3rd on June 5th, to Renescure. On June 30th, the Corps went up to work, dismounted, on back trenches in the Ypres area; the 1st Field Squadron to Vlamertinge under the VI. Corps; the 2nd to Dickebusch on the Kemmel Defences, under the V. Corps; the 3rd on trenches from Hill 63 to Neuve Eglise, later going on to Elverdinge defences, which they handed over to the 1st Field Squadron on August 7th, themselves working from August 16th on trenches east of Armentières, where, on August 30th, Lieut. Theodore Smith was killed. The squadrons were withdrawn about September 5th respectively to Esquelbecq, Roquetoire and Vincly (near Fruges), and the Divisions started training for the battle of Loos.

7. For the battle of Loos the 3rd Cavalry Division were placed at the disposal of the First Army. They proceeded to the Bois des Dames on September 20th, and the Field Squadron was employed on making cavalry tracks; on the 26th they assisted the 6th and 8th Cavalry Brigades to consolidate the position they had won on the east side of Loos, and were withdrawn on the 28th; Lieut. Pank was slightly wounded during the action. Meanwhile the Corps moved to Noeux le Mines for the battle; the 1st Cavalry Division reached Vaudricourt on the 25th and held and put in order the old German line behind Loos, afterwards working on the trenches under the XI. Corps, and being withdrawn on October 6th, the Field Squadron going to Serny, and on October 20th to Clarques; the 2nd Cavalry Division arrived in the neighbourhood of Ferfay on

the 29th September, whence a dismounted party with the Field Squadron went up to Vermelles for work on the "O.G." Line until the 17th October, during which period Lieut. Latham, the Medical Officer, was mortally wounded Towards the end of October, work was commenced by dismounted parties from the Corps on a G.H.Q. line (the B.C.D.); the 1st Field Squadron were located at Abbaye de Woestin and worked on the Forêt de Clair Marais section; the 2nd Field Squadron at La Nieppe on the La Belle Hotesse-Wallon Cappel section; the 3rd Field Squadron at Lugy (near Fruges) on the Sempy section. This work was continued until the end of December, small parties working with Labour battalions being kept on until the middle of February, 1916; meanwhile the headquarters of the Field Squadrons settled for the winter at Wierre au Bois (near Samer), Williametz and Coupelle Neuve, respectively. On December 31st, 1915, the Corps formed a Dismounted Division for work in the trenches; the composite Division proceeded to La Philosophe and worked on 2nd Line trenches in the Hohenzollern Redoubt, east of Vermelles, until its return to the Corps on February 15th, 1916; Major Johnson was appointed C.R.E., and Lieut. Grimsdale, Adjutant R.E. of the Division; during the period, Lieut. Pank (3rd Field Squadron) was wounded on January 22nd, 2nd Lieut. Chappell (3rd Field Squadron) was killed on February 3rd, Lieut. Greathead (1st Field Squadron) wounded on February 8th, Lieut. Wise slightly wounded and Lieut. Carnduff killed (both 2nd Field Squadron) early in January.

8. Towards the end of March, 1916, the British Cavalry Corps was broken up, the 1st Cavalry Division being allotted to the First Army, the 2nd to the Second Army and the 3rd held in G.H.Q. reserve, being later attached to General Gough's Reserve Corps. The 1st Field Squadron, at the end of March, sent up a detachment to Vedrel to work on the Estrée-Cauchie-Verdrel Line, under the IV. Corps, this work being continued until June 19th, when mounted training was carried out at Hardelot. On June 26th, the 1st Cavalry Division arrived at Querrieu for the Somme Offensive, the Field Squadron having to construct several bridges over the stream; during July they stood to and moved up on several occasions, and on July 24th proceeded dismounted to Fricourt for work with cavalry, on trenches at Montauban and Bernafay Wood, under the XIII. Corps; this work was continued until the formation of the cavalry Corps at the beginning of September, 1916. The 2nd Field Squadron moved on May 12th to Ledinghem, and at the end of May detachments were sent to work under the Canadian Corps at Abeele, and the V. Corps at Bailleul, while Lieut. Armstrong was sent to the Second Army School at Wisques as an instructor. In July the Squadron moved to Au Souverain and a party was sent to La Crèche to work with dismounted Cavalry on trenches concrete

O.P.'s, etc., round Hill 63, until September, when the Division marched to near Querrieu to join the Cavalry Corps, the Field Squadron being sent on in advance to near Fricourt. The 3rd Field Squadron, during May and June, trained at Le Touquet and St. Riquier, and also worked on the G.H.Q. Line north of Fruges. On June 24th the Division marched to near Querrieu for the Somme offensive and the Squadron cut gaps in the wire west of Albert; on July 3rd they moved back to Hocquincourt, and to Vecquemont on the 8th; the Field Squadron was then employed till the end of the month on trench work with dismounted cavalry in front of Contalmaison and Mametz Wood, a track east of Le Carcaillot to south of Carnoy, water supply at Carnoy and roadwork east of Albert. In August they went to Le Quesnoy (west of Amiens) and a party was sent up to help the Divisional machine gunners in the Leipsig Redoubt; the Squadron moved on August 5th, to Dompierre, and another party was sent to Aveluy for work under the II. Corps, where Capt. Cobb and Lieut. Hay were wounded; on September 9th, the parties rejoined and the Division marched to Querrieu to join the Cavalry Corps.

B. THE INDIAN CAVALRY CORPS.

1. Before the war only one Field Troop (without horses) was maintained in India; this was the 1st Indian Field Troop with the 1st (K.G.O.) Sappers and Miners at Roorkee. A certain number of men of the 3rd Sappers and Miners had been trained in mounted duties, and equipment for a field troop was maintained at Kirkee.

2. The first cavalry to reach France from India was the Secunderabad Cavalry Brigade, who accompanied the Indian Infantry Corps and landed at Marseilles on September 27th, 1914. This brigade was accompanied by the 1st Indian Field Troop (Capt. R. C. R. Hill and Lieut. F. S. Collin) who had mobilised at Roorkee on August 8th, and left Bombay on September 3rd. The brigade concentrated at Orleans on October 7th, and reached Vieille Chapelle on November 1st, and were employed on trench work between Rouge Croix and Festubert until the end of December, under the Meerut and Lahore Divisions. The Field Troop was withdrawn to Basse Rue (near Berguette) on December 25th, and the Brigade then joined the Indian Cavalry Corps.

3. On November 7th, 1914, the 1st Indian Cavalry Division landed at Marseilles and concentrated at Orleans on November 15th. They were accompanied by the 2nd Indian Field Troop (Capt. E. K. Molesworth and Lieut. T. B. Harris) and consisted of men drawn from the 2nd (Q.V.O.) Sappers and Miners at Bangalore; the equipment had been obtained from the 3rd Sappers and Miners, and the men were mounted in Indian tongas belonging to the

Gwalior Transport Corps. The Troop had mobilised at Bangalore on September 18th, and left Bombay on October 16th. In accordance with the Indian organisation, a C.R.E. with several Field and Assistant Field Engineers accompanied the Division (Col. C. E. Baddeley, Majors G. A. Leslie and A. G. Bremner, Captains A. R. C. Sanders and E. K. Squires and Lieut. A. A. Chase, Survey Officer). The Division reached Auchel on November 30th.

4. On December 14th, 1914, the 2nd Indian Cavalry Division (2 Brigades) landed at Marseilles, and concentrated at Orleans on December 22nd. No Field Troop accompanied the Division, but there was a C.R.E. and several Field and Assistant Field Officers (Engineers). (Lieut.-Col. H. J. Marshall, Major S. D'A. Crookshank, Captains D. Ogilvy and B. H. Fox). The Division reached Mametz (near Therouanne) on December 31st.

5. On the arrival of the 2nd Indian Cavalry Division it was decided to form an Indian Cavalry Corps, which assembled by the end of December, 1914, in the neighbourhood of Aire. The Secunderabad Cavalry Brigade, with the 1st Indian Field Troop, joined the 2nd Indian Cavalry Division.

6. On the formation of the Corps it was decided to abolish the Indian organisation of R.E. with Cavalry, and to adopt the British system. Accordingly the C.R.E.'s, Field and Assistant Field Engineers were dispersed and the formation of two Indian Field Squadrons put in hand, the drivers, equipment and wagons to come from England, the sappers from India. On December 14th, 1914, Capt. W. H. Evans and Lieut. Nosworthy were sent to Aldershot to collect the British contribution; they arrived in Rouen on December 24th, and joined the Indian Cavalry Corps at Clarques on January 2nd, 1915. It was found, however, that India was unable to supply any more sappers, and after some delay, Major W. H. Evans and Capt. B. H. Fox were sent to Aldershot on March 17th to collect, train and bring out British sappers and the remainder of the equipment; the detachments reached the Corps on May 10th and 17th, 1915, after which the formation of the 1st and 2nd Indian Field Squadrons at Wittes and Erny St. Julien was rapidly completed. (1st.—Majors A. G. Bremner and W. H. Evans, Capt. A. A. Chase and Lieut. H. G. Greswell). (2nd.—Major S. D'A. Crookshank, Capts. D. Ogilvy and B. H. Fox). The two Indian Field Troops stayed with the Corps until July, 1915, when they were broken up and sent to the Indian Infantry Corps.

7. The Canadian Cavalry Brigade came to France in May, 1915, as a dismounted unit attached to the Canadian Corps. They were joined early in October, 1915, by the Canadian Field Troop, also dismounted, which had been raised at Aldershot on September 1st, 1915, and consisted of British sappers (Capt. R. F. Mainguy, Lieut.

S. F. C. Sweeney and 2nd-Lieut. O. R. Lyster). After being employed in the trenches about Kemmel Hill, under the Canadian Corps, they were sent to the 1st Indian Cavalry Division at the end of January, 1916, to train as cavalry, later being attached to the 2nd Indian Cavalry Division. In June, 1916, the Ambala Brigade of the 2nd Indian Cavalry Division, with a troop of the 2nd Indian Field Squadron, were sent to Mesopotamia and their places were taken by the Canadian Cavalry Brigade and the Canadian Field Troop. The Canadian Field Troop was, however, not finally merged into the 2nd Indian Field Squadron until January, 1917.

8. Apart from the Secunderabad Cavalry Brigade, the Indian Cavalry Corps did not come in contact with the enemy until January, 1915, when each Division in turn was put into the trenches at Festubert for a short period; the 1st Indian Field Troop remained up for some time, working under the 3rd Division. From February to the end of April, 1915, the Corps was employed on constructing G.H.Q. Defences in the neighbourhood of St. Venant and the Forêt De La Nieppe (H.Q., R.E., 1st Division, St. Hilaire and 2nd, Clarques). During the early part of 1915 the Corps moved up on several occasions in support of attacks, returning always to the Aire area; on March 11th to Auchel for the Neuve Chappelle battle; at the end of April into Belgium for the 1st Gas Attack at Ypres; on May 17th east of Lillers for the Festubert attack; on May 27th to Ypres for the 2nd Gas Attack (1st Division only). On the latter occasion the 1st Indian Cavalry Division were put in the trenches at Hooge and both the 1st Indian Field Squadron and 2nd Indian Field Troop did a good deal of front line work at Hooge and Railway Wood. (Capt. J. C. Wickham severely wounded). From the end of June to the end of July, 1915, dismounted men from the 1st and 2nd Divisions were employed on the reserve trenches and strong points in the Laventie (under the Indian Infantry Corps) and Noeux-Les-Mines (under the IV. Corps) areas, respectively.

9. On August 1st, 1915, the Corps, after concentrating in the Aire area, marched south to join the newly-formed Third Army in the Flixicourt area (Field Squadrons at Domart-en-Ponthieu and Belloy-sur-Somme). During August and September each Division in turn held a portion of the line at Thiepval, under the 51st Division, while dismounted parties also worked on reserve defences near Senlis under the X. Corps. On September 21st the Corps was inspected by Lord Kitchener, and on September 22nd moved into the Doulens area to stand by for the battle of Loos. On October 13th the Corps moved back into the Flixicourt area, shifting on the 22nd to the Hallencourt area (Squadrons at Liomer and Villeroy). And on December 16th to Gamaches area (Squadrons at Embreville and Villeroy). The Field Squadrons held trench warfare schools through-

out the winter and a great deal of work had to be done on repairing roads. An emergency dismounted Division was formed on paper with the senior Field Squadron Commander (Major W. H. Evans) as C.R.E. From January to March, 1916, two dismounted digging parties, each with a dismounted Field Troop, were sent up from each Division to work on Corps defences in the Third Army area; instructors and men for work were also supplied to the Army School at Flixicourt. Towards the end of March the Indian Cavalry Corps was broken up. The 1st Indian Cavalry Division moved northwards to the Auxi-Le-Chateau area, where the Field Squadron was employed on the construction of the Third Army School at Auxi-Le-Chateau. The 2nd Indian Cavalry Division stayed in the Fourth Army area. Both Divisions were subsequently attached to General Gough's Reserve Corps.

10. The 1st Indian Cavalry Division remained in the Auxi-Le-Chateau area until May; special training was carried out on the St. Riquier training ground; the Field Squadron was employed on the construction of a Divisional School at Vacquerriette. On May 10th the Division moved to the area west of Avesnes-Le-Comte (Squadron at Leincourt), in close support of the infantry of the Third Army; Capt. R. S. Rait Kerr was left as instructor at the Third Army School, with a small detachment from the Field Squadron. A Divisional School was constructed at Givenchy-Le-Noble and a detachment was sent to Arras to work for the R.H.A. of the Division. On June 30th the Division marched to the Doulens area, ready for the Somme Battle, moving to the Auxi-Le-Chateau area on July 2nd, and to the Aubigny area (Squadron at Agnieres) on July 20th. The whole Field Squadron was employed under the XVII. Corps until the beginning of September, just north of Arras, on front line system redoubts, concrete field gun emplacements and dug-outs for Corps Heavy Artillery; Lieut. F. A. Farquharson was wounded slightly on August 27th. On September 3rd the Division marched to the St. Riquier area, and on September 13th reached the Allonville area near Querrieu, where they joined the newly-formed Cavalry Corps.

11. Except for a training period at St. Ricquier, the 2nd Indian Cavalry Division stayed in the Alloncourt area until July 1st, 1916, when they proceeded to Bussy-Les-Daours for the Somme offensive. The Field Squadron went on to Meaulte and later to Fricourt, and until the formation of the Cavalry Corps in September, 1916, was employed on helping their Division in attacks, making cavalry tracks, shifting guns in Mametz Wood and general trench work under the XIV. and XV. Corps.

(*To be continued*).

GEOLOGY AS APPLIED TO MILITARY REQUIREMENTS.

Lecture delivered at the S.M.E., Chatham, by A. BEEBY THOMPSON, M.I.Mech.E., M.I.M.M., F.G.S., on 29th Oct., 1925.

THE incessant demands for increased supplies of water to comply with the more exacting conditions imposed by the medical profession and sanitary authorities, place upon the Engineers an increasing burden of responsibility. These demands are no less insistent in military than in civil circles, and in districts of congested population, low rainfall, or where the geological conditions are unfavourable, Nature unaided fails to satisfy needs; but whereas, under civil conditions years may often be occupied in detailed studies before embarking upon a scheme of supply, under military conditions it is often a question of days or even of hours.

The execution of emergency water supplies, such as are usually needed during a Military expedition, call for quick, confident, and perhaps, courageous decisions, and these cannot be made without a fair knowledge of the principles of geology and hydrography. To-night I propose, with your permission, to outline the principles which guide one in the search for supplies of water capable of quick development, neglecting the larger subject of water conservation or long distance transmission from available supplies.

The time factor usually precludes any detailed geological examination being carried out, but if topographical (contoured) or geological maps are available they will be found of great service and should at once be obtained. Without, however, any assistance from maps an engineer with geological instincts will quickly sum up the general situation from a hasty reconnaissance of the country. From the nature of the topography, scenery, vegetation, and rock fragments in river beds, an experienced observer will quickly acquaint himself with the main features of interest and direct his steps to the obvious spots of promise.

But, before proceeding further, it is proposed to discuss very briefly the progress of water from its precipitation onwards. Potable waters mainly owe their origin to the sea, which furnishes a practically limitless source of supply, forming as it does 75 per cent. of the earth's surface. By a series of complicated meteorological processes involving evaporation and air currents, set up chiefly by temperature differences, water vapour is carried in the atmosphere until it is confronted with conditions which cause its precipitation. When the atmosphere can no longer hold its charge of moisture at the temperature prevailing it is precipitated, either gently as mist or dew, or more violently thrown down as rain, snow, hail or sleet.

This water is not equally deposited on the earth's surface. Large portions of the earth are desert because rain rarely falls, but even in regions of good rainfall the amount of precipitation varies greatly within short distances. Hill ranges encourage rainfall by chilling moisture-laden air, and in the higher ranges, where the temperature is always low, the accumulated snows of winter form glaciers which are a perennial source of water and the main feeders of most great rivers of the World. It is the winter-accumulated snow and ice that furnishes the regular supplies of water for most of the great hydro-electric stations.

Being the condensed product of evaporation, water reaches the surface in a state of comparative purity, but during its descent it dissolves oxygen and carbon dioxide from the atmosphere, and this latter being an acid plays a very important part in subsequent events bearing upon economic water problems. Water is one of the most powerful solvents known, so that on coming into contact with the earth it quickly dissolves soluble substances which it may meet. The carbon dioxide in solution causes the water to attack limestones in particular, and in this way carves out passages and chambers in their midst which later become important reservoirs for water.

Having reached the surface, water is disposed of in three ways.

1. Surface run-off.
2. Evaporation and absorption by vegetation.
3. Percolation into the ground.

In temperate climates percolation, with which we are mainly concerned for ground water supplies, approximates 25% of the rainfall, run-off amounts to roughly another 25% whilst evaporation and vegetation account for about 50%.

Rainfall is fairly evenly distributed over the year in some temperate countries, but in others its fall may be confined to one or more brief periods of the year. In tropical and mid-continental countries there are generally defined seasonal rains, and so regular is their appearance, if not the amount of precipitation, that in some regions the exact date of the first rainfall of the season is repeated every year. An annual rainfall of between 20 and 40 inches per year, say 2,000 to 4,000 tons of water per acre, may be regarded as an average for most thickly populated fertile countries, but there are regions of no rainfall as well as regions of deluges. In one sector of Assam the rainfall averages over 400 inches (33.3 ft.) per annum. Rain may fall in gentle showers or in deluges, frequently or at long intervals, in hot or cool weather, on forested, cultivated or barren land, and the ratio of run-off to absorption is influenced by these factors. A fall at the rate of 1 inch per hour attracts attention, but falls of 4 inches to 8 inches per hour have been recorded, whilst rates up to 24 inches per hour have been measured for brief periods.

In many countries of temperate climate the summer rainfall has little or no influence upon ground water supplies, as most of the rainfall is dissipated by surface run-off, evaporation and consumption by vegetation. In this connection capillarity plays an important role, for until water passes below a certain depth it is subject to constant losses which vary with the local conditions of soil and climate.

Water reaching the earth flows over the surface, and if the rocks are porous a certain proportion is absorbed. Naturally the ratio of absorption to losses depends upon such factors as :—

a. The contours of the land.

b. Obstructions to the passage of water, such as vegetation, or surface irregularities.

c. Nature of the rocks.

d. Geological structure.

Were the whole land surface composed of an unbroken sheet of impervious rock all precipitated water would be quickly lost by run-off and other causes, but fortunately Nature introduces innumerable obstacles.

The first important point which I wish to emphasise is that, broadly speaking, the earth everywhere is water-saturated below a varying distance from the surface.

This level of saturation is known as the water-table. The water occurring below the water-table is, however, only stagnant in certain special cases, and the great mass of it is constantly, if slowly, flowing from higher to lower levels, often emerging as springs, and being replenished by upland rainfall, mist and dew.

Were the earth composed of uniform material, then the water-table, concentration, and flow of underground water would be a comparatively simple affair, and what we have to consider is the factors which modify its occurrence.

Most important of all are the properties of rock known as porosity and permeability.

Porosity may be defined as the ratio between air space and mineral matter in a given volume of dry rock, and therefore represents the relative amount of water which that rock can hold when saturated. Rocks vary enormously as regards their porosity, and although we are considering everything below the water level as saturated, the porosity in many cases is so low as to be negligible, and such rocks are to all intents and purposes dry. Examples of rocks of negligible porosity are illustrated by granite and, indeed, practically all igneous rocks, compact marbles, well-cemented sandstones, etc.;

from these all gradations are found up to the highly porous beds such as loose sands, gravels, etc., where the porosity may approximate 30%.

Mere porosity, however, is not sufficient to ensure a supply of water, not only must the bed contain the water, but it must be able to give it up readily; in other words it must be permeable. Permeability is the property that allows a flow of water through the rock, and is dependent on the size of the pore spaces. A good water-yielding stratum or *aquifer* must, therefore, be both porous and permeable. To make the difference between these two properties quite clear, consider a substance like clay. That dry clay is highly porous is obvious from the way that it will absorb water, in fact, many clays have a porosity as high as 50%.

Wet clay does not, however, give up its water readily, and can be used as a waterproof material, as in the "puddling" of earth storage tanks, etc. Clay, therefore, has a high porosity but a low permeability, and is useless as a water yielding stratum, indeed, it forms, when moist, just as effective a barrier to the passage of water as a non-porous rock such as granite.

The porosity and permeability of rocks has, therefore, a very important bearing on the water-table. In homogeneous, porous rocks, in countries of moderate rainfall, the water table tends more or less to follow the contour of the ground, but with a less accentuated form; that is, the contours of the water table flatten out and become less marked as sea level is approached, till the two surfaces, that of the ground and that of the water table, approximate at sea level.

As, however, the earth is composed of rocks of very varying porosity and permeability, many factors enter to modify the water table. Where, for example, an impervious bed interrupts the seaward flow of the underground water, the water table may reach the surface and a spring results, and the vast majority of springs will be found to be located at the junction of pervious and impervious beds.

Just as the visible flow of water in a river is confined to a certain channel by its banks, so the underground flow of water is controlled by the arrangements of pervious and impervious beds. This feature taken in conjunction with simple hydrostatic laws constitutes the basis of water finding.

Underground supplies of water may be roughly divided into two classes, those obtained from recent deposits, such as river valley deposits, delta deposits, etc., and those drawn from solid formations, sandstone, limestone, etc. I propose to deal mainly with the first, on account of their importance in giving quick emergency supplies.

In considering valley deposits it is simplest, though not strictly accurate, to imagine the valley sides and floor as being of solid rock and more or less impervious, either on account of actual imperviousness or on account of being already saturated with water.

Actually, taking the whole drainage area of a river system, the visible flow of the river and its tributaries may be regarded merely as the surplus water in the great never-ending cycle comprising evaporation from the ocean, transport by wind and formation of clouds, precipitation as rain and return by gravity flow to the ocean. In drier climates the same great cycle of events is taking place, but with the exception of occasional floods the whole of the gravity flow to the ocean may take place below ground. In hundreds and thousands of desert and semi-desert parched and arid valleys, without a drop of visible water, but with the bones of animals killed by drought, this slow silent flow of water seaward is taking place only a few feet below the surface. The simplest and yet most striking illustration of this is to be found in many valleys in semi-desert countries, where great expanses of valley gravels are interrupted by rocky barriers which form narrow gorges. In each of these gorges there may be a considerable surface stream, but below the gorge this sinks below the surface and leaves an absolutely dry water course only used by flood waters; the next gorge down stream, however, again restricts the area of flow and so raises the water table to the surface, and a visible stream results.

The great value of the underground flow of water lies in the fact that it is infinitely slower than the surface flow, thereby leading to the conservation of great volumes of water. If we imagine a river system carved out of wholly impervious rock and with no surface soil or gravels, then the effect of rainfall would be temporarily a great flood and then a dry water course, which is, in effect, what happens to the visible water in semi-desert regions.

In nature, however, a considerable portion of the rainfall is taken up by porous beds, and so slow is the flow of water through these that they act much as a reservoir, and tide over the periods of drought between the occasional heavy rains, the only effect of a prolonged period of drought being a certain lowering of the water table in the valley deposits.

With regard to these valley deposits themselves, they vary greatly, as an inspection of any river valley will show. Gravels, sands and clays (muds) alternate and replace each other in what appears at first sight hopeless confusion. Some gravel beds are cemented with clay or lime, and will not yield water although well below the water table of the valley. If, however, the bed of a winding river course is examined, certain definite features will be noticed that influence subsoil flows. On the convex curve where the current is strongest we shall find only the coarsest material, the fine sand or mud being swept along till it comes to rest in quieter water, generally in the concave curve. As in course of ages river erosion causes a snake-like movement of the curves down stream, it is easily understandable how this alternation of types occurs. In locating wells in valley deposits the important points are therefore to try and select sites (1) where the water will naturally tend to collect (2) where the coarser deposits of old channels are likely to be struck. With regard to (1), we must try to picture the valley stripped of its recent deposits and, remembering that even underground water is always trying to find a lower level, endeavour to reason out where the underground flow is most likely to be. Picture, for example, a wide dry watercourse, half a mile or so across, flanked on one side by gently rising ground, and on the other by a steep hillside. The probability—though there is no absolute certainty—is that the valley, stripped of its deposits, would continue the general slope of the two sides, so that its deepest point would not be in the centre of the present dry water course, but close up to the steeper side, where probably the best water supplies would be obtained. Again, when such a valley narrows to a gorge through more impervious rock, there is likely to be a ponding back of the underground water, so that copious supplies may be expected at such a location. Again in such valleys old river terraces often give a clue as to former river channels and thus afford a guide to the probable location of coarse gravels and sands.

River courses present varied and peculiar features, which must be considered before determining a course of action. The nature of their beds depends upon the character of the rocks composing the drainage area. They may have a gentle or steep gradient, and the material composing their beds may be sands, gravels, rubble or boulders, or mixtures of any of these. Usually the upper reaches of river courses contain coarser material than the lower sections when sea level is approached or the gradient flattens; in gorges the material is coarser than in wide flats, and in most cases there are alternations of fine and coarse detrital material through which water percolates at variable speeds if below the water table. These detrital deposits are composed of the more or less rounded fragments of the rocks of the district, and when limestones are prevalent the material may be mainly calcareous, otherwise the sands and gravels are generally mostly silica or fragments of igneous rocks.

In some cases the fragmentary beds become cemented with lime and converted into a conglomerate impervious to water, at other times coarse gravel may be so tightly cemented with clay as to be impervious to water, but generally there are intervening layers of uncemented material which carry water.

Some sluggish running streams meandering over wide flat plains have mainly silty beds which yield no economically valuable supplies of water, but even amidst such surroundings it may be possible to pick up sandy strips, often indicated on the surface, representing ancient river courses.

These latter conditions are exceptional rather than general, and in the majority of cases valleys carrying the drainage of a large catchment area contain an abundance of permeable beds capable of yielding copious supplies of water.

When selecting a site for a water well the valley gradient should be carefully observed. Any elevation of the water table should be noted, or if water is forced to the surface by a contraction of the channel or other obstruction, a site should be selected upstream rather than downstream, where water often follows narrow channels less easy to pick up.

Along many narrow river courses in hilly or rocky country there are considerable variations of the gradient, and water may be periodically raised to the surface along a reach of some distance.

Whether there is surface flow or not, there is always some subsoil movement of water in valleys of any importance, and what I wish to emphasise is the fact that these lower waters are usually quite isolated from the upper, and so preserved from contamination with surface or upper water to which rain can carry pollution direct from the surface.

Obviously all ground waters were once surface waters, but in most cases the percolated water enters beds at an elevation and at a distance from habitations, also the water is subjected to a slow process of filtration and perhaps aeration, which ensures its purification. That these lower waters are commonly effectively isolated from the upper waters is proved by the variable static level of waters struck in different acquifers of a series of valley sediments. Rarely is a series of sediments homogeneous. Water is found to enter a driven tube well at different depths, between which little or no water is found. The water level of deeper acquifers may be higher or lower than the upper. In those cases where the downstream flow is restricted and the point of admission far upstream, the static level is higher with depth. On the other hand, where a very permeable bed underlies less permeable deposits, the water may have a lower static level.

In both cases isolation from surface pollution is assured, and if the water fails to satisfy the chemists it must be due to peculiar circumstances needing investigation.

Another characteristic which proves that these valley sediment waters are separated from each other is the occasional variable quality of the water. In regions, particularly where the rainfall is low and sporadic, the waters at different levels show variable mineral contents in solution. Lower waters may be more or less mineralised than upper according to the circumstances. Sometimes a big rise of water table due to an exceptionally heavy rainy season may cause all the upper waters to be undrinkable, whilst the lower remain unaffected. This is due to leaching of salts from gravels which have for a long period been left untouched by water.

When rivers discharge into the sea or into large lakes a fan-shaped delta is usually developed. Unless the currents are strong, silts may predominate, but generally such silty deltaic deposits contain lenticles of sand which yield water freely when struck. The sands are often much finer in grain than further up-stream, and sometimes it is difficult to obtain useful supplies of water without drawing in much sand.

The reason for stressing the value of river valleys as sources of water supply, it will be gathered, is due to the ease and speed with which acquifers can be reached and water made available. As a rule, driven tube wells can be employed as the sediments are generally unsolidated and the water table is within 20 ft. of the surface. That tube wells are not toys was demonstrated by results in the war, but the extent to which they could be used was a revelation to me and to others. By no other method could supplies of good water be rendered available at short notice. Shafts sunk into these valley deposits are generally unsatisfactory, for they need lining; the sand constantly runs in and requires cleaning out, and it is impossible, without special plant, to proceed deeper than the first water, which it is always preferable to avoid.

Apart from pronounced river courses and deltas there are other locations where recent sandy deposits can be explored for water. Thus the sandy fans of detritus from mountain valleys—the results of storms—may be followed to a point below the water table of the valley, in which case copious supplies of good water may be made available. Such deposits were successfully developed by tube wells on the Struma plains near Monastir, during the war.

There are frequently strips of coastline along which sandy sediments, composed of land wash and beach sand and gravels, have grown, forming admirable reservoirs for rain water. Admitted water washes out the salt and holds back the sea water, so that unless drawn too rapidly good water can be obtained at about sea level for long intervals between rains. Coastal sand dunes may be a source of good water along some shores where rainfall is low.

An obvious and easily developed source of supply is from springs, which often yield a water of high purity. Such salts as they contain are rarely injurious to health. Springs usually appear at the junction of an impervious bed and an acquifer on a sloping hillside when the continuity of the strata is broken by a valley. Water may ooze along a long strip of country which becomes boggy or issue from a few more or less separated spots, where the water concentrates due to some local peculiarity. Trenches can be dug along the outcrops to lead away the water. In limestone districts water tends to carve out by solution definite passages, so that large concentrated bodies of water emerge from the ground at low points. Springs of this nature reach enormous volumes at times, forming indeed rivers both in the ground and on their exit. Such are naturally comparatively rare, and the usual spring met with may yield a few hundred to a few thousand gallons hourly. As the yield of the usual type of spring falls off rapidly with the advance of the dry—usually summer—season a careful record of performance should be kept so that future yields can be approximately predicted.

Turning now to water supplies from the solid strata much more attention must be paid to the geology of the district. Here again the underlying principle is that underground water is always trying to find its way to lower levels, but its course is profoundly modified by the distribution of pervious and impervious beds so that in dealing with the older and more consolidated sedimentary beds, more difficult water problems are met with. It is rarely possible to reach useful aquifers without sinking shafts or drilling wells and the water table is usually below 30ft. from the surface, thus preventing the use of surface suction pumps.

In nearly all cases, water gains access to the porous beds, such as sandstones, limestones, etc., along their outcrops, and such outcrops vary in form according to the thickness, dip and strike of the bed and the topographic form of the surface. In many cases the higher inland areas, where rainfall is greatest, are composed of the least porous rocks so that much of the precipitation is carried off by surface rivers and streams. These latter cross the outcrop of porous beds into which part of their water constantly passes. A stream in its winding course may cross and recross the outcrop of a porous bed many times, thus giving numerous points of infiltration. Vegetation, such as forests or moorland heather and moss, play an important part in impeding run off and so increasing the amount of infiltration into porous beds. To deduce the subsequent underground flow of the water, a knowledge of the geological structure of the district is essential. Water will naturally tend to collect where the strata have been folded into synclines and basins, though the faulting of a porous dipping bed against an impervious clay will give the same result.

A hasty survey of the district will generally disclose the main geological features. The direction of dip and nature of the sediments can generally be ascertained by visits to all outcrops, and especially in water courses which cut through any surface soils. A visit to any nearby hills may also prove very useful. From the contours of the country one is able to judge of the extent to which any water-bearing stratum would be drained by the valleys or water courses, and the character of the sediments determines their probable value as water yielders. An unbroken succession of clays or shales is one of the most unpromising features to be met with. If, however, there are moderately thick beds of interposed sandstones, sands, gravels or limestones in the series, there is every chance of obtaining water when they are struck below the water table of the district.

These more compacted and cemented beds yield water far less freely than alluvial deposits. Usually water movements are more closely connected with fissure systems than porosity, but occasionally free yielding loose sands are encountered, when their capacity depends on their coarseness, thickness and continuity. Generally, water issues from a series of joint cracks and fissures such as nearly always break the homogeneity of the rock. This causes somewhat uncertain yields, but if a main fissure system be penetrated a well of large capacity may result. The firing of a shot may improve matters in some hard rocks. Supplies from chalk are mainly derived from fissures and flint beds, for although highly porous, chalk is not very permeable.

For the above reasons large yields must not be anticipated as a rule from boreholes of moderate depth and diameter. Under such conditions as described, important volumes of water could only be obtained by the lengthy operation of sinking large diameter shafts and driving headings along main fissured systems. At times, however, very free-yielding acquifers are struck by boreholes which give natural flows or pumping outputs of from 5,000 to 25,000 gallons per hour. I am here referring to wells of moderate depth, say within 500 ft. From deeper sources much larger yields may often be obtained, owing to the high pressure under which the water occurs. Two exceptionally large producing boreholes were finished in the Salonika area during the war. In one case the large supplies were obtained from the decomposed surface of the metamorphic rocks underlying a fair thickness of clays and sands. The other well was completed in a coarse gravel at the junction of the sedimentaries and the older metamorphic rocks. These wells were never tested to their full capacity, but were capable of very large outputs. As a rule, yields in excess of from 1,000 to 2,000 gals. per hour cannot be anticipated from wells of 6 to 8 in. diameter within a depth of, say, 500 ft.

Artesian wells—that is, naturally flowing wells—are only obtained under certain geological conditions. In large basins surrounded by high ground deep-seated acquifers, protected by a thick impervious covering, may hold water under high pressure. Theoretically the water in such a basin or trough should acquire a pressure equal to the head created by the water table in the hills where the water finds admission. This pressure is often approximated, and if the permeable stratum is struck, large natural flows of water result, or if the well is capped a high pressure is registered. This is the text-book type of artesian structure, but there are other and more frequent circumstances which result in artesian flows.

Flowing water may result from drilling on gently sloping flanks of hills where porous outcropping beds are lenticular, thus preventing the free escape of admitted water. When penetrated at a spot far below the level of the outcrop, the enclosed water may be under a considerable head. Many such wells were struck when drilling in the tertiary sediments flanking the hills near the Salonika base.

Natural flows are frequently struck in deltas or estuaries and along littorals, where both the water table and land surface approximate sea level. In these cases flows usually result from the difference in gravity between sea and fresh water. Sea water, owing to its higher density, will support a higher column of fresh water. The difference of about 2% in the weight of fresh and sea water creates a static head at sea level, even when there is no appreciable frictional resistance to its seaward movement; consequently, if a very permeable bed is struck large flows of water may be obtained. Salonika city supply was obtained from wells of this type, when, however, the acquifer was composed of fine and loose sands which could only be kept stabilised by the most careful adjustment of flow.

An engineer called upon to provide water supplies in a new area should form his opinion on the following points:—

The amount and distribution of rainfall in the region.

The extent and character of the water-sheds (catchment) draining into the zone of occupation.

The topography of the region. Relative elevation, and particularly the drainage system.

The nature of the rocks of the area. Old or new, metamorphic, igneous or sedimentary, whether argillaceous, arenaceous or calcareous.

The main character of the river courses (whether clay, sandy, limey, coarse rubble, gravel or fine sand).

The nature of any springs.

From a brief critical survey a keen observer will have decided where he can most quickly tap supplies of water. He will know roughly the kind of water he is likely to find, and he will have formed a very fair idea concerning the permanence of supply at various parts of the region. The unpromising areas will have been noticed.

ENGINEERS AND THE ARMY.

By MAJOR-GENERAL G. WALKER, C.B., C.B.E., D.S.O.

On the 7th October last, Major-General H. F. Thuillier delivered an invaluable lecture on the above subject, at the Royal United Service Institution. In the course of the lecture General Thuillier traced the history of the "Ordnance" Corps, as the Royal Artillery and Royal Engineers used to be called, and showed how a good many of the difficulties which Royal Engineers have to contend with are directly traceable to the anomalous position in which the Corps was formerly placed in relation to the rest of the Army. I do not propose to follow the lecture in detail, but to take as texts for this article certain plain difficulties which we have to face at present and which are clearly brought out in the lecture and the discussion which followed it. In considering these, my object is to try and show what we, as Royal Engineers, can do to overcome the difficulties, quite apart from any possible changes that might be made in the Service regulations.

2. To facilitate matters, I shall tabulate certain statements taken from the lecture and the discussion and consider each separately. The statements will unfortunately be divorced from their context, but everybody can read the context for themselves in the Journal of the R.U.S.I. What I am going to say may sound egotistical, but it is the result of my own experience in the Corps over a period of a good many years, and whether the writing may seem egotistical or not, it is at any rate an effort to put before my brother officers the methods which I have found helpful in overcoming the difficulties. I may say at once that I am not going to discuss Regulations, Establishments or Army Policy. That is not our office. Our business is to devise means to make the Engineer Arm efficient, under the existing rules, whatever they may be.

3. The statements I propose to discuss are as follows. They are paraphrases not textual quotations.

I. Taken from the lecture.

(a) Various branches of the Army are brought up and trained in watertight compartments. We have a mentally partisan outlook before we really become soldiers. *Esprit de Corps* is good, but if it tends to make us disdain and neglect the study of the work of other branches it becomes an evil.

II. From the Discussion.

(a) An officer of Infantry at a large military station states that on only two occasions has a R.E. officer been attached to his unit.

(b) There is a practical difficulty in training R.E. officers in matters military, in consequence of the fact that we have 1,000 officers and only 12 field units. The work a sapper has to do on manœuvres is more or less imaginary.

(c) The Engineer in Chief and Chief Engineers of Armies must be not only skilled engineers but skilled soldiers.

(d) I should like the regulations to require that the Engineer in Chief should dine and drink a glass of port with his Chief of Staff as frequently as possible.

(e) I would impress on you the importance of an engineer officer possessing a Staff College certificate. The Corps should have men of strong personality, supported by sound technical knowledge and wide military experience, to fill high engineering posts in the field.

(f) One of the most difficult questions facing us at present is the military education of the Royal Engineer officer. Our great difficulty when we want to attach R.E. Officers to other units is to devise means whereby they can be spared from barrack work.

4. The above is rather a formidable looking list of difficulties, but given good will and a determination to succeed, none of them are insuperable. I shall now proceed to discuss them seriatim.

I. (a) Specialised training, at first, is essential for an engineer. At the same time the spirit in which the training is administered by instructors is all important. The young Royal Engineer is rightly taught to be a soldier first and then to be an engineer. If the instructor will inculcate the principle that the pupil is learning to be a soldier in order that he may face the music alongside other soldiers, and that he is learning to be an engineer in order that he may supply the wants of other soldiers, the novice will get a just appreciation of his position in the military world. This is, I know, done nowadays, but I can testify that it was not always so. The young officer must have *Esprit de Corps*, but it must be of such a nature that it will make him realise that the honour of his Corps and his own personal honour also, depend and depend alone on their usefulness to other people. I have never known a case in which a useful R.E. Officer or a useful R.E. unit was overlooked or slighted by other people. Self-respecting humility and humanity are the things that are worth while. Self-praise never did any one any good. I know that when I left the S.M.E. and went into the Army, I was astonished to find how small a place the engineers filled in comparison with my estimation of their value. Those were days when *Esprit de Corps* was very narrow. In fact, I have heard my fellows say that other people knew nothing and did nothing. The real truth was that these critics never tried to find out what others either knew or did, and it was the critics who were the really ignorant. The cure is for the instructor first to impress the pupil, and then for the pupil, as soon as he gets the chance, to mix as much as possible with officers of other arms, play games with them, dine with them and discuss things with them. He must try to learn their point of view and then apply all his energy to helping them, whether in the field or in barracks.

II (a) (f) These two items have produced in the past the greatest difficulties for R.E. Commanders. The difficulties have, I think, arisen from two causes. Firstly, from a rather unbalanced zeal in R.E. Commanders to have their own job *of the moment* perfectly done, and secondly, from a lack of appreciation of the fact that their job of the moment is not their whole duty. I know quite well that I shall have people saying that I don't realise the difficulties of barrack work. Its intricacies, its grinding labour, its financial pit-falls, etc., etc. If I don't I ought to know, none better, and I am sure I do know. At the same time I know also that some people sit in offices too long, some people like an office; everything is to hand, and the routine of a well-run office is regular and not upsetting. These people get into a groove and *forget* that this work which they are doing in peace is the only present method of keeping their professional engineer attainments bright and up to the mark, and that it is not the reason for which they exist. War is what they exist for, not peace and, if they neglect their training for war they are neglecting their duty. Now how are they to do it? In every well-run C.R.E.'s District there is time for reasonable leave. In any District where this essential is not arranged for there is something the matter. Again, there is no question but that people go sick occasionally. In both these cases someone has to work "double tides." It is unfortunate, but it is true. The C.R.E. has to make arrangements, and he does it. I believe, in fact I know, that it will not stretch a C.R.E. too much to make the necessary arrangements also for the military training of his works officers. In some places he can swap them over with unit officers for a bit, but, apart from this, if he will set himself down *early in the year* to make out a programme by which military training and leave shall be arranged for, he can generally do it easily.

The training cannot be on ambitious lines, but an officer can go to a battalion for battalion training for a bit, or go as liaison officer with a brigade for brigade training, and so on. It can be arranged if it is tackled, even if it means that a foreman of works has to do the D.O's. job for a bit. Frankly, it is better to let the M.F.W. carry on—in fact anything is better—than that the R.E. officer should not be trained, and systematically trained, year by year, in the military side of his work. Theoretical military training, lectures, &c., can all be done in the winter. This can be arranged with the Staff of the Command, Division or Area. I know they are only too glad to help. In this connection it should be stated that G.O.C's. have to report on the military attainments of R.E. officers and are always out to help them to improve them. It is for us to see that the answer is not that "we have no time." Briefly, then, it appears to me that the R.E. officer can get a good deal of military training but that it means that R.E. Commanders must arrange it to a programme.

(b) This is dealt with above to a very large extent. At the same time a great deal more can be done by arranging that officers do not serve too long either on works or in field units. The idea that an officer must be always "Works" or always "Field Company" is a wicked one. We must get a reasonably constant flow of officers between the two classes of work. Our officers must all have a wide experience of their duties.

As regards the sapper work on manœuvres—we all know that, *technically*, it is of small value. On the other hand manœuvres really teach more to the Staff, as regards handling formations, than anything else, and the R.E. unit commanders and officers learn how to move with other troops and get an insight into the methods of handling large formations which they would not get otherwise. Further, even if no work is actually done, the R.E. Officers and N.C.O.'s can work out a good many new and emergency problems as regards reconnaissance and organisation that the routine field works course can never present. Lastly, it is of the utmost service to all concerned to realise that, when there is no work for the sapper to do in war (it will seldom happen) it is a very good thing to let him do *nothing*. I have known some very good sappers to get killed because this point of view did not strike their superiors. In fact, I have been uncomfortably near it myself.

(c) (e) The Staff College is a thorny question for us. We have few vacancies and the competition for them is great. If we had more we should be much better off, as every one who can should go to the Staff College. Still, we are dealing with things as they are. How can we make the present rules help us more?

At present an officer who goes to the Staff College is inclined to hope that he is going to better himself and never be a D.O. again. It is only human nature that he should do so, but it is the wrong point of view to take up. I have known officers, on the other hand, who have tried to get back to regimental work for a time, in order to keep their hand in, and who have not been able to do so. Valuing the staff College training as I do, I should like to see Staff College graduates clamouring to get back to Corps work for a time; not necessarily for their own advantage but in order that they may be able to disseminate the Staff College point of view amongst their brother officers. Let us imagine how helpful it would be, in training works officers, if one at least of them had been to the Staff College. It would be child's play to him to do it and it would be invaluable to the others. In my experience I have known this done by one officer under my own command with great advantage to himself and to other people. In my view every officer who has passed the Staff College should regard himself as an apostle of the Staff College teaching. We engineers, especially, require this teaching, as, without it, we are much handicapped in our efforts to apply our technical knowledge to the requirements of the Army. R.E. officers have now far greater opportunities than ever before of acquiring sound technical knowledge, but if we are to produce officers for the high engineering posts in the field, who have wide military knowledge, it is essential that those who go to the Staff College should not be cut off entirely from the technical side of the work of their Corps, and also that they should, as far as in them lies, endeavour to pass on the knowledge they have acquired at the Staff College to their less fortunate brethren.

Personality is dealt with under the next heading.

(d) Here we are brought face to face with the human side of the problem. It has been said that "sappers" are all either mad, married or Methodists. It was rather a cruel jest, and must have been made by some one who had been stung by the aloofness of some ancient "sapper." However, it is an expression that is sometimes heard even now, so we will consider it in detail.

First, let us take the "madmen." We all know that it is one of the weaknesses of scientific souls to be inclined to bury themselves in their science. They are full of it and find it hard to prevent it from interfering with their dealings with other men. The soldier scientist must beware of this failing. By virtue of his adopted profession his first duty is to deal, and deal kindly, with other men. His science must not be allowed to puff him up. Other men may not be scientific in his sense of the word, but they have attainments of which he knows nothing. The scientific recluse is of no use to an army in the field.

As regards the "married"—well, I think this is pure jest—possibly the remark was made by one whom people would not marry. At the same time we are a married Corps, and, being such, we must see to it that marriage does not prevent us mixing with other people. It really ought to help us to get to know people.

As regards the Methodism. This is a difficult subject to write about. We all know, however, that there are such people as religious recluses. A man's religious views are his own business, but we have the authority of the best of books for saying that religion must not prevent a man mixing with his fellows. He must live in the world but not be of the world. Again, there is the question of duty. Duty to the Service, duty to one's fellow men. Nothing is, I think, more inspiring than to see the way a really religious man does his work and influences all those, with whom he comes in contact, for good. You can't do this by being a recluse.

Now we come to the question of dining and drinking port. We Englishmen do most of our real business to the accompaniment of eating and drinking. It may be foolish, but it's our way and it's a way of very old standing, in fact, it's part of our nature. I hold no brief for port drinking, though I am fond of it myself. I know, on the other hand, that some people don't like it and that with others it does not agree. The kernel of the question is, however, that, whatever you elect to drink, *don't drink it alone*. Share your pleasure with other people and try and share their troubles also. Remember that troubles shared are troubles halved.

Lastly, what about personality, what does it mean in this relationship? Every man has some personality born in him, some nice, some the reverse. I take it, however, that the personality required by the soldier means that he shall be imbued most strongly with a sense of duty; that he shall count himself as nothing in comparison with his duty; that he shall be firm in Council; that he shall be kindly and humane in his dealings with all men, and that, finally, he shall believe that, as he is trying to do his best for every one, they, in their turn, are doing their best for him. That is the spirit that makes men follow you and believe in you, and want your help and advice.

CONSTRUCTION OF BASINGSTOKE MANŒUVRE CAMP.

By MAJOR A. V. T. WAKELY, M.C., *p.s.c.*, R.E.

INTRODUCTION.

Some apology is needed for the insertion in the *Royal Engineers Journal* of a description of such a simple work as the construction of a Camp for an Infantry Brigade. It is work which many hundreds of R.E. Officers have done before. Thousands of drawings and estimates of materials must have been made, used, and then filed away for future reference.

Nevertheless, when the present writer was instructed to prepare designs and estimates for a camp for the 4th Guards Brigade, he could find none of these drawings and he had to start with a blank sheet of paper. This wasted much valuable time, which could have been available for unit training, and, owing to the speed at which the work had to be done, it must be admitted that strict economy in design did not receive as much attention as it deserves. It is thought that the pages of the *Royal Engineers Journal* offer the best opportunity for providing R.E. Officers generally with an outline to work upon should they at any future date be faced with a similar problem. It is not argued that the designs submitted in this article are the best possible, they could be improved upon in many respects. Those officers, however, who have neither the time nor the inclination to work out a plan for themselves will find below designs and a scheme of work which operated with success at Basingstoke.

STRENGTHS AND SCALE OF CAMP ACCESSORIES.

2. The camp was erected on Basingstoke Common to accommodate the 4th Guards Brigade and attached troops, a total strength of 140 officers, 3,200 O.R.'s and 600 horses. The units are shown in Appendix 2.

The layout was made out in May, 1925, by the Staff Captain 4th Guards Brigade and the O.C. 11th Field Coy. R.E. It was submitted for approval to G.O.C., London District, and D.D.M.S., Aldershot Command. The areas allotted to units are shown in Appendix 4.

The scale of camp accessories to be constructed by R.E. was laid down by Command for all camps, and is shewn in Appendix 1. The following remarks on this scale suggest themselves as the result of experience at Basingstoke :—

(*a*) Scale of ablution benches should be increased to 1-ft. run of bench per 10 men.

(*b*) Duckboards at the scale of 20 per battalion should be provided for general use in the camp.

(*c*) Officers' latrines should be at the rate of one seat per four officers.

(*d*) Showers or "Bains Douches" are better than 2,300-gallon tanks for bathing purposes.

Supply of Materials.

3. A list of the stores required was made out at the end of May by O.C., 11th Field Co., R.E., on the forms shown in Appendices 2 and 3. The figures (not shown) for Appendix 3 are merely the number of articles (Appendix 2) multiplied by the amount of material shown in Appendix 5. In making out this list an allowance of about 10 per cent. should be made for contingencies. After the camp is occupied there are generally many demands, more or less justified, made by units. There is also maintenance and repair work. These necessitate a small reserve apart from the C.R.E.'s reserve mentioned below.

The stores were ordered by C.R.E. 2nd Division for all camps. The C.R.E. kept a reserve in his own hand for emergencies. This system worked well; it is better than if Field Company Commanders ordered their own stores. Part of the C.R.E.'s reserve was required in the case of Basingstoke, since two extra units were put into this camp after the stores had been ordered. It is suggested that Field Company Commanders should be allotted a small sum (say, £10) for local purchase of urgent stores which cannot be foreseen, *e.g.*, tow, wire, nails, etc.; this would save time and money when the camps are at a distance from Aldershot.

The C.R.E. ordered the bulk of the stores, except water supply stores, to be delivered at Aldershot, whence they were transported by lorry to Basingstoke on 17th and 18th July. The lorries worked to a schedule made out by 2nd Division. The tonnage moved was 90 tons. It is absolutely necessary to work the transport to a time schedule, otherwise there is great confusion and no certainty of supply. The arrangements made in this case worked extremely well. Water supply stores having been ordered from Messrs. Ockenden and Smith were delivered at Basingstoke Station. They were brought to the site by Field Company transport, five G.S. wagons having been provided for this purpose and for general work in the camp.

Manufacture.

4. The 11th Field Coy. R.E. moved to Basingstoke on 17th July, and immediately proceeded with the manufacture of camp accessories.

There are two methods of manufacture:—

(1) To bring out all raw material to the camp, manufacture the articles required, and then proceed with erection.

(2) To make all the articles under Divisional arrangements before going out, then transport the made articles to the site.

The first method is preferable, since it allows a certain latitude for emergencies. Also the lorries required for the transport of the manufactured articles are about double the number required for the raw material. It was found at Basingstoke that it was not possible to make out an accurate list of the number of articles required, owing to unavoidable changes in the layout of the camp and in the units to be accommodated. Appendix 2 shows what was eventually provided, but this list is about 10 per cent. more in total than the original list made in May, 1925.

ORGANISATION OF COMPANY.

5. The organisation of the Company for the construction of the camp was as under :—

Trade.	No.	N.C.O.i/c.	General Nature of Work.
Carpenters & Joiners.	12	1 Sergt.	Manufacture and erection of cook shelters, latrines, etc.
Sawyers.	2	—	Erection and working Saw Bench.
Electricians	2	—	Erecting Electric Light and Power.
Plumbers.	15	1 Sergt.	Water Supply.
Pioneer Carpenters.	10	1 Sergt.	Erecting stands for water points.
Unskilled Labour (1)	10	Inf. Cpl.	Digging trenches for water supply.
,, (2)	10	Ditto.	Digging holes for uprights, etc.

It will be noted that the section organisation of the Field Company was broken up for this work. This is necessary since the tradesmen must be grouped by trades. It is better and tends to quicker work to form these groups at the beginning, and to keep the same men on the same work. With this organisation the camp was constructed in 20 working days. It was finished on 15th August, the whole company having been taken for field works on four days during the period 20th July to 15th August.

METHOD OF MANUFACTURE—CARPENTERS' WORK.

6. The following is a brief description of the general method of manufacture organised on factory lines for turning out cook shelters, latrines and all carpenters' work.

(1) The layout of the dump when stores arrive should be such that there is room opposite the stack of each size of timber to cut timber to length and to construct the shelters, etc. In photo No. 2 four stacks can be seen, 3-in. × 2-in., 6-in. × 1-in., 3-in × 1-in. and 9-in. × 1-in. This system avoids long carries and consequent waste of time.

(2) Opposite each of these stacks a bench (see (*a*) Photo 2), for cutting timber to length, is made.

(3) Having made a list of the lengths of timber required for each article, three men are put to work at each bench and they cut the total number of each length required.

(4) Templates are then made as under :—

Cook shelters and officers' latrines—2 templates each, one for each gable end.

Ablution bench—one template for framing.

Latrines and grease traps—one set complete as a sample.

These are made under the careful supervision of the senior N.C.O. Carpenter.

(5) Two men then work on each template and construct the number of each article required.

ERECTION.

7. For small cook shelters, of which there were a large number, a plan template carefully squared was made for erection purposes. One point was fixed on the ground in accordance with the layout of the camp. The advantage of a template is that unskilled labour can be put on to dig the holes for the posts without supervision of officers and senior N.C.O.'s. Templates were also made for the latrines showing the exact position of the pits. These templates were of great value since a large number of men can be put on to dig holes quickly without elaborate measurements.

DESIGN OF CAMP ACCESSORIES.

8. The design of each article is shown in the photographs; the amount of material required for each is given in Appendix V.

The following remarks on these designs are based on the experience gained at Basingstoke :—

(*a*) *Cooks' Shelters.*—Wire stays are required unless the shelter is firmly fixed to 4-in × 3-in. piles in the ground. The stays are quicker to put up.

(*b*) *Meat Safes.*—Muslin is very unsatisfactory as a covering. Some safes had to be re-covered twice, and most of them were quite useless for keeping out flies. Wire gauze should be an authorised issue.

(*c*) *Grease Traps.*—Of the two types shown in Plate 4, the smaller one is the better. The large one is difficult to clean out and the tray should be larger. The small type is suitable for officers' and sergeants' messes and small units. Two small traps per battalion are better than one of the large pattern.

ENTRANCES TO THE CAMP.

9. (*a*). The main entrance to the camp from the London Road was improved by laying old road metal 4-in. thick and steam rolling it. This metal was delivered to the site at 7s. a ton by the Basingstoke Urban District Council. It was much cheaper than sleepers and the road was far more satisfactory. About 30 yards of road was laid down.

(*b*) A new entrance was made east of the above, but as there was no slope on the ground at the point chosen, very little metalling was required.

(*c*) For the R.A.S.C. Depot, a loop road 110 yards long and 12ft. wide was provided. This was made with road metal as described in (*a*) above. Without this road, lorries could not have entered the depot, and the working of the depot would have been very difficult. The road stood up well to the work. It was very quickly made and no foundation or excavating was attempted. (See Photo No. 1, South Corner of Camp, and Photo No. 7.)

The total cost of these three entrances was £29, 76 tons of metalling being used. Sleeper roads would have taken three times as long to lay and would have been double the cost.

SUBSIDIARY WORKS.

10. (*a*) As the electric power and lighting mains of the Basingstoke town supply ran alongside the camp, it was decided to instal a small circular saw. This was an 18-in. saw driven by a 20 h.p. D.C. motor. It was extremely useful, especially when an extra demand for duckboards arose on account of very bad weather. The cost of installation of power lines and meter was £7.

(*b*) Electric light was laid on to the 11th Field Co. lines, Brigade Headquarters, R.A.M.C., and the Officers' Messes of the four battalions. The cost of this was borne by the units concerned. Since the stores were returned when the camp was dismantled, and since extremely favourable terms were obtained from the Basingstoke Borough Electrical Engineer, the cost per unit was very small, and the lighting was much cheaper than lamps or candles.

Installation charges and current consumed came to £2 6s. 8d. per battalion officers' mess.

(c) Two thousand feet of four-strand wire fence was erected to rail off a "right of way" from the camp on the western boundary.

(d) A considerable number of notice boards were required, and also posts for marking roads throughout the camp. It is important not to forget these articles when making out lists of stores.

WATER SUPPLY.

(a) Consumption.

11. The estimated consumption of water was 30,000 gallons per diem. The Waterworks Engineer of Basingstoke agreed to supply this by tapping a 3-in. main near the camp, on condition that sufficient storage was installed to deal with the peak load. A 2-in. meter was asked for, but was refused on the grounds that the supply to the civil population would be cut short. A 1-in. meter was, therefore, installed. The pressure was 70-75 lbs. per sq. inch. The curves in Plate 2 show:—

Curve (1).—The supply from the 1-in. meter under test. The Waterworks Engineer was asked to make this test to give data on which to calculate the storage required.

Curve (2) was then made out, showing the estimated consumption. A study of these two curves showed that storage of about 9,000 gallons was required to deal with the evening load—chiefly washing. Consumption between 3 p.m. and 8 p.m. was estimated at 18,000 gallons and supply would be 9,000 gallons.

Curve (3) shows the actual average consumption. This curve was made out after experience of the working of the system had been gained. It will be noted that the morning load was more prolonged than anticipated, and that the evening load was smaller than estimated. The latter was due to the extraordinary cold weather during camp. Had the weather been very hot, there would have been a very great strain put upon the system. The actual average consumption was 20,000 gallons per day.

Water Points.

(b) A water point was authorised for each unit, and after an investigation of Curves (1) and (2) the storage decided upon was:—

One 2,400 gallon Water Point.
Four 1,600 ,, ,, Points.
Two 400 ,, ,, ,,

Total storage 9,600 gallons. Two-in. mains with 1-in. service pipes were used.

The general arrangements for water supply were :—

(1) One 100 or 150 gallon tank to be provided at each cook-house to be filled by unit watercarts from the water-point. (See Photo No. 3.)

(2) Ablution benches to be near the water point so that basins could be filled from the taps and taken to the benches.

(3) Horse troughs (600 gallon) were supplied direct from the mains with a low stand pipe.

Each water point, therefore, had to have—

(i) A 1-in. down pipe with stop cock and $1\frac{1}{2}$-in. hose on the end, for water-cart filling.

(ii) A row of taps for ablution and water bottle filling.

For bathing purposes shower baths on a scale of five per battalion were erected (see Photo No. 5). These were put direct on the main in order to provide sufficient pressure.

The general design of the water points is shown in photo No. 6. The following points in design call for notice :—

(i) It is absolutely necessary to put the tanks ten-feet high to give reasonable pressure for filling basins and water bottles.

(ii) A stop cock must be fitted on each down pipe.

(iii) A bench is required on which to rest buckets and basins to prevent men hanging them on the taps.

Time for Erection.

(*c*) The water supply system was erected in 17 working days by 13 pioneer plumbers and two Class II. plumbers with a sergeant in charge. A labour party of two N.C.O.'s and 10 men did the unskilled work.

The piping was secondhand, which necessitated plugging and testing the portion laid twice daily, and also the tanks were not new and had to be patched. The pioneer plumbers were from the Army Vocational Training Centre and had had no previous experience of this work. With skilled plumbers and good material the work could have been done in 12 or 14 working days.

Maintenance Party.

(*d*) A maintenance party of two plumbers ran this water supply during camp. Their chief work was the repair of taps and keeping the water points full. The daily duties of these men on the latter work is indicated in Plate No. 2.

The reason why this party had to fill the water points regularly was that the supply from the town mains could not be brought into the camp at the highest point of the system, and there was not enough pressure to fill all points simultaneously. Great care had, therefore, to be exercised in manipulating stop cocks so that all parts of the system were kept fully supplied.

Points Regarding Water Supply.

(*e*) The following points should be noted as regards water supply of camps in future :—

(1) It is best to run a short length of pipe from the water points to the ablution benches and to have the taps on the benches.

(2) A stop cock must be provided on each branch of the system to enable refilling to be carried out.

(3) To prevent waste of water very strict orders must be issued to units. It is suggested that the Engineer Officer in charge should draft out these orders and that they should be issued by Brigade to all units in camp.

(4) A timed programme for the use of shower baths is necessary if the best use is to be made of them.

Water Supply Stores.

(*f*) Appendix 6 shows the water supply stores actually ordered for this system, and will give an indication of what is required for work of this nature. An important item as regards water supply work is the equipment of tools. A Field Company does not possess many of these articles, and they must be obtained from store. Appendix 6 shows what was taken out to Basingstoke.

APPENDIX. 1.

SCALE of CAMP ACCESSORIES laid down by Command H.Q. issued under 2nd Division Administrative Instructions for Manœuvres, 1925, No. 1.

1. WATERING.	600 gallon troughs	1 per 100 horses.	
2. COOKHOUSES.	Infantry Battalion	Officers	1 small.
		Sergts.	1 small.
		O. Ranks	1 large.
	Other units in proportion.		
3. GREASE TRAPS.	One per Cookhouse.		
4. MEAT SAFES.	,, ,, ,,		
5. INCINERATORS.	One per battalion, or equivalent.		
6. ABLUTION.	Double benches 11′ lengths, duckboards on each side, 40 ft. run for 1,000 men.		
	Average 2 lengths per battalion waterpoint.		
7. BATHING.	One 2,300-gallon tank per 1,000 men.		
8. LATRINES.	(*a*) One single seat box. 1 per 6 officers.		
	(*b*) Ten-seat boxes. 10 seats per 100 men.		
	C.I. shelter to be put over.		
	C.I. sides. Canvas backing.		
	Latrine screens to be put up by each unit.		
9. URINALS.	Single. 6 ft. C.I. bent J shape on uprights.		
	Double. One on each side of uprights.		
	Scale :— Group of Officers' Latrines	1 single.	
	Each N.C.O.'s ,,	1 single.	
	Each pair of 10-seater latrines	1 double.	

APPENDIX 2.

REQUIREMENTS OF UNITS.

Unit.	Cookhouses		Grease Traps.	Meat Safes.	Incinerators.	Water Tanks, (i) Stands for (ii) Covers for	Latrines.		Urinals.	Ablution Benches. (11ft. Lgths).	Horse Troughs. (complete)
	Large	Small					Officers	O. Ranks (10 seats)			
H.Q. 4th Gds. Bde. / Bde. H.Q. Sig. Sec.	—	1	1	1	—	1	5	—	2	—	—
2nd Bn. Gren. Gds.	1	2	3	3	1	3	8	5	6	4	1
3rd Bn. Cold. Gds.	1	2	3	3	1	3	8	6	6	4	1
1st Bn. Irish Gds.	1	2	3	3	1	3	8	6	6	4	1
1st Bn. Welsh Gds.	1	2	3	3	1	3	8	6	6	4	1
19th Fd. Bde. R.A. / R.A. Bde. Sig. Sec.	—	5	5	5	2	5	4	3	4	2	4
19th Pack Bty., R.A.	—	3	3	3	1	3	2	2	3	2	2
1st Sqdn. Life Gds.	—	2	3	2	1	1	2	1	3	1	1
11th Fd. Co., R.E.	—	3	3	3	1	2	2	1	3	1	1
"O" Batty., R.H.A.	—	3	3	3	1	3	2	1	3	1	2
R.A.S.C. (Depot)	—	1	1	1	1	1	—	—	—	1	—
R.A.M.C. (Hospital)	—	—	1	—	—	—	3	—	1	—	—
N.A.A.F.I.'s (3)	—	—	3	—	—	—	—	—	—	—	—
Totals	4	26	35	30	11	28	52	31	43	24	14

APPENDIX 3.

SUMMARY OF MATERIALS REQUIRED.

Camp Accessory.	Number required from Appendix 2	Timber Foot run.						Corrugated Iron Sheets.		Nails lbs.					Angle Irons	Plain Wire No. 12 S.W.G. Coils 28 lbs.	Leather 1" wide, ft. run.	Biscuit Tins.	Muslin, Yards	Barbed Wire. Coils 28 lbs.	Staples.	Horse Troughs 600 gall. complete.	Remarks
		5"×3"	4"×3"	3"×2"	9"×1½"	6"×1"	3"×1"	6'	9'	4"	3"	2½"	2"	1"									
Cook shelters, large ..																							
" " small ..																							
Grease traps, large ..																							
" " small ..																							
Meat Safes																							
Incinerators																							
Water Tank Stands ..																							
" " Covers ..																							
Latrine Shelters																							
Two Seats																							
Four Seats																							
Ten Seats																							
Twenty Seats ..																							
Sixty Seats																							
Latrine Seats																							
Single																							
Ten Seats																							
Urinals																							
Ablution Benches ..																							
Duckboards																							
Horse Troughs																							
Trestles for Storage Tanks																							
Posts & Notice Boards ..																							
Subsidiary Works ..																							
Total Add 10% contingencies ..																							
Total to be ordered ..																							

APPENDIX 4.

BASINGSTOKE COMMON CAMP LAY OUT. AREAS ALLOTTED TO UNITS.

	Feet.
Brigade Headquarters	700 x 150
Infantry Battalions (each) ...	700 x 400
Squadron Life Guards	540 x 300
"O" Battery, R.H.A.	600 x 300
Field Artillery Brigade—	
Officers' Lines	160 x 160
Battery Lines (each)... ...	280 x 160
Battery Horse Lines (each) ...	420 x 80
Gun Park (Brigade)	640 x 140
Pack Battery, R.A.	420 x 140
11th Field Company, R.E. ...	430 x 320
R.A.S.C. Depot.	350 x 250

APPENDIX 5.

LISTS OF MATERIALS REQUIRED FOR CAMP ACCESSORIES.

WATER POINT OF 6-400 GALLON TANKS.

TIMBER.

Rough Hewn Logs 12"-15" cut to size ...	9
5" x 4"	200 F.R.
4" x 1"	60 F.R.
3" x 2"	250 F.R.

NAILS.

6"	4 lbs.
4"	1 lb.
3"	$2\frac{1}{2}$ lbs.

DOGS. 18

N.B.—Water supply stores and piping omitted.

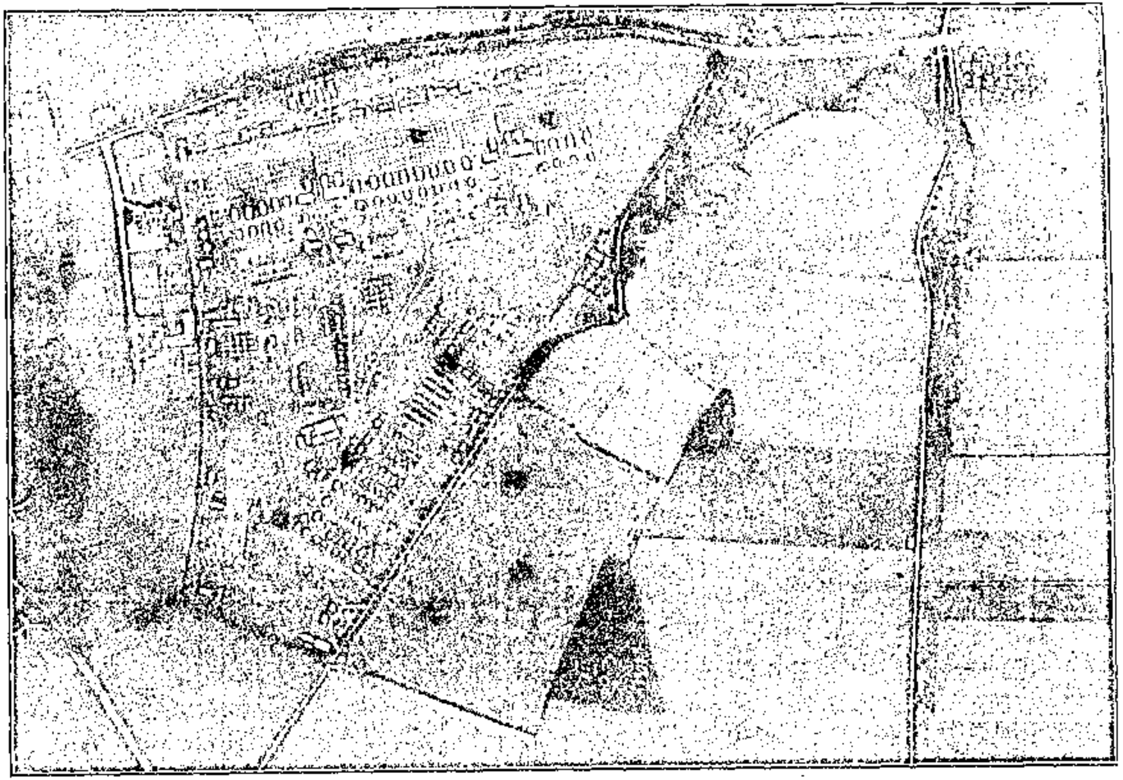
LARGE COOK SHELTER.

CORRUGATED GALVANISED IRON 6' SHEETS.

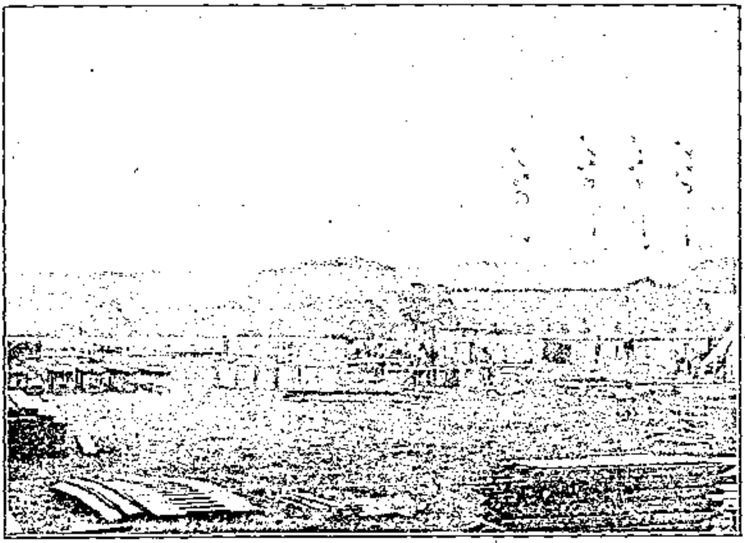
Roof	20 sheets.	Total
Back	10 sheets.	40
Ends	10 sheets.	Sheets.

WIRE	12 S.W.G.	80 F.R.
TIMBER	3" x 2"	240 F.R.
NAILS	3"	3 lbs.
	4"	$2\frac{1}{2}$ lbs.

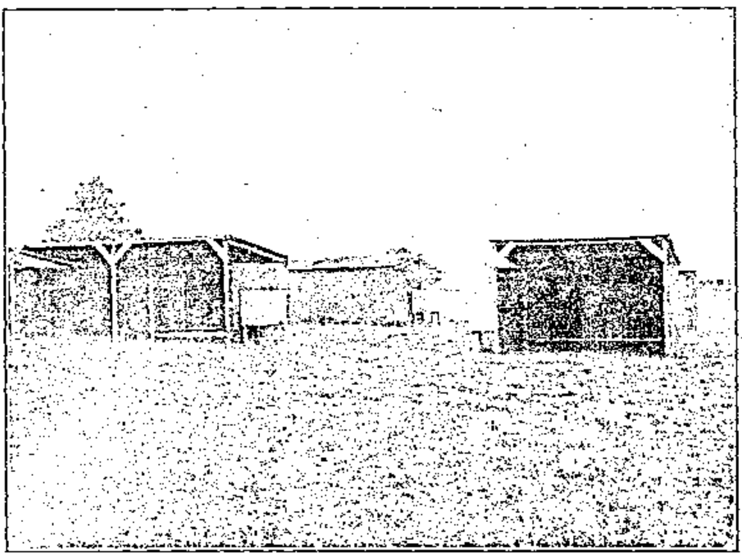
CONSTRUCTION OF BASINGSTOKE MANŒUVRE CAMP.



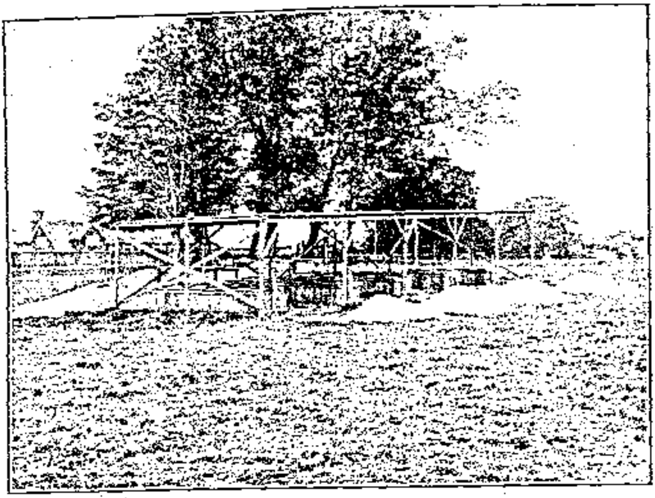
No. 1. Air View of Camp in occupation.



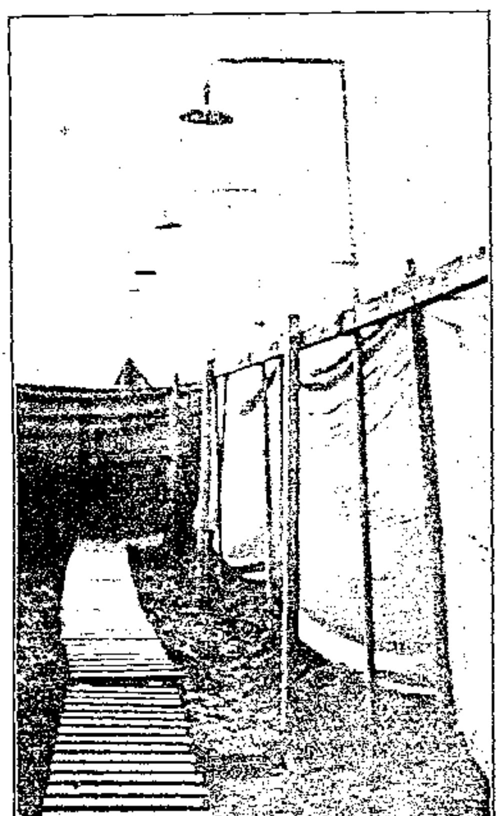
No. 2. R.E. Dump and Manufacturing Yard.



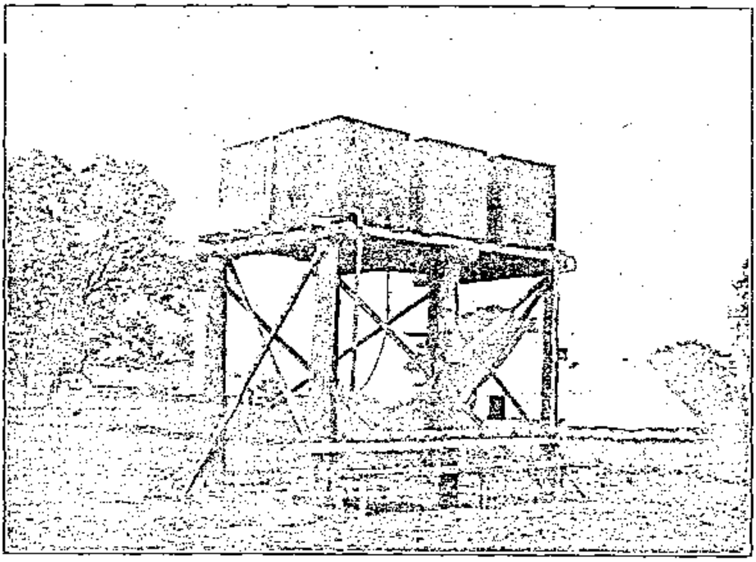
No. 3. Large and Small Cook Shelters.



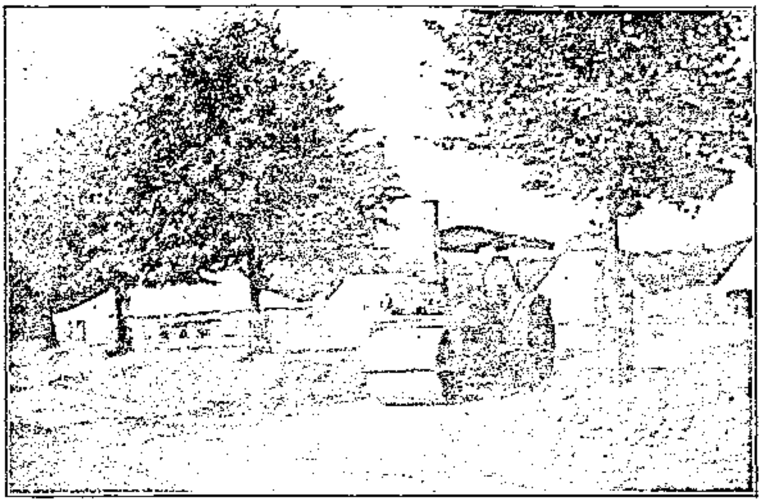
No. 4. Latrines for One Battalion—Screens not yet erected.



No. 5. Showers for One Battalion.



No. 6. Details of Water Point for Bde. Hd. Qrs. and One Battalion.

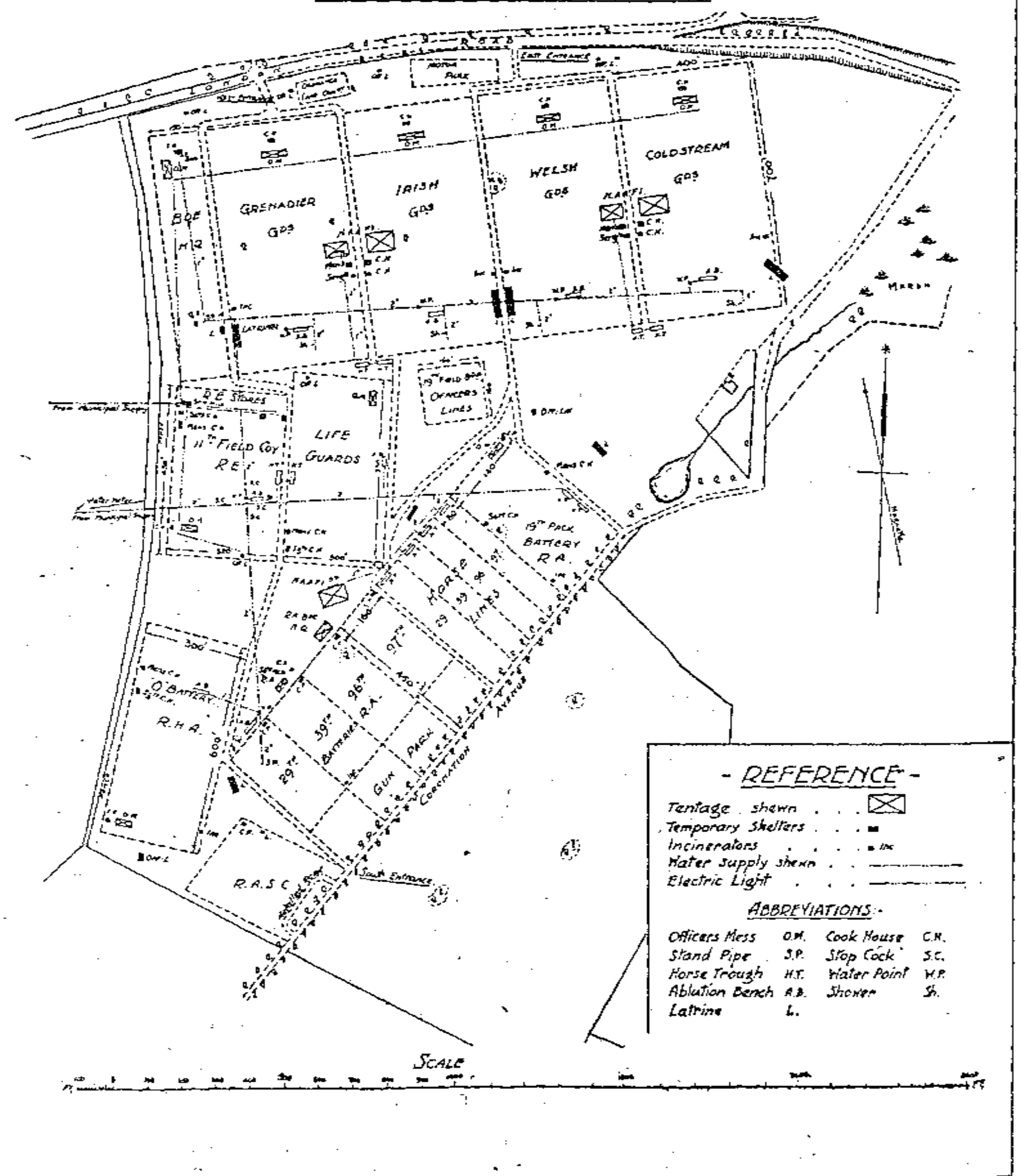


No. 7. Making entrance to R.A.S.C. Depot.

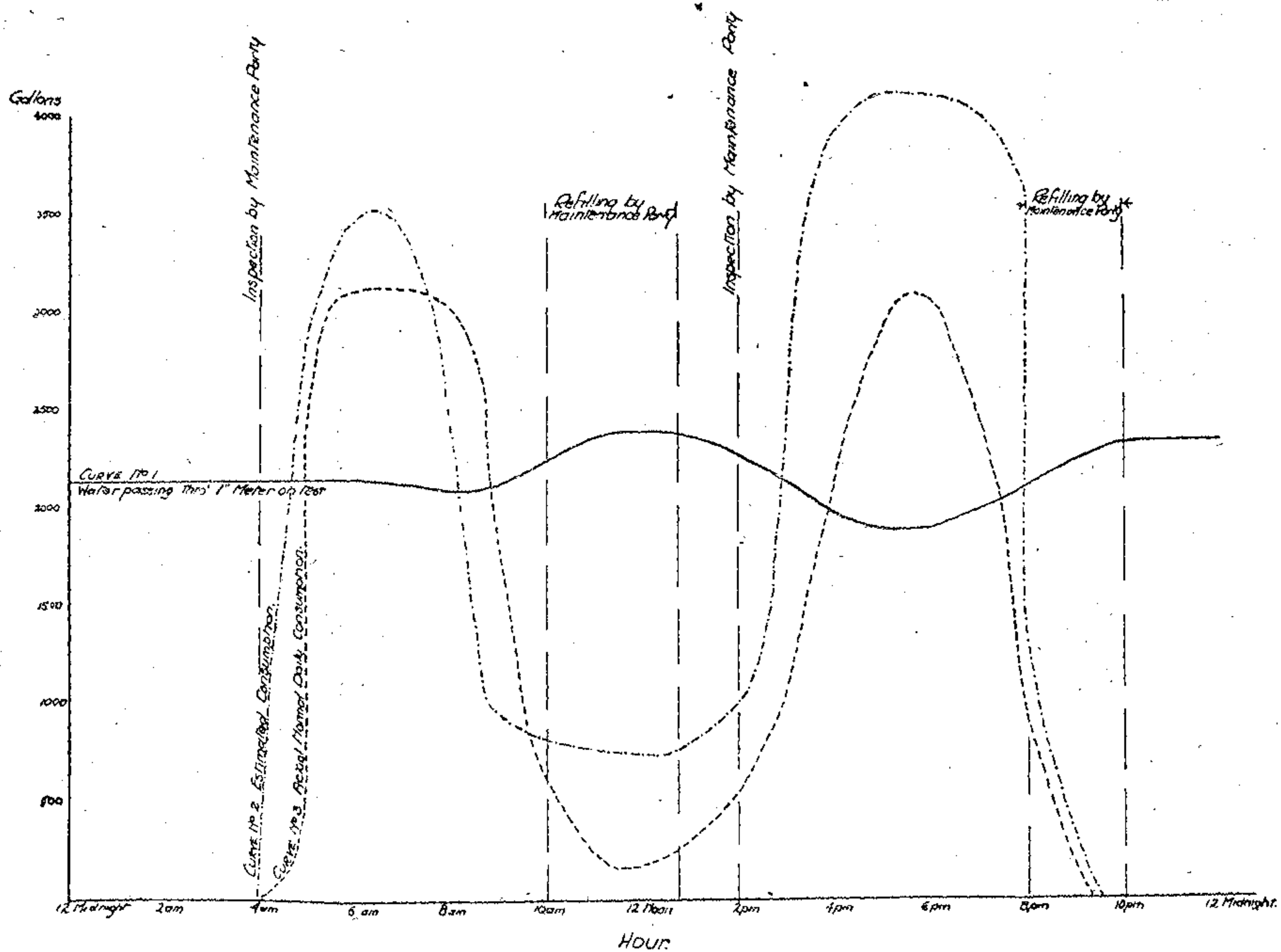
Plate I.

PLAN of BASINGSTOKE COMMON CAMP

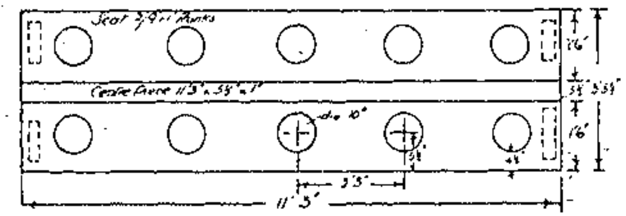
4TH GUARDS BRIGADE



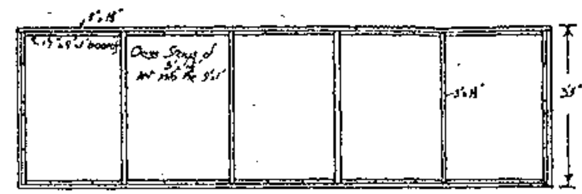
CURVES SHOWING ESTIMATED & ACTUAL CONSUMPTION OF WATER AT BASINGSTOKE CAMP



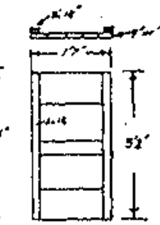
LATRINE—TEN SEATS—BASINGSTOKE CAMP



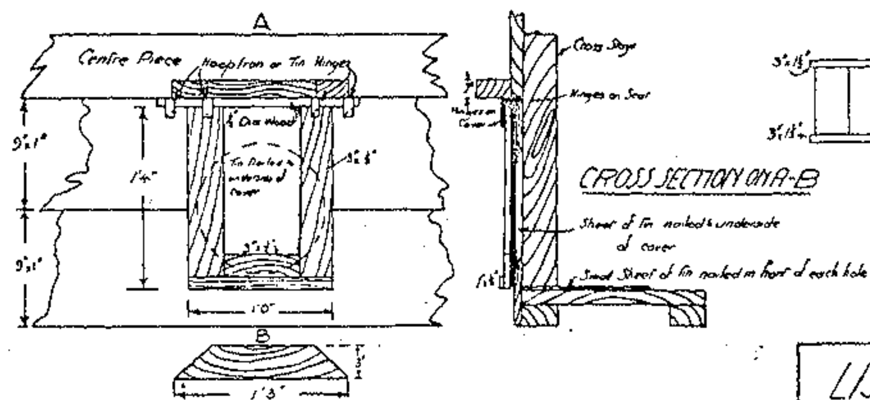
PLAN OF TOP

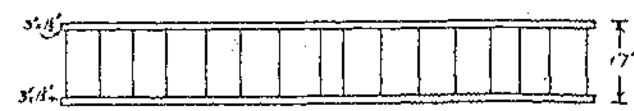


PLAN OF FRAME



ENDS





SIDES

DETAILS OF COVERS SCALE 1/8th

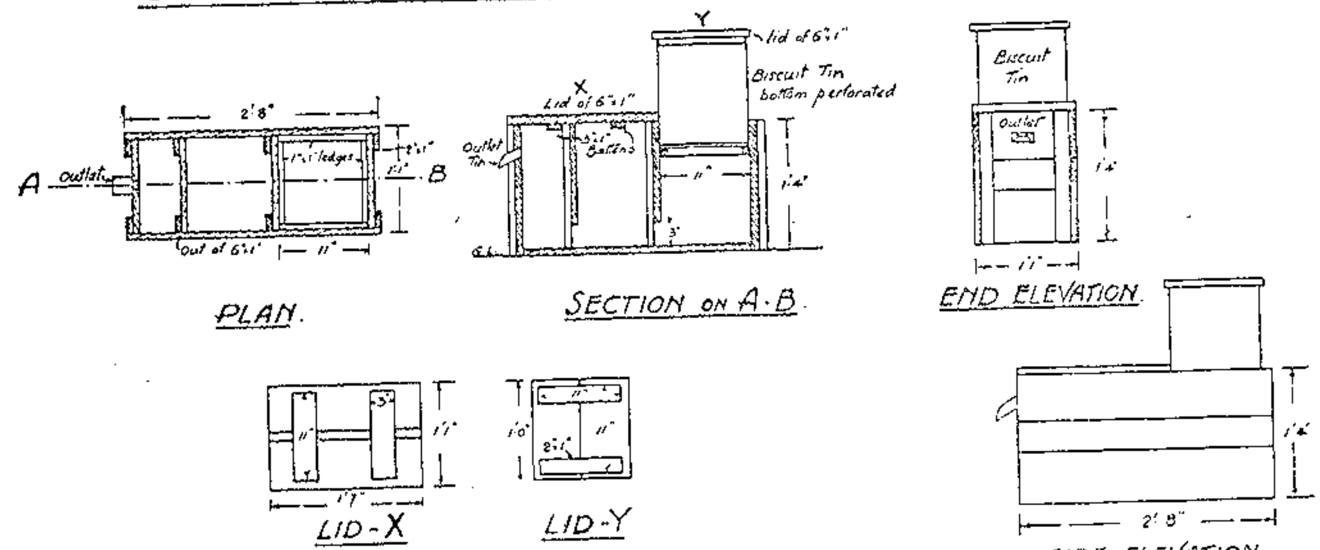
General Scale ½ inch equals 1 foot

LIST OF MATERIALS REQUIRED FOR 10 SEAT LATRINE

Timber 9" × 1"	130 F.R.		Timber 6" × 1"	30 F.R.
Timber 3" × 2"	50 F.R.		Timber 3" × 1½"	60 F.R.
Timber 5" × ½"	35 F.R.		Timber ½" × ½"	15 F.R.
Leather or Hoop Iron Hinges	40		Tin (Biscuit tins cut)	15 Sq. ft.
Nails 2"	7 lbs		Nails 2½"	½ lbs.
Nails 3" (as required)	— lbs		Nails 4"	¾ lbs

Plate IV

— GREASE TRAPS — BASINGSTOKE CAMP —



DETAILS OF SMALL GREASE TRAP

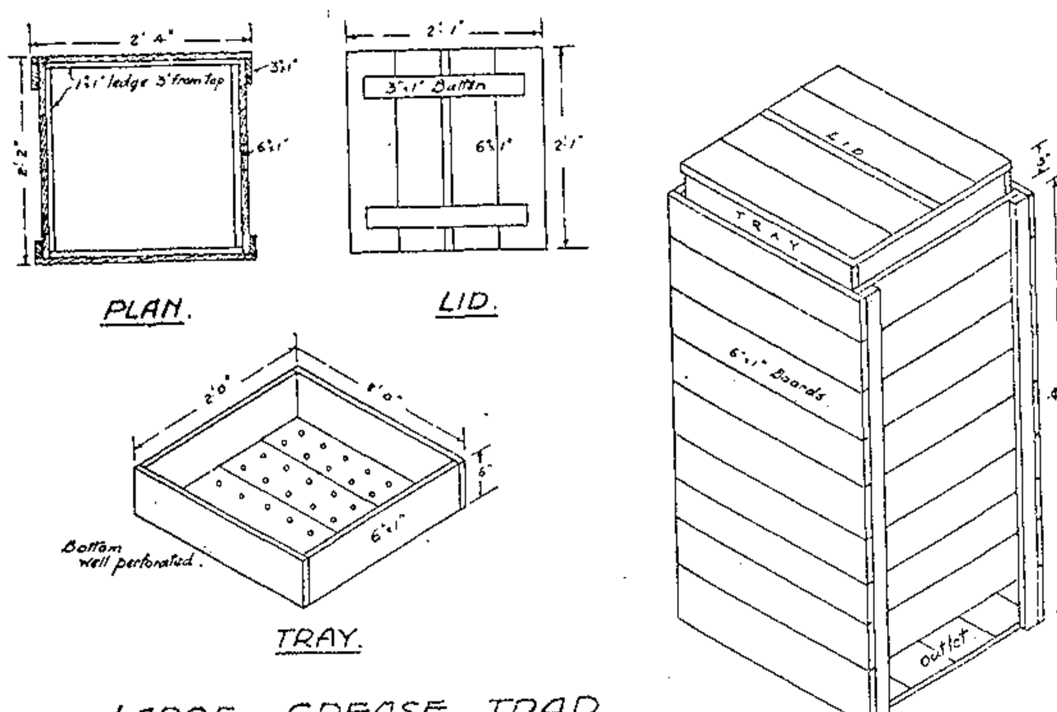
LIST OF MATERIALS REQUIRED FOR:-

SMALL GREASE TRAP

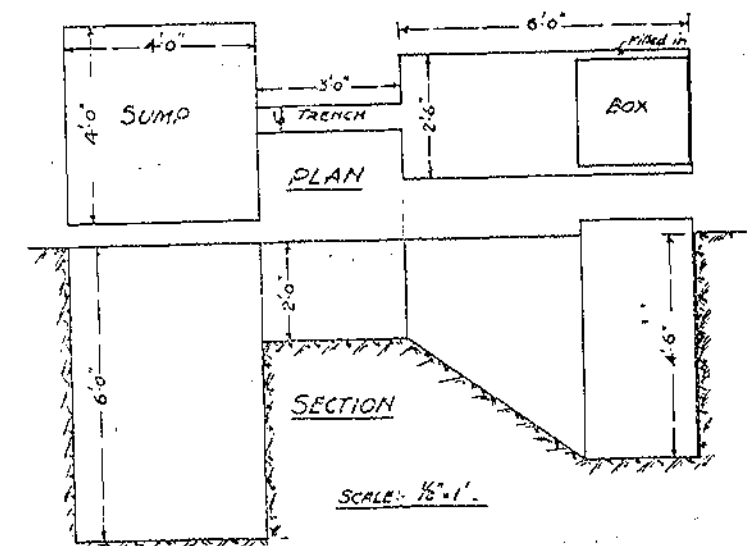
Timber	6"x1"	40	Ft. Run.
	3"x1"	8	" "
	2"x1"	10	" "
Biscuit Tin.			
Nails	2½"	¾	lbs.
	2"	½	"

LARGE GREASE TRAP

Timber	6"x1"	20	Ft. Run.
	3"x1"	30	" "
	1"x1"	12	" "
Nails	2½"	4	lbs.
	2"	1	lb.



LARGE GREASE TRAP



SMALL COOK SHELTER.

CORRUGATED GALVANISED IRON 6′ SHEETS.

	Roof 12 sheets.		Total	
	Back 6 sheets.		28	
	Ends 10 sheets.		Sheets.	
WIRE	12 S.W.G.	80 F.R.		
TIMBER	3″ x 2″	190 F.R.	6″ x 1″	8 F.R.
NAILS	3″	2½ lbs.		
	4″	2 lbs.		

LATRINE SHELTER (THREE BAYS).

GALVANISED CORRUGATED IRON 9′ SHEETS				21 Sheets.
TIMBER	3″ x 2″	300 F.R.	3″ x 1″	100 F.R.
NAILS	3″	3 lbs.	4″	2 lbs.

ABLUTION BENCH.

TIMBER	9″ x 1″	25 F.R.
	3″ x 2″	20 F.R.
	3″ x 1″	25 F.R.

GALVANISED CORRUGATED IRON 1-6′ SHEET cut to shape.

NAILS	3″	1 lb.	4″	¼ lb.

NOTE—Bench should be 11′ 0″ long c.f. M.F.W. Plate 131.

INCINERATOR.

ANGLE IRON PICKETS	9
6′ SHEETS C.I.	6
WIRE 12 S.W.G.	6 yds or ½ lb.

MEAT SAFE.

TIMBER	6″ x 1″	100 F.R.	3″ x 2″	50 F.R.		
	3″ x 1″	40 F.R.	1″ x 1″	15 F.R.		
	1″ x ¼″	50 F.R.				
NAILS	6″	½ lb.	4″	1 lb.	2½″	2½ lbs.
	2″	¼ lb.	½″	¼ lb.		

MUSLIN 30 yds.

HOOKS, STEEL MEAT 2 or 3.

LEATHER HINGES 3.

NOTE.—The meat safe can be improved by the addition of two shelves, in which case 180 F.R. of 6″ x 1″ is required.

BASINGSTOKE CAMP—APPENDIX 6.

WATER SUPPLY STORES.

Piping Tubes 4″ (12 feet long)	5
Piping 2″	5,000 ft. run
„ 1″	2,500 „ „
Piping pieces 2″	20
„ „ 1″	20
Gunmetal Fullway valves 2″	10
„ „ „ 1″	10

Stopcocks 2"	1
Connectors Screw long 2"	10
,, ,, short 2"	10
Tees 4" to 2"	10
,, 2" equal	20
,, 2" to 1"	14
Crosses 2"	1
Bends 2"	32
,, 1"	40
Sockets 2"	20
,, 1"	20
Sockets Reducing 2" to 1"	16
Backnuts 2"	62
,, 1"	46
Ball-valves 1"	10 (3 spare)
Bib-cocks 1"	85
,, ½"	32
Plugs 4"	10
,, 2"	12
,, 1"	1
Rubber Sheeting for Washers	7 lbs.
Showers complete with Bib-cock	24
Tallow and Tow	14 lbs. of each
Tanks 400 galls.	25
Tanks 100 and 150 galls. (for Cookhouses)	28
Delivery Hose 1½" (for Water points)	7 lengths
Dogs 12"	100
Trees (14 ft. long) (9"-12" diameter)	60
Timber (5" x 4")	1,000 F.R.
(3" x 2")	2,000 F.R.

Also lead, bolts, nuts and washers for repair of Tanks.

EXTRA TOOLS FOR WATER SUPPLY.

Screw cutting machine (hand) (Field Company Equipment)	1
Pipe Wrenches, flat link 4"	4
,, ,, ,, 2"	4
,, ,, ,, 1"	2
Stocks and Dies (Gas) 2"	1
,, ,, ,, 1"	1
Spanners, Stillson	1
Cold Chisels	6
Files, round	2
Tools, pipe cutting, three wheel 2"	2
,, ,, ,, ,, 1"	2
Ratchet drilling and tapping machine	1
Plumber's bench (to be constructed)	
Vices pipe (Field Company Equipment)	2

ADDITIONS AND CORRECTIONS TO BATTLE HONOURS OF R.E. UNITS.—R.E. JOURNAL, DECEMBER, 1925.

Page 633. *Mount Sorrel.*
The last date of this battle was 13th June and not 15th.

Page 635. *Albert*, 1916.
For 233rd Field Co. of 31st Div. read 223rd.

Page 637. *Bazentin.*
Strike out IIA. Corps Signal Co. and IV A. Corps Signal Co. as the II and IV Army Corps were not engaged in this battle.

Page 638. *Delville Wood.*

Add after 7th Divn.	61st Field Co.	14th Div.	E.
	62nd ,, ,,	,,	E.
	89th ,, ,,	,,	E.
	14th Divl. Signal Co.	,,	D.
	77th Field Co.	17th Div.	E.
	78th ,, ,,	,,	D.
	93rd ,, ,,	,,	E.
	17th Divl. Signal Co.	,,	D.
	XIII Corps Signal Co.	XIII Corps	N.E.
	XIV ,, ,, ,,	XIV ,,	N.E
	XV ,, ,, ,,	XV ,,	N.E.

Page 639. *Pozieres.*

	Add X Corps Signal Co.	X Corps	D.

Page 641. *Guillemont.*
Line 35 after 24th Divn. for 5th Div. read 55th Div.

	Add XIV Corps Signal Co.	XIV Corps.	N.E.
	XV ,, ,, ,,	XV Corps.	N.E.

Page 642. *Ginchy.*

	Add XIV Corps Signal Co.	XIV Corps.	N.E.
	XV ,, ,, ,,	XV Corps.	N.E.

In the *R.E. Journal*, June, 1925, page 24. The last day of the Battle of the Aisne is 12th September, 1914, not 15th.

BATTLE HONOURS OF ROYAL ENGINEERS UNITS.

(Continued).

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	62nd ,, ,,	,,	E.
	89th ,, ,,	,,	E.
	14th Divl. Signal Co.	,,	D.
	77th Field Co.	17th Div.	E.
	78th ,, ,,	,,	D.
	93rd ,, ,,	,,	E.
	17th Divl. Signal Co.	,,	D.
	XIII Corps Signal Co.	XIII Corps	N.E.
	XIV ,, ,, ,,	XIV ,,	N.E
	XV ,, ,, ,,	XV ,,	N.E.

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XV Corps.

133rd Army Troops Co.	XV Corps	E.	
134th Army Troops Co.	,,	,,	
149th Army Troops Co.	,,	N.E.	
217th Army Troops Co.	,,	E.	
2nd Indian Field Sqdn.	2nd Indian Cav. Div.	,,	Attached XV Corps.

III Corps.

23rd Field Co.	1st Div.	,,
26th Field Co.	,,	,,
1/1st Lowlands Fd. Co.	,,	,,
101st Field Co.	23rd Div.	,,
102nd Field Co.	,,	,,
128th Field Co.	,,	,,

MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
III CORPS.			
1/1st Northumbrian Field Co.	50th Div.	E.	
1/2nd Northumbrian Field Co.	"	"	
7th Field Co.	"	"	
74th Field Co.	15th Div.	"	Working on roads and huts in area.
XIV CORPS.			
55th Field Co.	Guards Div.	"	
75th Field Co.	"	"	
76th Field Co.	"	"	
59th Field Co.	5th Div.	"	
1/2nd Durham Fd. Co.	"	"	
1/2nd Home Counties Fd. Co.	"	"	
12th Field Co.	6th Div.	"	
1/1st London Fd. Co.	"	"	
2/2nd West Riding Fd. Co.	"	"	
83rd Field Co.	20th Div.	"	
84th Field Co.	"	"	
96th Field Co.	"	"	
1/1st Edinburgh Fd. Co.	56th Div.	"	
2/1st London Fd. Co.	"	"	
2/2nd London Fd. Co.	"	"	
XV CORPS.			
97th Field Co.	21st Div.	"	
98th Field Co.	"	"	
126th Field Co.	"	"	
1/1st West Lancs. Fd. Co.	55th Div.	"	
2/1st West Lancs. Fd. Co.	"	"	
2/2nd West Lancs. Fd. Co.	"	"	
1st New Zealand Fd. Co.	New Zealand Div.	"	
2nd New Zealand Fd. Co.	"	"	
3rd New Zealand Fd. Co.	"	"	
228th Field Co.	41st Div.	"	Attached 21st Divn.
233rd Field Co.	"	"	Repairing roads in area.
237th Field Co.	"	"	

SIGNAL COMPANIES.

MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
4TH ARMY.			
4th Army Signal Co.	4th Army	N.E.	
III CORPS.			
III Corps Signal Co.	III Corps	E.	
XIV CORPS.			
XIV Corps Signal Co.	XIV Corps	"	
XV CORPS.			
XV Corps Signal Co.	XV Corps	"	
III CORPS			
1st Div. Signal Co.	1st Div.	"	
23rd Div. Signal Co.	23rd Div.	"	
50th Div. Signal Co.	50th Div.	"	

MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
XIV CORPS			
Guards Div. Signal Co.	Guards Div.	E.	
5th Div. Signal Co.	5th Div.	,,	
6th Div. Signal Co.	6th Div.	,,	
20th Div. Signal Co.	20th Div.	,,	
56th Div. Signal Co.	56th Div.	,,	
XV CORPS.			
21st Div. Signal Co.	21st Div.	,,	
55th Div. Signal Co.	55th Div.	,,	
N.Z. Div. Signal Co.	New Zealand Div.	,,	

THIEPVAL. 26TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
RESERVE (5TH) ARMY.			
119th Railway Co. R.E.	G.H.Q.	E.	
174th Tunnelling Co. R.E.	,,	,,	
179th Tunnelling Co. R.E.	,,	,,	
252nd Tunnelling Co. R.E.	,,	N.E.	
236th Army Troops Co. R.E.	Reserve Army	D.	No diary.
1/1st Hants. A.T. Co.	,,	N.E.	
No 2 Siege Co. R. Anglesey.	,,	,,	
No 6 Labour Bn. R.E.	,,	D.	
5th Field Survey Co. R.E.	,,	,,	No diary.
No. 12 Pontoon Park	,,	N.E.	
No. 5 Pontoon Park	,,	E.	Nos. 2, 3, 4 Sections only
II CORPS.			
135th Army Troops Co. R.E.	II Corps	N.E.	
148th Army Troops Co. R.E.	,,	E.	
67th Field Co. R.E.	11th Div.	,,	
68th Field Co. R.E.	,,	,,	
86th Field Co. R.E.	,,	,,	
79th Field Co. R.E.	18th Div.	,,	
80th Field Co. R.E.	,,	,,	
92nd Field Co. R.E.	,,	N.E.	
V CORPS			
4th Siege Co. R. Monmouth R.E.	V Corps	N.E.	
225th Field Co. R.E.	39th Div.	D.	
227th Field Co. R.E.	,,	,,	
234th Field Co. R.E.	,,	N.E.	
CANADIAN CORPS.			
1st Can. A.T. Co. R.E.	Canadian Corps	N.E.	
No. 1 Siege Co. R. Monmouth R.E.	,,	,,	
1st Can. Field Co. R.E.	1st Can. Div.	,,	
2nd Can. Field Co. R.E.	,,	,,	
3rd Can. Field Co. R.E.	,,	,,	
4th Can. Field Co. R.E.	2nd Can. Div.	E.	
5th Can. Field Co. R.E.	,,	,,	
6th Can. Field Co. R.E.	,,	,,	
7th Can. Field Co. R.E.	3rd Can. Div.	,,	
8th Can. Field Co. R.E.	,,	N.E.	
9th Can. Field Co. R.E.	,,	,,	

SIGNALS—RESERVE ARMY.

THIEPVAL. 26TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
Reserve Army Signal Co.	Reserve Army	N.E.	
II Corps Signal Co.	II Corps	N.E.	
11th Divl. Signal Co.	11th Div.	E.	
18th Divl. Signal Co.	18th Div.	"	
"O" Corps Signal Co.	V Corps	N.E.	
39th Divl. Signal Co.	39th Div.	E.	
Canadian Corps Signal Co.	Canadian Corps	N.E.	
1st Can. Divl. Signal Co.	1st Can. Div.	E.	
2nd Can. Divl. Signal Co.	2nd Can. Div.	"	
3rdCan. Divl. Signal Co.	3rd Can. Div.	D.	Relieved 1st Can. Divl. Signal Co. on 28th September, 1916

NOTE.—The smaller Signal Units, E.9 Airline and Cable Sections are notincluded as it is quite impossible to trace them.

LE TRANSLOY. 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
4TH ARMY.			
No. 3 Special Co.	Special Brigade G.H.Q.	E.	
No 4 Special Co.	"	"	
No. 1 Special Battn.	"	N.E.	
No. 2 Special Battn.	"	D.	"F" Co. in oil mortar attack 7th October, 1916.
110th Railway Co.	G.H.Q.	N.E.	
119th Railway Co.	"	"	
178th Tunnelling Co.	"	D.	
179th Tunnelling Co.	"	"	
183rd Tunnelling Co.	"	E.	
133rd Army Troops Co.	XV Corps	N.E.	
142nd Army Troops Co.	XIV Corps	"	
149th Army Troops Co.	XV Corps	"	
214th Army Troops Co.	III Corps		
216th Army Troops Co.		D.	No diary.
217th Army Troops Co.		N.E.	
221st Army Troops Co.	III Corps	"	
232nd Army Troops Co.	XIV Corps	D.	No diary.
238th Army Troops Co.	III Corps	N.E.	
280th Army Troops Co.	XIV Corps	"	
281st Army Troops Co.	III Corps	"	
282nd Army Troops Co.	III Corps	"	
1/3rd Cornwall A.T. Co.	III Corps	D.	No diary.
1/1st Sussex A.T. Co.	XV Corps	"	No diary
1/1st Wilts A.T. Co.		N.E.	
4th Field Survey Co.	4th Army	D.	No diary.
No. 4 Pontoon Park	"	N.E.	
No. 5 Pontoon Park	"	"	
No. 4 Bridging Unit (I.W.T.)	"	D.	No diary.
No. 1 Labour Battn. R.E.	XIV Corps	N.E.	
No. 2 Labour Battn. R.E.	XV Corps	"	
III CORPS			
63rd Field Co.	9th Div.	E.	
64th Field Co.	"	"	
90th Field Co.	"	"	
73rd Field Co.	15th Div.	"	
74th Field Co.	"	N.E.	
91st Field Co.	"	D.	Working on Tramway at Martinpuich.

LE TRANSLOY. 1st-18th October, 1916.

Unit.	Formation.		Remarks.
III Corps.			
101st Field Co.	23rd Div.	N.E.	
102nd Field Co.	,,	E.	
128th Field Co.	,,	N.E.	
1/3rd London Field Co.	47th (London) Div.	E.	
1/4th London Field Co.	,,	,,	
2/3rd London Field Co.	,,	,,	
7th Field Co.	50th (Northumbrian) Div.	,,	
1/1st Northumbrian Fd. Co.	,,	,,	
1/2nd Northumbrian Fd. Co.	,,	N.E.	
XIV Corps			
9th Field Co.	4th Div.	E.	
1/st Durham Fd. Co.	,,	,,	
1/st Renfrew Fd. Co.	,,	D.	
12th Field Co.	6th Div.	E.	
1/1st London Fd. Co.	,,	,,	
2/2nd West Riding Fd. Co.	,,	,,	
83rd Field Co.	20th Div.	,,	
84th Field Co.	,,	,,	
96th FieldCo.	,,	,,	
1/1st Edin burgh Fd. Co.	56th Div.	,,	
2/1st London Fd. Co.	,,	,,	
2/2nd London Fd. Co.	,,	D.	
XV Corps.			
69th Field Co.	12th Div.	E.	
70th Field Co.	,,	,,	
87th Field Co.	,,	,,	
1/2nd London Fd. Co.	29th Div.	,,	Attached to 12th Div.
97th Field Co.	21st Div.	D.	
98th Field Co.	,,	,,	
126th Field Co.	,,	E.	
200th Field Co.	30th Div.	,,	
201st Field Co.	,,	,,	
202nd Field Co.	,,	,,	
228th Field Co.	41st Div.	,,	
233rd Field Co.	,,	,,	
237th Field Co.	,,	,,	
1st N.Z. Field Co.	New Zealand Div.	,,	
2nd N.Z. Field Co.	,,	,,	
3rd N.Z. Field Co.	,,	N.E.	
Reserve (5th) Army.			
174th Tunnelling Co.	G.H.Q.	N.E.	
252nd Tunnelling Co.	,,	,,	
134th Army Troops Co.	II Corps	D.	No diary.
236th Army Troops Co.	Reserve Army	,,	No diary.
1/1st Hants Army Troops	V Corps	N.E.	
5th Field Survey Co.	Reserve Army	D.	No diary.
No. 12 Pontoon Park	,,	N.E.	
No. 6 Labour Bn. R.E.	,,	,,	
Canadian Corps.			
1st Canadian Army Troops Co.	Canadian Corps	N.E.	
2nd Canadian Army Troops Co.	,,	,,	
3rd Canadian Army Troops Co.	,,	,,	
1st Canadian Field Co.	1st Can. Div.	,,	
2nd Canadian Field Co.	,,	,,	
3rd Canadian Field Co.	,,	,,	

LE TRANSLOY, 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
CANADIAN CORPS.			
4th Canadian Field Co.	2nd Can. Div.	N.E.	
5th Canadian Field Co.	,,	,,	
6th Canadian Field Co.	,,	,,	
7th Canadian Field Co.	3rd Can. Div.	,,	
8th Canadian Field Co.	,,	,,	
9th Canadian Field Co.	,,	,,	
10th Canadian Field Co.	4th Can. Div.	D.	
11th Canadian Field Co.	,,	N.E.	
12th Canadian Field Co.	,,	D.	

SIGNALS.

LE TRANSLOY. 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
4th Army Signal Co.	4th Army	N.E.	
No. 4 Army Wireless Co.	,,	D.	No diary.
C Corps Signal Co.	III Corps	N.E.	
9th Div. Signal Co.	,,	E.	
15th Div. Signal Co.	,,	,,	
23rd Div. Signal Co.	,,	,,	
47th Div. Signal Co.	,,	,,	
50th Div. Signal Co.	,,	,,	
J Corps Signal Co.	XIV Corps	N.E.	
4th Divl. Signal Co.	,,	E.	
6th Divl. Signal Co.	,,	,,	
20th Divl. Signal Co.	,,	,,	
56th Divl. Signal Co.	,,	,,	
P Corps Signal Co.	XV Corps	N.E.	
12th Divl. Signal Co.	,,	E.	
21st Divl. Signal Co.	,,	D.	
30th Divl. Signal Co.	,,	E.	
41st Divl. Signal Co.	,,	,,	
N.Z. Divl. Signal Co.	,,	,,	
Reserve Army Signal Co.	Reserve Army	N.E.	
No. 5 Army Wireless Co.	,,	D.	No diary.
Canadian Corps Signal Co.	Canadian Corps	N.E.	
1st Can. Divl. Signal Co.	,,	,,	
2nd Can. Divl. Signal Co.	,,	,,	
3rd Can. Divl Signal Co.	,,	,,	
4th Can. Divl. Signal Co.	,,	,,	

ANCRE HEIGHTS. 1ST OCTOBER-11TH NOVEMBER, 1916.

Unit.	Formation.		Remarks.
RESERVE ARMY (5TH).			
No. 2 Special Co.	Special Brigade G.H.Q.	E.	
No. 1 Special Battn.	,,	D.	
119th Railway Co.	G.H.Q.	N.E.	
110th Railway Co.	,,	,,	
174th Tunnelling Co.	,,	E.	
179th Tunnelling Co.	,,	,,	
252nd Tunnelling Co.	,,	N.E.	
236th Army Troops Co.	5th Army	D.	No diary.
1/1st Hants A.T. Co.	,,	N.E.	
No. 1 Siege Co. R. Monmouth	V Corps	,,	
No. 4 Siege Co. R. Monmouth.	X Corps	,,	
No. 2 Siege Co. R. Anglesey	XIII Corps	,,	

ANCRE HEIGHTS. 1st October-11th November, 1916.

Unit.	Formation.		Remarks.
Reserve Army (5th).			
5th Field Survey Co.	5th Army	D.	No diary.
No. 5 Pontoon Park	,,	,,	
No. 12 Pontoon Park	,,	N.E.	
No. 6 Labour Bn. R.E.	XIII Corps	,,	
II Corps.			
134th Army Troops Co.	II Corps	D.	No diary.
135th Army Troops Co.	,,	E.	
148th Army Troops Co.	,,	,,	
1st Field Sqn.	1st Can. Div.	,,	Attached 18th Div.
67th Field Co.	11th Div.	,,	Attached 18th Div.
68th Field Co.	,,	,,	Attached 18th Div.
86th Field Co.	,,	D.	Attached 18th Div.
79th Field Co.	18th Div.	E.	
80th Field Co.	,,	,,	
92nd Field Co.	,,	,,	
219th Field Co.	32nd Div.	,,	Attached 18th Div.
81st Field Co.	19th Div.	E.	
82nd Field Co.	,,	,,	
94th Field Co.	,,	D.	
105th Field Co.	25th Div.	E.	
106th Field Co.	,,	,,	
130th Field Co.	,,	,,	
206th Field Co.	32nd Div.	,,	
218th Field Co.	,,	,,	
219th Field Co.	,,	,,	
225th Field Co.	39th Div.	,,	
227th Field Co.	,,	,,	
234th Field Co.	,,	,,	
Canadian Corps.			
1st Can. A.T. Co.	Can. Corps	N.E.	
2nd Can. A.T. Co.	,,	,,	
3rd Can. A.T. Co.	,,	E.	
1st Can. Field Co.	1st Can. Div.	N.E.	
2nd Can. Field Co.	,,	E.	
3rd Can. Field Co.	,,	,,	
4th Can. Field Co.	2nd Can. Div.	N.E.	
5th Can. Field Co.	,,	,,	
6th Can. Field Co.	,,	,,	
7th Can. Field Co.	3rd Can. Div.	E.	
8th Can. Field Co.	,,	,,	
9th Can. Field Co.	,,	,,	
10th Can. Field Co.	4th Can. Div.	,,	
11th Can. Field Co.	,,	,,	
12th Can. Field Co.	,,	,,	

SIGNALS.

ANCRE HEIGHTS. 1st October-11th November, 1916.

Unit.	Formation.		Remarks.
Reserve Army Signal Co.	5th Army	N.E.	
No. 5 Army Wireless Co.	,,	D.	No diary.
B Corps Signal Co.	II Corps	N.E.	
18th Divl. Signal Co.	,,	E.	
19th Divl. Signal Co.	,,	,,	
25th Divl. Signal Co.	,,	,,	
39th Divl. Signal Co.	,,	,,	
O Corps Signal Co.	V Corps	N.E.	
Canadian A.C. Signal Co.	Canadian A.C.	N.E.	
1st Can. Divl. Signal Co.	,,	E.	
2nd Can. Divl. Signal Co.	,,	,,	
3rd Can. Divl. Signal Co.	,,	,,	
4th Can. Divl. Signal Co.	,,	,,	

ANCRE. 1916. 13TH-18TH NOVEMBER, 1916.

Unit.	Formation.		Remarks.
81st Field Co.	19th Divn.	E.	
82nd Field Co.	,,	,,	
94th Field Co.	,,	D.	
225th Field Co.	39th Divn.	E.	
227th Field Co.	,,	,,	
234th Field Co.	,,	,,	
10th Canadian Fd. Co.	4th Can. Divn.	E.	
11th Canadian Fd. Co.	,,	,,	
12th Canadian Fd. Co.	,,	,,	
V CORPS			
5th Field Co.	2nd Divn.	,,	
226th Field Co.	,,	,,	
1/1st East Anglian Fd. Co.	,,	,,	
56th Field Co.	3rd Divn.	,,	
1/1st Cheshire Fd. Co.	,,	,,	
1/1st E. Riding Fd. Co.	,,	,,	
206th Field Co.	32nd Divn.	,,	
218th Field Co.	,,	,,	
219th Field Co.	,,	,,	
152nd Field Co.	37th Divn.	,,	
153rd Field Co.	,,	,,	
154th Field Co.	,,	,,	
1/1st Highland Fd. Co.	51st (High) Divn.	,,	
1/2nd Highland Fd. Co.	,,	,,	
2/2nd Highland Fd. Co.	,,	,,	
1st Field Co. 63rd (R.N.) Div.	63rd (R.N.) Divn.	,,	
2nd Field Co. 63rd (R.N.) Div.	,,	,,	
3rd Field Co. 63rd (R.N.) Div.	,,	,,	
XIII CORPS			
210th Field Co.	31st Divn.	N.E.	
211th Field Co.	,,	E.	
223rd Field Co.	,,	D.	
224th Field Co.	40th Divn.	N.E.	
229th Field Co.	,,	,,	
231st Field Co.	,,	,,	
FOURTH ARMY.			
No. 1 Special Co.	Spec. Brig. G.H.Q.	E.	
No. 2 Special Co.	,,	,,	
No. 1 Special Battn.	,,	N.E.	
174th Tunnelling Co.	G.H.Q.	E.	
179th Tunnelling Co.	,,	N.E.	
183rd Tunnelling Co.	,,	,,	
252nd Tunnelling Co.	,,	E.	
1/1st S. Midland Field Co.	48th Divn.	D.	
1/2nd S. Midland Field Co.	,,	N.E.	
2/1st S. Midland Field Co.	,,	,,	
FIFTH ARMY.			
134th Army Troops Co.	II Corps	D.	No diary.
135th Army Troops Co.	,,	,,	
148th Army Troops Co.	,,	E.	
1/1st Devon A.T. Co.	XIII Corps	N.E.	
145th A.T. Co.	,,	,,	
3rd Canadian A.T. Co.	Canadian Corps	,,	
No. 1 Siege Co. R. Monmouth.	V Corps	,,	

ANCRE, 1916. 13TH-18TH NOVEMBER, 1916.

Unit.	Formation.	Remarks.	
FIFTH ARMY.			
No. 4 Siege Co. R. Monmouth.	X Corps	N.E.	
No. 2 Siege Co. R. Anglesey	XIII Corps	D.	
No. 6 (Labour) Bn. R.E. .	,,	,,	
II CORPS.			
67th Field Co.	11th Divn.	E.	
68th Field Co.	,,	,,	
86th Field Co.	,,	D.	
79th Field Co.	18th Divn.	,,	
80th Field Co.	,,	E.	
92nd Field Co.	,,	,,	

SIGNALS.

ANCRE, 1916. 13TH-18TH NOVEMBER, 1918.

Unit.	Formation.	Remarks.	
4TH ARMY.			
4th Army Signal Co.	4th Army	N.E.	
No. 4 Army Wireless Co.	,,	D.	No diary.
C Corps Signal Co.	III Corps	N.E.	
48th Divl. Signal Co.	,,	D.	
5TH ARMY.			
5th Army Signal Co.	5th Army	N.E.	
No. 5 Army Wireless Co.	,,	D.	No diary.
B Corps Signal Co.	II Corps	N.E.	
18th Divl. Signal Co.	,,	E.	
19th Divl. Signal Co.	,,	,,	
39th Divl. Signal Co.	,,	,,	
4th Canadian Divl. Signal Co.	,,	,,	
O Corps Signal Co.	V Corps	N.E.	
2nd Divl. Signal Co.	,,	E.	
3rd Divl. Signal Co.	,,	,,	
32nd Divl. Signal Co.	,,	,,	
37th Divl. Signal Co.	,,	,,	
51st (High.) Divl. Signal Co.	,,	,,	
63rd (R.N.) Divl. Signal Co.	,,	,,	
N. Corps Signal Co.	XIII Corps	N.E.	
31st Divl. Signal Co.	,,	E.	
40th Divl. Signal Co.	,,	N.E.	

To be continued.

ENGINEER SERVICES.

A LECTURE GIVEN TO THE ARMY CLASS, LONDON SCHOOL OF ECONOMICS, LENT TERM, 1925.

By COLONEL J. W. S. SEWELL, C.M.G.

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IN order to get the utmost from auxiliary arms and services, a commander must sufficiently appreciate those conditions which impose limitations upon their output. The object of this lecture is to explain so far as the time at disposal permits, what are the limitations imposed by *force majeure* upon the R.E.

Whilst engineering is by no means a mystic cult acquired by esoteric processes, it of course possesses a technique which can no more be acquired from books and lectures alone, without years of experience, than can the science of commanding a battalion or a company of infantry. I shall therefore make no attempt to explain technical methods of execution, but will aim at giving a picture of the general system of control with a view to your acquisition of a sympathetic understanding of the work of the sapper and of the aid which he requires of you to carry out work for you.

Let me first show you in some perhaps exaggerated sketches what to avoid. A staff officer who does not understand the sapper's work is apt to demand far more output than can be effected with the means at disposal in the time available. You must realise at once—and this is going to be made perfectly clear in future revises of *Field Service Regulations*—that the man who orders a work is primarily responsible for ensuring that the means of execution, that is, men, material, and especially transport, are available.

Now we will suppose a division newly-formed, with a staff that have not a deep insight into engineering possibilities; which in consequence wants more than can be obtained. Of course it is the C.R.E.'s duty to point out this fact, and to ask for a priority programme. If you shake him off, he must and will make his own selection—probably not what you consider the most urgent items: this is not a happy beginning. It is still worse if you give a priority selection and then change your mind 48 hours later—rendering nugatory 48 hours' work of the R.E. and you know not how much of the C.R.E.'s energy. It is again bad work if you give a priority programme without due thought as regards your ability to supply your part of the mutual effort: or act in such a manner that the

C.R.E. will discover that you have demanded as an essential something which you do not really regard as an essential.

For example, you demand that I, as C.R.E., shall make half a million bricks. Clearly I must find a bed of suitable clay: I shall want fuel for baking the bricks, and labour.

I find that the only patch of clay is occupied by a brigade camp. "G" for tactical reasons is unwilling to move them. "Q" thinks he can get the brigade to close up a bit and give me one corner but objects to carting the fuel so far. I rake together a gang of local cut-throats, whom "Q" promptly requisitions to unload some supplies. If I infer the bricks are not only going to cause me much trouble, but are not regarded by "Q" as very essential, shall I be far wrong? Are we not likely at this stage to misunderstand each other?

Programme of Work.

The moral of this is that you should act just as you would do, say, in packing for a foreign tour. Make up a list of what you would like to have and classify it as

(i) Essentials.
(ii) Important.
(iii) Non-essentials.

Clearly you must have essentials at all costs: you may as well save yourself trouble and cut out the non-essentials at once. Then you sum up the aggregate of your means in men and materials, and *transport* for obtaining the important services: you get in your own mind some idea of the order of priority of the important items: you then order the essentials to be done, and in consultation with your experts (in a joint conference preferably) determine how far your "means" will permit the important items to be carried out in the time available. Thus you can form a "programme." Retention of a reserve of energy is normally desirable.

As commander or staff officer it is *your* responsibility to see that the means are available for the execution of any work you may order. This principle applies both in peace and war. A trained officer has usually a very sound knowledge of the exact amount of assistance he may demand from an auxiliary arm. He is apt to be somewhat vague as regards the limitations of a "Service."

Limited Potentiality.

In order to acquire this essential knowledge, you must study the economic factors which impose those limitations. (This you can well do, as I am trying to show you, without any extensive knowledge of the technique of the Service.) These economic factors differ in peace and war. In war, for example, a director has in effect an unlimited call on the public purse: but limitations are imposed, as doubtless you have been informed by others, by other considerations; normally, by the amount of transport available at some stage or other; but also by available labour and the manufacturing output of the U.K. I have not time to dilate on that subject. In peace as you well know, a director is limited by the funds put at his disposal by Parliament, I am now going to take the general system of control of Engineer Services in peace as my theme and to explain the economics of the system of control.

DEFINITION OF ENGINEER SERVICE.

First, however, we must define what "Engineer Services" means both in peace and war.

Now *F.S.R.*, Vol. 1-66, says:—

> 1. Engineering work in a theatre of operations may be generally classified into:—
>
> i. Field engineering.
> ii. Works services.
>
> It must be realised, however, that the line of demarcation between these categories, in certain cases, will be difficult to define.
>
> 2. Field engineering is intimately connected with tactical operations in progress or in contemplation, and is executed by the troops, including R.E. units, placed under a commander's orders, supplemented by such organized or unorganized civilian labour as may be necessary and available.
>
> Works services, which are carried out under the responsibility of the D. of W. and his representatives, relate to all engineering work of a general nature other than field engineering work.

Read also *F.S.R.*, Vol. 1-43 (xvi), which defines the duties or some of them, which fall under the head of "Works Services." Now please note sentence in 1-66, "the line of demarcation will be hard to define." It is indeed: in fact it is recognised that the Engineers of front line formations must perforce incept as field engineering work, to be performed in the most hasty manner, works which are of the nature of works services, but if executed under the ægis of the D.W., would be executed in a more semi-permanent manner. For example, roads, water supply, division and brigade headquarters, shelters for troops, and camp accessories. The demarcation line will possibly have to be, either in effect or even by regulations, defined by a geographical line.

We may consider that there will in effect be a line some miles in rear of the front line, forward of which liability to attack will render it necessary to abdicate direct administrative control by G.H.Q.

However, that may be, I think you will understand the difference between the work done by the R.E. in war, as an auxiliary arm for the commander of a fighting formation, and the work done as an administrative service for the Q.M.G. It is the latter class of work which in peace falls under the head of "Engineer Services." But whereas in war, provision is the important factor, and the requirements of the universal provider (the Q.M.G.) must be met; in peace, finance is the controlling factor, and a productive branch of the Army Council (the M.G.O.) is established, to whose available funds Q.M.G. must reduce his demands. Hence the control by the M.G.O. in peace of the branch which "produces" accommodation.

Classification of Engineer Service.

Now this "accommodation" may be divided into two categories—

(A) Buildings and other construction (*e.g.*, ranges) generally.

(B) Production where requisite (*i.e.*, where no local supply is available) of such consumables as electric light and water.

Let us consider first (A). Again expenditure must be divided into two heads:—

(i) Capital expenditure, on new construction.

(ii) Expenditure to maintain existing construction in an efficient state of repair.

Capital Services.

The financial authorities from Parliament downwards, are naturally and properly most careful about capital expenditure, for it will be obvious to all of you that additional construction involves a permanent increase of annual army expenditure in order to maintain it in repair: in consequence the control over capital expenditure is most strict and indeed involves the sanction of Parliament itself to every item of any magnitude. Note the qualification implied in the last two words: you will of course say "If Parliament is going to attempt to scrutinize the necessity for a new bit of fence round an officer's quarter or a new lathe in a workshop, or a new telephone line on a range, the scrutiny must be valueless, inasmuch as the maze of detail will be far too great for any such body as the Army Council even, let alone the Treasury and above the Treasury, the Public Accounts Committee, to spare time to give it all effective consideration." Quite so! in consequence a hard line is drawn: every new service which costs over £2,500 to complete must be referred by the Army Council to the Treasury (and eventually to Parliament) for sanction. These we call "Part I Services." But for services which cost under £2,500, a bulk allotment is made by

Parliament: this is purposely kept low and it is obviously necessary to ensure that Part I Services are not smuggled through by cutting them up into several Part II Services. That is the principle of control: let us see how it is operated.

PART I SERVICES ORIGINATED IN COMMAND.

The demand for a new service may originate in some quite subordinate command, *e.g.*, from an area or even a sub-area commander, who may consider that a new recreation room or ground or a new road or some barrack accessory (*e.g.*, a guard room) is necessary. Theoretically, he demands this from the C.R.E., who refers it to command: in effect the demand is naturally conjointly made: the commander sees M.G.A.: C.R.E. reports to C.E. Let us suppose that "Command" favours the scheme and does not "turn it down" out of hand. A preliminary estimate is called for: the work is scrutinized from every point of view, including, of course, possible reduction of cost by variation of the original proposal.

Then a letter is written to the War Office stating the reasons which support the proposal, the estimated cost, and any re-action which may result on, for example, the total cost of light and water consumed by the command. The W.O. may now turn down the scheme altogether, for reasons which have not come within the purview of the command; for example, it may be the intention of the Q.M.G. (though not yet published as a decision) to effect some alterations in barrack policy, such as will involve the occupation of the barracks in question, by a different arm of the Service, which would render nugatory the proposed addition.

But normally W.O. will accept the proposal in principle, and will now ask for further information in the form of a more detailed estimate (not worth preparation until the proposal had been tentatively accepted in principle) and sketch designs and a more detailed report of indirect results.

This is a troublesome stage for everybody and unless conducted with forbearance and tact may well lead to friction. On the side of the command, its R.E. executive probably are already overworked: it is trying, under those circumstances, to be asked to get out estimates, designs and reports for a service for which, however sympathetic the W.O. may be, it is fully recognised that it is most improbable that funds will be forthcoming for a long period, having in view existing commitments. From the W.O. aspect it is essential to ensure that the scheme has been very fully considered, that all "luxuries" have been lopped off, and that every expense has been listed, and all secondary effects have been reviewed. Commands with overworked R.E. are somewhat apt to put up schemes without full consideration. It has to be considered whether all such accessory work as drainage schemes, roads of access, fences, land questions, supply of water and light have been brought into the estimate. It has also to be considered—and these are points too often forgotten in commands—whether water and light are really available (the head of water may be insufficient to rise to proposed site—the W.D. generating station for E.L. may be already fully loaded). Finally it may well be that this construction and the provision to it of the necessary light or power or heat may be the last straw which renders it economic to scrap some existing system of supply and to instal more modern and more economic plant. Let us however suppose that all this work has been carried out. The W.O. now says "very well; you may put this proposal on your Estimates book." This means that it may be registered in command as a tentatively approved scheme; from amongst the total number so registered, M.G.A. may select some half dozen to put forward in September of each year to W.O. as proposals for inclusion in the ensuing year's army estimates. Please bear in mind these pet schemes of commands thus awaiting funds, whilst I turn to what is meantime going on at the War Office.

Part I.—Originating at War Office.

It will be obvious to you that the principal proposals for expenditure will result from the barrack policy of the Q.M.G. He alone can say to his colleagues—

- (i) We have to find accommodation to replace that lost by the transfer of the Curragh Barracks. I propose we construct barracks for a division at Catterick.
- (ii) New units have been added to the army (*e.g.*, an A.D. brigade, and a Tank Corps). We must provide accommodation.
- (iii) The progress of mechanicalisation demands more extensive repair workshops.
- (iv) The standard of living has gone up and the married establishment has been increased. In the interests of morale and recruiting the A.G. is pressing for dining rooms for troops: C.I.G.S. demands more training and lecturing accommodation and more schools. I want more married quarters for officers and men.

It will I think be obvious to you that only a small portion of the available funds can be devoted to the execution of the command schemes to which I alluded before, unless these are in effect accessory to the main programme of the Council.

PART I FUNDS. ALLOCATION.

Now let us consider what funds are available: in effect the Army Council are working to a fixed sum (or rather a reducing sum total) for the whole army. Again, they must distribute the sum over the maintenance costs of personnel, the cost of training the army, and the cost of arming, equipping and housing the army. To keep a clear head is obviously difficult, and in general the distribution between these contending claims is kept roughly in a proportion known by long experience to produce good results. In consequence the sum available for the capital expenditure is approximately the same every year: let us assume a figure of £1,250,000 and turn to *Army Estimates* 1924/25, in order to see how such a sum is distributed. You will note that expenditure shows a total estimate, the sum expended in previous years, the sum to be spent in 1924/25 and a balance for future years.

I think it will be clear to you that such a service as Catterick, and indeed the majority of Part I Services, cannot be executed in one year, even were cash available. Indeed at Catterick the labour which contractors can maintain in that one locality will not permit of the expenditure of more than about £250,000 per annum out of an estimated total cost of £1,250,000 for that camp. Having in view the arrears of barrack construction owing to the war years, the loss of the Curragh barracks, and the re-organisation of the army, you will realise the very complex problem which the Q.M.G. has to face, and will hardly be surprised that the aggregate commitments (*i.e.*, the balance still to be spent on works in course of execution) amount to £2,500,000 or twice the total funds available annually. It is in consequence necessary to put aside annually as a first charge, about £1,000,000 out of the £1,250,000 for the further development of what are known as "Continuation Services." It will again be clear to you that as a result, firstly, new commitments can only be undertaken as existing commitments die out (*i.e.*, as works are completed): secondly, that only a comparatively small sum can be available for any command schemes, however desirable they be. However, you will notice that this does constitute a reserve.

PART I. E. & M. SERVICES.

Even out of the assumed quarter-million left over from continuation services, there are certain capital services falling under category B (production of electric light, water, etc.), which must have first choice, either from the necessity of expansion to meet requirements of increased camps, or because modernisation is essential to reduce annual expenditure. As this latter matter is one of importance, very imperfectly understood even by the R.E. themselves, I must devote a few words to it. In the past :—

(i) As barracks have expanded, there has been an opportunist tendency to put down an engine here for pumping water, another there to pump sewage, a third to generate E.L., a fourth to provide power for a workshop, etc. Now with machinery, as with other efforts in life, economy lies in concentrated effort (mass production).

(ii) Mechanical science again has made vast strides since the war, perhaps largely due to such economic causes as increased costs of labour and fuel. Whereas pre-war and war steam engines for generation of E.L. might consume from 35 lbs. to 50 lbs. of steam per k.w. per hour, modern steam plant consumes only 15 lbs. Any expansion of output then is a proper occasion to consider the installation of modern plant, after full investigation of the future annual costs of operation. Such considerations as these involve reference back to commands of their proposals of Part I Services and, I fear, some chafing at our insistence on full considerations being given to these economies.

Part I. Central Control.

Finally as regards these Part I Services, I would observe that not only is financial control exercised in some detail even by Parliament itself, but even as regards designs, specifications and contracts, very little responsibility can be devolved on to the executive: these are prepared in the War Office for all the more important services, and the executive is charged only with the responsibility for ensuring that the contractor executes the work in accordance with the designs, specifications and terms of contract.

Part II. Services.

Now let us turn to the Capital Services which cost under £2,500 and you will see a very different picture. You will notice that a lump sum of about £250,000 is voted by Parliament under Head V.B.2 of the Army Estimates. Speaking broadly, this is divided up by the War Office and allotted in lump sum to commands. The only restriction imposed is that services costing over £300 must receive W.O. sanction. The principal reasons for this are to ensure that:—

(i) There is no attempt to carry out a Part I Service by cumulative Part II items.

(ii) To ensure that such expenditure will not be rendered nugatory by some policy or programme not yet entirely formulated and therefore not yet disclosed to commands.

The *modus operandi* between W.O. and commands is as follows :—
In the "Statement of proposed services" submitted to W.O. in September to enable Army Estimates to be compiled, "Command" schedules various items estimated to cost between £300 and £2,500 and in addition asks for a lump sum (based on average expenditure of preceding years) to cover expenditure on services under £300. After Army Estimates have been approved or (say) about the beginning of the following April, W.O. will in effect reply "Here is £30,000: of the items over £300 enumerated by you, such and such items must not be executed: such and such items will be executed: the remainder may be executed if you still wish to do so, and can spare the funds: in any case after executing the items we have told you to execute, the balance of the £30,000 is at your disposal." The M.G.A., in his turn, writes to areas "Execute such and such items for which I herewith allot you so much: I also allot you £............. (let us say £3,000) for any minor items you may see fit to execute, with the proviso that you must obtain my sanction to any one item over £200."

PART II. CLASSIFICATION.

I do not wish to confuse you but should at this point interpolate that as regards these Part II Services, they are sub-divided into :—

Barrack Services,
Fortification Services,
A.O.D. Services,
Hospital Services,
Telephone Services,
Mechanical Services,
W. D. Estates.

The restrictions imposed on the last six are far more stringent: in effect they are all decided at the W.O. somewhat similarly to the methods previously stated for Part I Services, the reasons being that policy as regards these six matters cannot well be left to local views.

PART II. USE OF LUMP ALLOTMENTS IN DISTRICTS.

Reverting to consideration of the lump sum for minor services which reaches a C.R.E. and his commander, and we have assumed to be in the region of £3,000, it is here that the closest co-operation and appreciation of each other's work can result in the greatest benefit to the local military community as a whole. Especially in some of the older barracks, considerable improvements in the convenience of administration and in the comfort of the troops can often be effected by well-considered schemes of *re-appropriations* at surprisingly low cost. In the case of defensive barracks, these often have surplus accommodation, some of which can be converted to dining rooms or lecture rooms or corporals' messes. It is advisable however, to avoid re-appropriations of an opportunistic nature and to think out a scheme for a general re-appropriation, which will really modernise the barracks when you add proposals for new constructions, such as the addition of sanitary annexes and other extensions. You can then put it forward as one whole Part I scheme for modernisation of X barracks; but you will have more chance of getting on with the scheme if you cut it up into such separate re-appropriation proposals and other items as can legitimately be done as Part II Services, *e.g.*,

(i) Re-appropriations which require W.O. sanction and special allotment of funds by W.O.

(ii) Re-appropriations which require W.O. sanction but can be done with local funds.

(iii) Re-appropriations which can be approved by M.G.A. and can be done with local funds.

(iv) Additions or extensions which do not involve re-appropriations, and can be done with local funds.

(v) New construction involving Part I expenditure.

To get (i) and (v) will, for reasons which I told you (under Part I), be a matter of time: but if you make the other re-appropriations separate schemes and are prepared to find the funds from your bulk allotment, approval can usually be obtained with reasonable rapidity. You must, however, realise that it is not permissible to execute any one service as a series of Part II Services in succeeding years, if the aggregate of these annual expenditures amounts to Part I Service. You may not build walls and roofs in one year and then put in floors, etc., in the next, if the aggregate cost exceeds the limit of your authority for initiating expenditure.

Part III. Services.

The principal expenditure of a C.R.E., however, is incurred in maintaining W.D. properties in efficient repair: buildings, roads, training areas, telephones, installations, fences, etc., and this is a costly business: any one C.R.E. may be responsible for expenditure on maintenance amounting to from £50,000 to £100,000 per annum.

Before going further, I must emphasise that it is a financial crime to expend any of this money on new services. It is not always easy to get commanders to realise this: I hypothesised a Part II allotment to a district, of £3,000, but M.G.A. may prefer to centralize control of Part II expenditure to a greater extent and may only allot, say, £1,000 to the unfettered discretion of the local commander.

It is difficult sometimes to understand why a service costing, say, £150 cannot be carried out when you know that C.R.E. has £50,000 to spend. Please realise that this £50,000 is definitely allocated to maintenance and maintenance only. In effect the whole of the Part III funds voted by Parliament are passed on to C.R.E's as lump sum allotments, although a minor portion may not be sent out at the beginning of the year but may be kept back for emergencies arising from fire and storm, etc.

PART III. PROGRAMMES.

Efficient maintenance demands careful organisation and programmes which look years ahead. Methods will vary with the character of the C.R.E. and his D.O's, and control must on the whole rest on careful inspection by superiors. There is much which could be said, but there is no time now to dilate on the subject, nor is it very essential that you should study it, though there is nothing mysterious about it—it is hardly even technical, it is a matter which you may reasonably leave to your R.E. without undue anxiety. But the elementary principles for a C.R.E. are:—

(i) Put aside specific sums for periodical repairs, *e.g.*, painting, renewals of roofs and floors, roads and fences. Painting alone may absorb from 25 per cent. to 35 per cent. of the maintenance funds: and you can understand how a definite painting programme can be arranged on an 8-years' cycle, on the basis that every building must be painted externally once in 4 years, internally once in 8 years.

(ii) C.R.E. will name some special services which he desires to be executed and will allot funds for those.

(iii) He will allot the balance of the money as lump sums to his D.O's.

D.O.R.E., in his turn, will sub-divide his lump allotments, allocating part of it to cover the cost of repairs noted as necessary at his quarterly, etc., inspections, and part to cover the cost of men employed on routine maintenance and urgent repairs.

PART III. URGENCY.

It is necessary to keep a few such men in a directly employed gang in order to meet demands for urgent repairs. Whilst, admittedly, the stitch-in-time may actually save nine, there is a natural human tendency on the part of D.O.R.E. to oblige local commanders and staffs by executing with such gangs minor services which are not really urgent. This results in increase of the gang; we cannot take on artisans *de die in diem*, and it is not always possible to employ all such men on important work: there is always a tendency towards "finding" work for some of them from time to time. This spells waste: you should therefore curb any tendency on the part of yourselves or of those under your control to put in "urgent requisitions" for repairs, which are not in fact urgent.

Control by Cost Accounts.

In the control of Engineer Services we have welcomed cost accountancy and have agreed with finance and accountancy branches forms of account which serve the dual purpose of army accounts and of engineer control—thus obviating many of the returns formerly required.

Devolution.

Properly applied, cost accounts should render possible greater devolution of responsibility and allow more freedom in administration to subordinate administrators. To the superior they afford reliable comparative statistics, which will reveal at once, when read by men accustomed to their use, whether, and if so where, waste is taking place. Thus they should enable superiors and auditors to take wider views and to free themselves from meticulous detail. May I take this opportunity to interpose a few words on control by regulations and audit.

"R.E.S."

The regulations (*Regulations for Engineer Services*) which govern the execution of Engineer Services, are only intended as a guide to principles. It is fully recognised that we cannot make regulations to govern every circumstance which may arise, nor would it be proper or desirable to attempt it.

Audits.

An officer who understands and honestly endeavours to apply the principles inculcated to the best advantage of the public service with zeal and energy, has nothing to fear from superiors or from auditors. Audit is not carried out in any spirit of carping criticism, based on the letter of regulations, but with the wide view of ensuring the absence of fraud and the prevention of waste. Engineering experience is apt to reveal strange sides to human nature. When you appreciate and learn to allow for these factors, you will learn to understand better the outlook of auditors and financial advisers. You will also find them ever ready to help you through what may often appear to you to be terrifying financial morasses.

Sometimes you may think finance branches are obstructing your path: but remember that their aim is to prevent scandals, rather than to smell out crimes, and that financial scandals may and do result more often from ignorance, or sometimes from negligence, than from any actual fraud. Negligence of accountancy control by any of us may tempt some subordinate to his ruin.

Construction Accounts.

What we all want, then, is the simplest form of accounts which will reveal at once to our limited knowledge of financial matters whether there is a need at any point for a tighter rein. Hence the Engineer Construction Account. This R.E. keep for themselves, with the aid of the C.M.A.

Now let us examine this account and see how it can be used for control. See also the accounts for operative installations and comparative statistics which we get from them.

Engineering an Auxiliary to Infantry.

In conclusion, may I say a few words as regards the use of the Engineer Arm. Like other auxiliary arms, and all auxiliary services, its *raison d'etre* is, in common with those others, solely to assist in getting the infantry of the attack at the decisive moment to the decisive point, in the best possible condition as regards morale, minimum of loss in the advance to the attack, and maximum of efficiency of equipment and health. Whatever may be advisable as regards aid to this end, a final decision has never yet been attained, and I believe never will be attained, otherwise than with the club and the stabbing weapon. Since the war we have been somewhat deafened by the babel of enthusiasts who regard their own pet weapons or scheme as the one method of defeating an enemy. If they were all listened to, there would be few or none left to form the infantry phalanx: it would be analogous to the attempt to cool water in iron tanks by evaporative processes. It is quite effective, but is apt to leave no water to cool. Some talk about an Engineers' war; I do not know what they mean: land war is an infantry war; in effect all the aid given by auxiliary arms and indeed services involves some form of engineering: but because you label a man as an engineer, it does not mean that he is competent technically to control or direct every conceivable form of engineering at one and the same time. If indeed such a man exists, he must be a man of such superhuman talent that he could be spared for no subordinate post. Probably the higher the administrative position, the less is it desirable that the holder should know too much detail; otherwise he may and usually does fail to see the forest for the trees. The control of technical services should therefore at some point in the chain of command focus in administrators, preferably with staff training; it is, however, in that case necessary that such an administrator should know sufficient of the general principles which govern the work of the services that he may understand the advice of the technical heads, appreciate the difficulties, and hold a due sense of proportion. It is with a view to giving you some such insight into the technical work of the R.E. that I have directed my remarks in this lecture.

NOTES BY A CHIEF ENGINEER DURING THE GREAT WAR OF 1914-1918 (continued).

By Brigadier-General W. Baker Brown, C.B.

Details of Engineer Work.

I now propose to consider shortly some details of the actual work carried out in the Eastern Command during 1915-16. These can be divided into three large groups—

1. Work carried out for or in conjunction with the General Staff.
2. Work carried out for or in conjunction with the Q Staff.
3. Work carried out for or in conjunction with the Medical Staff.

Work for and with the General Staff.

Coast Defences. The first work to be considered is that connected with the Coast Defences. These gave comparatively little trouble, as the details connected with manning are all worked out beforehand. The local officers, therefore, knew exactly not only what they had to do, but how to do it, and the manning of the electric lights and the installation of the necessary additional telephones were a matter of only a few hours.

But a few words may be allowed for an appreciation of the excellent work done by the Electric Light mannings. These consisted, on the outbreak of war, of a weak R.E. unit at each port, which had to be completed with local territorials, and where the latter did not suffice, with detachments from the London, Tyne or Liverpool Electrical Engineers. During the progress of the war these manning details were drawn on again and again to form detachments for search lights for field service or for anti-aircraft defence, and were replaced by newly-trained men from the headquarters of one of these three units. Many additional lights were also installed during the war, for which manning details were provided. The material stood the strain of the prolonged running remarkably well, and during the whole period of four years and three months, the lights were run in all conditions of weather, and with a complete efficiency which could hardly have been bettered. From the nature of the work no notice appeared in the Press, and, as far as I know, no reference has been made to it in any of the books on the war. And yet the quiet steady manning of the Coast Defences by the R.A. and R.E. was one of the essential factors which kept the enemy from our shores, and allowed us to send overseas those magnificent armies which brought the war to a conclusion.

Additional gun defences were added during the war, but these were designed at the War Office under the supervision of Col. H. V. Kent, R.E., who made all preliminary arrangements for their execution. The Command had the responsibility of getting the work done.

The land defences of the Coast Fortresses did not differ in kind from the ordinary field defences, except perhaps in the case of the defences of Harwich harbour, where conditions arose which provide a warning for the future. The north side of this harbour is formed by a long sandy spit, on the north of which is situated the town of Felixstowe; north of this town there is the ordinary undulating country. In considering the position to take up for the land defences, the General Staff at the War Office found themselves on the horns of a dilemma whether to include Felixstowe in the defences or not. If they drew the line of defences south of the town, the line became very short, but a hostile landing force in occupation of Felixstowe would have made it very uncomfortable for the occupants of the permanent defences at the south end of the spit. On the other hand, if the line of defence was carried north of Felixstowe it would become much longer, and would require a larger garrison, and absorb more men than the General Staff were then prepared to allot. The final decision lay between these two extremes, and was to occupy an intermediate line on a small ridge running right through the centre of the town of Felixstowe. On the outbreak of war the local D.O.R.E., in pursuance of this scheme, commandeered a number of dwelling houses, putting some in a state of defence, and demolishing, or partly demolishing, others. Claims for damages were at once made which soon exceeded £40,000 in value, and when these reached the War Office two special valuers were sent down to assess the damage, and were at work when I joined the Command. Soon after, it was decided to construct additional batteries to the north of the town. This necessarily involved the occupation of the outer line of defence, and finally a complete Reserve Brigade was allotted this part of the defence instead of a single battalion.

Anti-aircraft Defence. When I joined the Command I naturally enquired what was the position as regards anti-aircraft defences, and was told the schemes for these were all prepared at the War Office, and that our responsibility was limited to the actual erection of guns and lights and accommodation for their personnel in named positions. Early in 1915, raids by Zeppelins were being carried out on the various naval and military establishments in the Thames Valley, but none of these had reached London, where the only defences were the naval guns and lights organised by Admiral Sir Percy Scott.

On some date in May, 1915, I happened to be motoring on duty with a member of the General Staff of the Command, and he told me that in a raid the previous evening one of the military establishments had been hit by a bomb, and asked if I knew anything about anti-aircraft defence. I was able to reply that I had had rather unique opportunities of studying the working of guns and lights in connection with coast defences, and that when on half-pay two years before I had attempted to work out some principles of defence against aircraft, and I had contributed a short article on the subject to a military paper.

As a result of this informal conversation, on returning to the office, I was asked by the head of our General Staff—Col. A. Hinde, R.A.—to explain my views to the C. in C., Sir Leslie Rundle. I pointed out that in my opinion our anti-aircraft defences suffered from two main defects: first, the attempt to allot each light to a particular gun or guns, and secondly, the concentration of the defences in the area of the dockyard or establishment to be defended, so that the enemy had only to drop his bombs among the lights to have a very good chance of hitting a vital spot. I therefore suggested that better results could be obtained if the defence guns and lights were distributed over a much larger area surrounding the establishment to be defended, so that they could engage the enemy *before* he reached his objective, and that the defences should be fought as a whole on the principle that the lights should search for and find the enemy aircraft, and that the guns should then engage the enemy while illuminated, without troubling as to which light was doing the illumination. Sir Leslie Rundle took the question up with his accustomed energy, obtained the support of Sir David Henderson, who was the head of the Flying Service at the War Office, and got permission to alter the defences. He appointed an executive Committee of Col. Hinde and myself, with Lt.-Col. Molony, R.A., as Secretary, and we began systematically to revise the whole of the Thames defences. On considering the experience of attacks up to date, two points were worthy of notice, the efficiency of the lights used and the inefficiency of the guns. There was at this time no regular equipment of lights for field use, but we had been able a few years before to get a field searchlight company formed at Aldershot which carried out experiments, and in connection with these we had elaborated patterns of light projectors, cables, and other details. Although this unit was not included in the Field Army establishments, the experience gained was of the greatest value in preparing the lights required for anti-aircraft defence. But these lights were of a small size, and our experience with coast defence had shown that such lights would lose much of their power at a range exceeding 1,500 yards (or 4,500 feet). We were, therefore, at first surprised to find the lights giving efficient illumination at heights of 9,000 feet and over. A little consideration showed that the difference was due to the fact that evening mist or fog—the great enemy of searchlights—is heaviest in the lower levels of the atmosphere, so that lights used for coast defence have to contend with mist throughout the whole extent of their range. If, however, such lights are turned upwards, the layer of mist is only about 100 feet thick, or less, and there is little interference. In practice the two-foot projector proved quite effective at ranges up to 5 miles and heights of 12,000 feet.

While, however, the lights were working better in a vertical position, the guns were very adversely affected by the altered conditions, as few guns at that time were capable of an elevation approaching 90° from the horizontal. We found also the armament allotted by the War Office included pompoms with a maximum range of about 3,000 feet and 6 pr. guns with a maximum elevation of 60° and a maximum effective height at the highest point of their trajectory of 6,000 feet. When the defences were first arranged it was thought that the enemy must come down to 6,000 feet in order to place his bombs with accuracy, but our limited experience at that date showed that the usual height of attack was 9,000 feet, and as our defences got more efficient the attackers kept at 12,000 feet or over. The naval defences of London were worse off than ourselves, as their guns were of old naval type and some not even fitted with a deflection leaf on the sights.

Our Committee got to work at once, rearranging and siting the best of the guns and lights and adding more as the War Office was able to supply. We brought Purfleet, where the defences had been installed by the London District, within our sphere of operations, and as defences were added at various manufacturing centres, such as Enfield and Dartford, they were linked up with others, until we had practically a continuous defended area from Faversham in Kent, covering the whole of the lower basins of the Thames and Medway.

The effect of our work was very marked. Instead of using the Thames as a guide, helped by the pillars of light at certain definite points, the enemy found himself met by a network of lights, picking him up and following every movement, till he did not know where he was or where he was going. He had in short "lost the Thames." Towards the end of 1915 he appears to have definitely abandoned this line of approach, and though he continued his raids—making land on our East Coast and following the railways to London—whenever he met our defences he was forced to high altitudes of 12,000 feet or over, from which he could not drop his bombs with any accuracy. Although the fixed defences could not stop raids they had made them increasingly difficult and hazardous.

In September, 1915, I was called to the War Office, where I was shown a scheme for applying the principles we had advocated to the defence of London itself. In pursuance of this it was proposed to place a ring of about 30 guns and 30 lights in the suburbs, to be followed by an outer ring as material became available. These defences were to link up with those at Enfield and Woolwich. Sites had been reconnoitred by officers from the War Office, and as the defences were to be kept well away from the centre, which was covered by the naval guns, all these sites came within the area administered by the Eastern Command. Most of the work fell on my C.R.E's at Woolwich and Hounslow, and was carried out efficiently and quickly.

At the same time our Committee rearranged the anti-aircraft defences of the defended ports, and many outlying places where ammunition was being manufactured were allotted defences.

When the G.O.C. Home Forces was appointed, Col. Sir E. Raban (late R.E.) was attached to the General Staff, Home Forces, as an R.E. adviser, especially for anti-aircraft defences, and after he had studied our methods gradually took charge of new schemes, while a special C.R.E., reporting directly to those H.Q., was appointed later to carry out the engineer work connected with these defences. So that before I left at the end of 1916, the C.E. Eastern Command was relieved of much of his responsibility in this connection. During 1916 much progress was made in range finding and in the shooting of anti-aircraft guns, while the defences were reinforced by mobile guns and lights and by special air squadrons, for whom a series of landing grounds had to be prepared. During this year these combined defences were successful in bringing to earth four Zeppelins and practically in breaking up this form of attack, though one more attack on a grand scale was made the following year.

Training Grounds and Rifle Ranges. The provision of training grounds for the troops calls for no comment, as any land required was easily obtained by our efficient Land staff.

For rifle ranges the War Office had early secured the services of Col. J. H. Cowan (late R.E.), the well-known rifle shot, and he became the head of an organisation for selecting and constructing rifle ranges all over the country. The Command had little to do with these (except land services) until the ranges were completed, when they became responsible for maintenance and for the supply of targets and accessories.

At first the full length ranges were little used, as there was no ammunition to spare for the purpose. In fact in May or June, 1915, a whisper went round the office that in the whole of the ordnance depots in England there was only one box of rifle ammunition remaining. But later, when ammunition became more plentiful, the new ranges were very largely used for training the new levies.

Each new hutment was supplied with covered miniature ranges, and these were also provided in connection with hired buildings.

Telephones. As already explained, the actual work on telephones was done by the G.P.O., so that our duty was limited to notifying the P.O. of the requirements of the Command.

Flying Establishments. Although the first flying establishments were constructed with a view to training, they were soon brought into our defence arrangements, so that they are best considered in this part of these notes. On the outbreak of war two permanent establishments for the flying service were under construction in the Command at Dover and Orfordness. At Dover the scheme included a complete set of barracks, which were being constructed by the Director of Barrack Construction. The erection of the hangars and preparation of the landing ground came under my C.R.E., and most of the work was done after the outbreak of war. At Orford it was intended to form an experimental station, but the work was delayed by the absence of water supply. A deep bore had been started by the War Office, but failed to find water at 900 feet. The preparation of the landing ground, and the erection of hangars and huts was pressed on after the war started, so the provision of water now became urgent. Barring a supply on the spot, the only possible sources were to draw on the town of Aldeburgh, which would necessitate the laying of several miles of water mains of a large bore, or the obtaining of water from the village of Orford, which was close to the site but separated by a salt water inlet 600 feet wide. Geologically Orford is one of the most interesting spots in England, as it is situated on what is known as the Coralline Crag, which is, I believe, the most modern deposit known in the British Isles. The Coralline Crag is a very spongy sandstone, and has the property of holding an extraordinary quantity of water. A hole dug down a few feet soon fills with water, and the inhabitants, in addition to drawing their water in their own gardens, also use this property to get rid of the sewage, which is run into cesspits sometimes only a few feet from the water supply. Having decided to utilise this source of water, there was no difficulty in selecting a suitable site as far from houses as possible, in erecting a suitable pump and constructing a shallow well. The practical difficulty had then to be faced of getting a four-inch main across the salt water inlet, and after some discussion I suggested that the method used for landing shore end cables might be suitable, the pipe being jointed on shore and floated across the estuary attached to casks or floats. Fortunately the depth of water was small, so that the curve in the pipe was not more than would be taken up by the spring of the metal. The job was finally done on these lines by a Field Company of Lancashire Engineers which was quartered in the neighbourhood.

In addition to the permanent aerodromes, a number of temporary establishments were constructed of which the best known are those at Northolt, Thetford, Hounslow and Lympne, the latter being the first constructed for the larger size machines. By the end of 1916, establishments had been completed in the Command for fifteen squadrons. The establishment for each squadron consisted of three aeroplane sheds, with auxiliary shops, transport sheds, and a hutment for about 250 officers and men. The total cost was about £25,000 per squadron, a figure which represents a startling contrast to the figure later on in the war, when the cost of an establishment on a rather larger scale reached £250,000. The details of aeroplanes have changed so much that our experience of ten years ago is now out of date, but I may mention that many of our difficulties centred on two points, the roof span and the nature of the flooring. The roof span of the first sheds erected was fixed at 65 feet, and this was increased later to 80 and then to 90 feet. These spans had to be bridged by wooden trusses, a Kingpost construction being used for the smaller span and a Belfast girder for the larger. For the floors of the sheds we went to the Road Board, who laid tar macadam and also formed a macadam apron round the entrance to each shed.

The plans for the establishment and all the detailed reconnaissance of sites were arranged by a special branch of the D.F.W's office under Col. W. Macadam, R.E. The Command had the responsibility of arranging for construction and maintenance.

Towards the end of 1915 it was decided to allot some squadrons for the defence of London. These were divided up into "flights," and for these we had to construct a string of 30 landing grounds in Suffolk, Essex and Kent. As these were selected partly for strategical reasons, we had to overcome some difficulties of construction. Each landing ground had to be lit at night and to be ready to administer "first aid" to any aeroplane landing, so that a small group of huts was required in each case.

Bridge over the Thames. Mention may be made here of the road bridge over the Thames at Gravesend, though this did not give much work to the staff of the Eastern Command. The object of the bridge was to provide a road passage over the Thames, which would avoid the roundabout route through London. The design followed the principle of our pontoon bridges, but the floats were formed of ships of several hundred tons burden and the baulks were massive baulks of timber. A cut 600 feet wide was formed of three ships with superstructure. The work was designed and executed by the Port of London Authority under the supervision of the C.E. Thames and Medway Defences, and the same authority arranged for maintenance and provided tugs to attend to the "cut." They also controlled the traffic in and out. A model of this bridge is preserved in the R.E. Museum at Chatham.

(To be continued).

"FULMAR" IN THE OCEAN RACE.

By CAPTAIN R. M. H. LEWIS, M.C., R.E.

Fulmar has been sold, and in a few years, like her predecessors, will be only a memory to members of the Corps. So many R.E. officers have managed in the past to forget Chatham and its iniquities while cruising in her that it is thought that an account of her last and most important race might be of interest, coming as it did as a climax to her best racing season in which she managed to carry off the laurels in two of the chief handicap races for small cruisers—the Burnham-Ramsgate race and the " Round the Isle of Wight " race.

The following account of the race over a 600-mile course, from Ryde, leaving the Isle of Wight to starboard, to the Fastnet rock off Cape Clear and back to Plymouth, is an amplification of *Fulmar's* log and has been reprinted in the *Yachting World.*

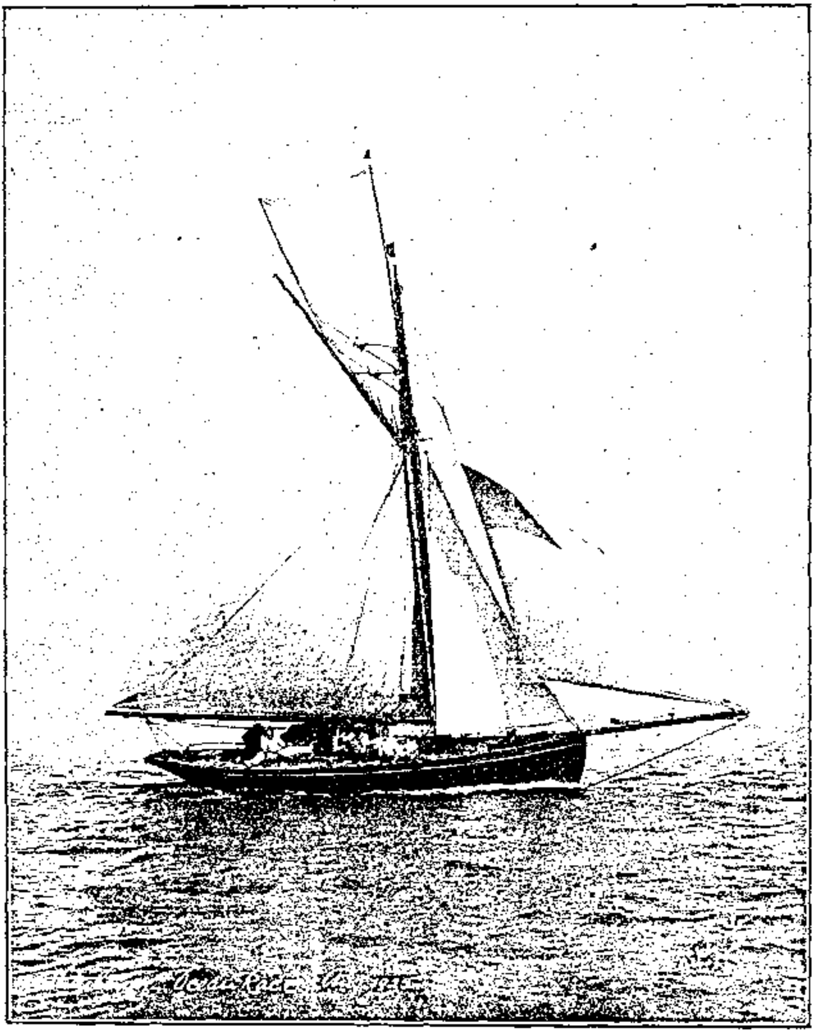
A perfect summer evening and almost a flat calm; the glass hitting the roof; six Sappers in high spirits, and only the inevitable hectic hour or two left to stow the remaining gear.

Such was the situation on the evening of Friday, August 14th, when *Fulmar* let go a cable's length west of Ryde Pier. The ship had been completely victualled at Gosport that day, the water tanks filled, and as many empty bottles as possible filled with water and stowed away. It was extraordinarily fortunate that a faulty inlet pipe to the starboard tank was spotted on watering at Gosport ferry pontoon, as a large amount of our limited supply would certainly have been lost when the ship heeled over. The leak was stopped by some rapid work with a soldering iron by the skipper on the trip over to Ryde.

Little remaining to be done on board, it was unanimously decided that a final dinner on shore was indicated, " to save the water supply." *Fulmar* was therefore abandoned and the entire crew turned in a few hours later as fully victualled as the ship herself. A visit to the Royal Victoria Yacht Club in search of sailing instructions proved barren of results, as the starters themselves apparently had, up to then, been told as little as we had, and only knew what we knew ourselves, that the race would start at 12 noon on the 15th.

The slight difficulty of fitting six people into five bunks having been satisfactorily solved by the simple process of the first five on board getting into the bunks, we awoke to find a glorious morning and a light easterly breeze.

"FULMAR" IN THE OCEAN RACE.



R.E.Y.C. Cutter "FULMAR," 14 tons.
Second in Ocean Yacht Race, 15th to 22nd August, 1925.

Crew:—Lieut N. A. Blandford-Newson (Skipper), Lieut. H. D. Bennett (Navigator). Hands:—Capt. R. M. H. Lewis, M.C., Lieuts. G. L. Watkinson, H. A. Macdonald, and P. L. Wilkinson.

Photograph by Beken & Son, Cowes, I.W.

A search for the racing flags of our rivals followed, but we could only find six besides ourselves—a most disappointing state of affairs, which it is to be hoped will not be repeated next year in the most sporting race of the season.

The list of entries for the race was as follows :—

Yacht.	*Rig.*	*Tons.*	*Owner.*
Jolie Brise....	Cutter	44	Mr. E. G. Martin
Izme	Bermudian ..	14	Major-General Seely
Fulmar	Cutter	14	Royal Engineers Yacht Club
Gull	Cutter	18	Mr. H. F. P. Donegan
Minna Dhu ..	Cutter	10	Mr. John Reidy
North Star ..	Ketch	37	Capt. M. Tennant
Saladin	Cutter	40	Mr. J. Simon
Filatonga	Yawl	16	Mr. J. L. Rigg
Banba........	Ketch	20	Mr. H. R. Barrett
Jessie L.	Cutter	27	Mr. C. J. Hussey
Chough	Cutter	17	Messrs. Fenner

Of these, however, only *Jolie Brise*, *Saladin*, *North Star*, *Gull*, *Jessie L.* and *Banba* were visible.

After a hasty breakfast some hard work followed preparing for the race, one hand once more going ashore in fruitless search for sailing instructions, and also to obtain one or two odd things which had been forgotten or consumed—the most important item being three dozen bottles of beer, for which we were later to be most devoutly thankful.

The dinghy lashed on deck, bower anchor and all spare clothing stowed, we got under way at about 10.15 a.m., our sole information about the race still being merely the time of the start, the position of the starting line, and the fact that we had to round the Fastnet and return to Plymouth. Shortly before gun-fire, while cruising up and down the starting line under mainsail, jackyarder and jib we received sailing instructions but no handicaps, which was rather disappointing. All such minor points, however, were forgotten in the excitement of the start. Five minutes before the gun we broke out staysail and jib-topsail, and we crossed the line a quarter of a minute late, level with *Saladin* and a little behind *Gull*. The moment of the start of the first Ocean Race is not likely to be forgotten by any of those who took part in it. It should also be memorable in the annals of the Royal Engineers Yacht Club for the fact that at least three of the crew wore yachting caps in honour of the occasion! The next item to occupy us was that of being photographed from Messrs. Beken and Son's launch—an event marked by a hasty placing of the crew to hide those portions of their anatomy not clad in "drawing-room yachting" style—in the excitement of which the fact that the jib-topsail sheet needed hardening passed unnoticed.

The light easterly wind gave us a beat down Spithead, and on bearing away for St. Catherine's we found ourselves third to *Gull* and *Saladin*. The spinnaker was set to port and fairly good progress was made, but off Sandown *Jolie Brise* romped past us under an enormous running sail which turned us green with envy. This left us fourth, with *Banba*, *North Star* and *Jessie L.* well astern. The wind dropping lighter and lighter, we appeared to hold our own with everyone except *Jolie Brise* and possibly *Gull*.

At 2.15 p.m. we passed St. Catherine's and set a course W.¼S. for the Lizard. Shortly afterwards we caught *Saladin* and kept company with her until dark. We were grateful to her crew for giving us the wireless weather report, but it did not sound very cheerful. Our companion edged to the southward during the night, and catching a light breeze, went away from us, leaving us cursing light variable airs all night and the next morning, the 16th. By this time we were organised into three watches of two, which we decided to stick to while the weather remained light. The watch next for duty was detailed to prepare the necessary meals, and the watch on deck washed up. This arrangement permitted the maximum of sleep for all hands and worked very well, though navigational activities occasionally necessitated assistance in washing up. The necessity of washing up in salt water, due to our limited water capacity, was rather trying, especially after breakfast.

The evening of the 15th saw our first and only casualty, the inevitable flare-up with a primus causing a badly burnt hand and nearly setting the head-sails on fire. The night of the 15th was uneventful with Portland Bill light showing up clearly and much shipping about. Little progress was made. A beautiful dawn on the 16th revealed to our joy our three rivals still in sight ahead, *Saladin* nearest, *Jolie Brise* ahead of her, and *Gull* hull-down. Considering the enormous advantage in the matter of light-weather canvas that these ships possessed over us, we were well content to have them still in sight. Of the ships astern only *Banba* was visible, hull-down. The beautiful dawn degenerated into an airless and broiling day with our rivals gradually drawing ahead. So little progress was made that bathing was indulged in quite safely, the clear blue water of the Channel being a pleasant change from the soupy compound of the Medway.

A light breeze coming up from the N.E. about 2 p.m. cheered us up considerably and sent us along at about four knots, with spinnaker to starboard. At sunset a last look round revealed *Saladin*, *Gull* and *Jolie Brise* hull-down, and that was the last we were to see of them for some time. The breeze freshening a little, we had Start Point abeam at 12.30 a.m. on the 17th. A steadily falling glass filled us with hope that the longed-for stiff breeze was coming, a hope, alas, not realised for many tedious hours yet. The day of the 17th dawned with overcast sky and still that steady, hopeful dropping of the glass, which had now dropped over two-tenths since leaving Ryde. The visibility having deteriorated considerably may account for our failing to sight our leading opponents at that time.

Land on the starboard bow at 1.30 p.m. was, after slight navigational argument, mostly facetious, at the expense of our hard-working skipper, located as the Lizard, and at 3.30 p.m. we gybed once more and altered course N.W., running through a number of the picturesque Cornish luggers.

7.22 p.m. saw us take our departure from the Runnelstone for our run to the Irish coast with the log streamed. If the wind remained steady we had high hopes of sighting once more the leading ships. *If* the wind remained steady: precisely the one thing it did not do throughout the first five days of the race. It seemed as if the elements were taking a hand in this race and enjoying it thoroughly.

The night of our departure from the Runnelstone saw us in a flat calm, once more, before 10 p.m., with a thick fog and a certain amount of shipping to add to the fun. Our mechanical horror of a fog-horn was produced, and sleep rendered impossible for the next few hours by its energetic use. The horn seems to have disturbed other people's sleep besides our own, as a steamer approached nearer than was pleasant, evidently mistaking us for a pilot boat.

Dawn of the 19th broke with visibility still poor and the glass still falling, but with the wind dropping light and patchy, necessitating continual trimming of sails. Visibility improved later, and at 11 a.m. the watch on deck executed a short song and a dance and reported *Gull*, *Jolie Brise* and *Saladin* in sight about three miles ahead. They were, of course, told to take more water with it, but they had the last laugh, and the song and dance was extended to the rest of the crew some ten minutes later. The three leaders all had spinnakers set to starboard, while we were reaching on the port tack and rapidly overhauling them. Our good breeze took us right up to them and then left us as if to say, "There you are, you've had your share." Need it be added that our jubilation was unbounded at finding ourselves, three days out, in close company with the leaders, and our unknown handicap still in hand? It more than made up for the many hours rolling alone, with the booms guyed and the reef points beating their ceaseless and monotonous tattoo, and for the constant and seemingly useless trimming of sheets.

The breeze, before it left us, took us within hailing distance of *Gull*, with *Jolie Brise* about a mile ahead, and *Saladin* abeam but well to leeward. "Hailing" distance, be it noted. The neighbourly

Gull tried to turn it into speaking distance. Most of *Gull's* crew bellowed at us and we shouted ourselves hoarse in return, but the word "what" was the only one distinctly heard for some time. *Gull's* log states that we told him that we passed the Runnelstone at 11 p.m., during the conversation; 7 p.m. was the noise we attempted to make. Owing to the lung-power required, conversation was languishing when *Gull* produced a hand with a remarkably clear speaking voice, suitable for drawing-room or fog-horn use. From him we learnt the handicaps, which were as follows :—

	Handicap.
Jolie Brise	scratch
Saladin	6 hrs.
North Star	6 hrs. 30 mins.
Gull	9 hrs.
Jessie L...	10 hrs. 40 mins.
Fulmar	12 hrs. 20 mins.
Banba	unknown

It appeared from them that, luck being with us, we need only fear *Gull*. We also learnt of *Gull's* ill-luck in carrying away her topsail halliard, for which we were extremely sorry. But for that stroke of ill-luck the chances are that *Gull*, on her previous and subsequent performance, would have won. Outbursts of melody followed the conversation from both ships; mercifully the distance must have slurred the noise we were making. The excessive state of drought produced by such vocal efforts turned our thoughts to a dip, but at that moment a large shark's fin appeared within three yards of the ship and, well, second thoughts are best. The skipper, hastily hurling his sextant to the deck, leapt below and returned with two large revolvers. The remainder of the crew having hurled themselves flat (they would have hurled themselves further but for the shark), he proceeded to indulge in some of the most execrable shooting we have ever had the misfortune to witness. The presence of the revolvers on board remains unexplained, unless it was in anticipation of a mutiny. From this echo of war, however, we were rudely recalled by the sight of *Jolie Brise* sailing away from us with a nice slant of wind which left *Gull* and ourselves severely alone. Right out of the middle of the fleet did that discriminating breeze take the scratch boat, and *Saladin* also got the fringe of it, leaving *Gull* and *Fulmar* rolling their masts out.

This was the deciding factor of the race, though we refused to recognise it at the time, and buoyed ourselves up with the thought of our twelve hours' allowance.

All the rest of that day and the night of the 18th-19th we remained becalmed; in fact, on more than one occasion the ship turned round in a complete circle. On the 17th we had begun to be seriously concerned with the question of water, as we seemed in for a long spell of calms, and as a precautionary measure cut ourselves down to 1½ pints of fluid per head per day, whether *aqua pura* or the bottled variety. It was then that we had cause to be thankful for that three dozen of beer. This limiting of liquid caused us no undue discomfort although the weather was broiling hot most of the time.

It was not until about midday on the 19th that we eventually got a light breeze from the west and went away closehauled at about 3½ knots, with *Gull* still in sight and *Saladin* just visible a long way to leeward. The glass continued its steady descent.

At 6 p.m. on the 19th we sighted the Irish coast, black against a yellow sky. This we made out to be Toe Head, and shortly afterwards Galley Head showed up. The *Fulmar* method of reading the log after long calms was then applied. As it is rather unique and highly scientific it is worthy of description. (*a*) First sight land. (*b*) Recognise it, if possible. (*c*) If you are skipper or navigator rush below with pencil, ruler and indiarubber and erase previous estimated position from chart, having first of all ascertained approximate bearing and distance from prominent shore object. (*d*) Insert correct position on chart and hastily measure distance from last land sighted. (*e*) Look up log reading and from this and real distance work out a percentage error for the log. (*f*) Insert small cross on chart at a distance from the correct position depending on the credulity of the crew. (*g*) Return on deck and inform the crew that the real position and the approximate position by dead reckoning coincide very closely. The game is suitable for one or more players, and is made more enjoyable, as was done in *Fulmar*, if one of the crew contrives to step on the log if it is left lying on deck at any time.

Another *Fulmar* pastime which was most enjoyable was the using of a sextant to check time and position. To be really enjoyed this must be done with the ship rolling heavily. Many hours can be whiled away estimating from your readings, and, provided an armed guard is put on the chronometer to prevent anyone altering it to fit in with the results of the observations, it is quite innocuous.

To return to more serious matters, a pitch dark night, a heavy swell and almost a flat calm found us with the flash of the Fastnet light showing up over the horizon. For this we made as best we could, puffs of wind coming from every direction. The strain of continuously trimming sails, gybing, and getting the spinnaker in and out with two-men watches was very severe, but the trouble taken was rewarded next morning as we gradually drifted round the lonely Fastnet Rock, with *Gull* a mile or so ahead and *Saladin* close astern. It must have been quite an event for the watchers on the lighthouse, this ocean race. "What ship are you?" "*Fulmar.*"

"When did *Jolie Brise* pass?" "7.30."—pause—another string of flags on the lighthouse—"Yesterday evening!" Groans from *Fulmar*. "Thank you." "I wish you a pleasant voyage." "Thank you!" So ended our conversation—and with it half our journey.

Round the mark—but only just. From the time of rounding until 11.30 a.m. on the 20th the only things moving were the sea-gulls and the glass—the latter accelerating its descent in a most cheering manner. *Gull* had edged in under the land and seemed to be going away slightly, but very slightly. *Saladin*, after standing well into Clear Island, caught a slight puff and began to overhaul us. We on *Fulmar* had time to admire a very beautiful shore and a coast which must surely be a yachtsman's paradise. But for the monotonous chant from the two junior members of the crew of "every day in every way it blows harder and harder." it would have been hard to imagine a more peaceful scene: not that we wanted peace just then with *Jolie Brise* twelve hours ahead. At about 11.30 a.m. the disciples of M. Coué hailed with triumph the advent of a light breeze from the west at last. It arrived only just in time to prevent *Saladin* overtaking us. This longed-for breeze continued to freshen every minute, and our spirits went up as the glass went down. 12.30 p.m. saw a fresh breeze from the south-west, the Fastnet dropping astern, and a jubilant crew *racing* at last, and making the most involved and hypothetical calculations as to how many hours we were going to hold the breeze before *Jolie Brise* got it. In our relief it is to be feared that we rather overdid the racing business, with the crew aft on the counter, and a pull here and a pull there as if we were racing a metre boat in the Solent. It was the spirit of the thing which counted, however, and it keyed us up to the right pitch for the somewhat strenuous run home, a run which, it seemed, would determine the first four places perhaps only by a matter of seconds. The results at any rate, were encouraging, as we appeared to be dropping *Saladin* slightly and were certainly holding *Gull*. The spinnaker was stowed below as the wind backed, and we set our course S.E. for the Longships. By 3.30 p.m. there was a grand sailing breeze, marred only by the black rain clouds gathering to windward, with the prospect of a fresh-water wetting to come. For the first time in the race spray was coming aboard, and the donning of oilies in the near future seemed probable. Old *Fulmar* was doing her seven to eight knots as far as we could make out from the patent log which had more or less given up the ghost.

By 5 p.m. the lee rail was just awash and the jibtopsail was taken in; the threatened rain arrived at the same time and amply fulfilled its early promise. Until we neared Plymouth we were now only to see our two immediate neighbours at intervals between rain squalls, which came down with some violence and increasing frequency. Just before dusk the only defect in *Fulmar's* rigging developed, the hook of the weather runner starting to open out under the strain. This necessitated luffing and substituting a shackle, an operation which allowed *Saladin* to gain considerably. It was indeed fortunate that this defect was discovered before dark, as if the hook had gone later the consequences might well have been unpleasant. These hooks were only fitted to the runners just before the race, in order to save overhauling the runner tackles every time the main sheet was eased. Just before dark it was decided to take down the jackyarder, to which we had stuck all day, as it seemed to be setting in for a dirty night. This operation was successfully accomplished with the aid of a hand aloft, though it took some time with the sheets to leeward. The night developed into one of pitch darkness, with heavy rain squalls and a rising though still comparatively short sea, and the glass still falling rapidly. At 10 p.m. a three-man watch was set for the first time, and the remaining three turned in to get what sleep they could. The chief difficulty in obtaining sleep was the large amount of water which was by now finding its way into *Fulmar's* innards, mainly through the cabin skylight. Blankets and spare clothes were soon soaked, and going on deck was merely exchanging one form of damp for another. At midnight, as the wind was freshening still more, it was decided to take in three reefs, for which purpose the ship was hove to for a short period and all hands were turned out. In order to balance the ship, the staysail had to be lowered also.

It appeared later that it might have been more politic to have eased sheets only, as the squall did not last more than an hour, and before dawn the watch on deck succeeded not only in shaking out the reefs, but also in setting the staysail, jackyarder and jib-topsail once more—a feat performed without turning out the watch below, and one entailing a certain amount of labour even in broad daylight, with only three hands on deck.

Dawn of the 21st broke with the wind slightly eased, with the same unpleasant succession of black rain squalls coming up. *Fulmar* had opened up slightly, necessitating about ten minutes' pumping with the world's worst pump every three hours or so. *Saladin* showed up about two miles to windward; she appeared to have reduced sail considerably. *Gull* was eventually spotted between rain squalls about three miles ahead, but owing to the bad visibility she was rarely seen. In addition, by this time a considerable long swell had got up, and it was a question of taking a hasty glimpse round for her on the crest of a wave before we sank into isolation in the trough. During the morning the clew of the jib-topsail blew out, and it had to be taken in pretty quickly before it flapped itself to shreds. It was immediately repaired, but wasn't actually set again till next day. About midday the wind piped up again, and all hands succeeded in hauling down the jackyarder much more easily than the previous evening.

About 1 p.m. the breeze, which had never been very steady from the south-west, started to back until we were close-hauled with no hope of weathering the Longships without a tack. We must have been somewhere near the centre of the depression about that time, as a period of comparative calm was followed by an extra fierce squall and what appeared to be a small water-spout passed us about a mile away. We were now getting in the track of the steamers, necessitating a sharp look-out in the poor visibility conditions, but none came unpleasantly near. At 2.30 p.m. we sighted land, and soon afterwards went about on the port tack, our example being followed by *Saladin*. We were then some seven miles off shore, just clear of the foul shore tide. At that time we caught one more glimpse of *Gull*, much closer in shore, and, we thought, probably up against a much stronger tide than ourselves. We had now practically a dead beat for the Longships, with the wind varying a point or so either side of south. We made the distance in a series of relatively short tacks, putting the ship about to suit the vagaries of the wind. Thereby we managed to draw right away from *Saladin*, which apparently stuck on to the port tack and was headed right off. Perhaps this was how we also left *Gull* behind, but we were unable to see exactly what she was doing.

The Longships light was passed at about 8 p.m., after which the wind gradually backed right round in the most amazing manner to give us a beam wind right into Plymouth Sound. At this point we ran into a nasty short sea, which threw the ship about considerably, and with it the watch below. 8.30 p.m. saw us moving like a train with a fresh beam wind, and, thank heavens, no rain. We were soon threading our way through a scattered Cornish fishing fleet making for home under easy sail; a certain amount of steamer traffic in addition added to the fun and necessitated a sharp look-out. This run from the Longships to Plymouth was sailing for the gods, with a wonderful breeze and a starry sky. 2 a.m. brought the Lizard abeam and a course was set for Plymouth. The wind had moderated by dawn, and we were greatly surprised to see no signs of *Gull* or *Saladin*. We could hardly credit that they had gained so far on us in the night as to be already over the line, as we appeared to have held them fairly well from the Fastnet. It took us some time to grasp the fact that the two white sails astern were our two friends, and how it had happened was as great a mystery to us at the time as it appears to have been to *Gull*. The occasion called for a celebration; Fulmar's health was drunk with all ceremony, although there was some talk about chickens which were not yet hatched.

As the wind was now moderating considerably it was time to start in on the job of making the ship and ourselves presentable. There was plenty to do! The jack-yarder and jib-topsail were hoisted for the last time, and all ropes ends coiled down. The cabin was then tackled. Everything below was in hopeless confusion, wet blankets, wet clothes and wet sails mingled with all sorts of oddments flung out of the racks on to the floor in the recent turmoil. Luckily the truant sun returned to start in on the job of drying our shore kit. A good meal, the first for some time, and we felt we could face the world again—when we had had a shave. And so 9.30 a.m. saw us burning our flares off Plymouth breakwater, and 9.48 saw us crossing the finishing line under conditions as peaceful as those prevailing when we crossed the line at Ryde, after 6 days 22½ hours continuous racing.

The finishing times were :—

		Corrected.
1st *Jolie Brise*	Fri., 14 hrs. 45 m. 37 sec.	Fri., 14 hrs. 45 m. 37 sec.
2nd *Fulmar* ..	Sat., 10 hrs. 48 m. 5 sec.	,, 22 hrs. 28 m. 5 sec.
3rd *Gull*	,, 11 hrs. 23 m. 15 sec.	Sat., 2 hrs. 23 m. 15 sec.
Saladin ..	,, 12 hrs. 54 m. 30 sec.	,, 6 hrs. 54 m. 30 sec.
North Star	,, 24 hrs. approx.	,, 17 hrs. 30 min.

Banba had not finished by midnight Sunday, and *Jessie L.* gave up near the Fastnet and went into Crookhaven under power.

The race was over—bar the shouting, which took the form of a dinner at the Royal Western Yacht Club at which the prizes were presented. *Fulmar's* share was a silver rose bowl which now adorns the headquarters mess. May the larger trophy be there to keep it company in the not too distant future!

MACAULAY'S SINGLE ELASTIC EQUATION FOR BEAMS.

By CAPT. W. D. WOMERSLEY, Royal Engineers (T), M.A., B.SC., A.M.INST.C.E.

FOREWORD. *By* LIEUT. A. MINNIS, R.E.

THE article which follows has been very kindly contributed by Capt. Womersley in response to a request for a full exposition of Macaulay's method of calculating the deflection of beams.

Capt. Womersley has desired that some explanation be given of its publication in this Journal, as it has already been published in the "Messenger of Mathematics," and in a recently published book on the "Strength of Materials," by Case (reviewed in this Journal).

It has not, however, been presented before in any publication generally read by R.E. Officers, and it will probably be new to most, except those who have gone through the Cambridge Course, and it is thought that it will be of interest as a refresher to them also.

As an illustration of the labour saved by Macaulay's method, (and, consequently, the greater chance of a correct solution), a comparison may be made with the old method in the solution of a simple case such as the first one given by Capt. Womersley.

Referring to Fig. 1 of the article :—

By the old method it is necessary to commence with two differential equations, one for AC and one for CB, introducing four constants on integration.

Thus, for AC

$$-EI\frac{d^2y}{dx^2} = R_A x$$

Integrating $$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} + C \quad \text{.......................} \quad (1)$$

Integrating again $$-EIy = R_A\frac{x^3}{6} + C_1x + C_2 \quad \text{..............} \quad (2)$$

for CB

$$-EI\frac{d^2y}{dx^2} = R_B x$$

$$-EI\frac{dy}{dx} = R_B\frac{x^2}{2} + C_3 \quad \text{.......................} \quad (3)$$

$$-EIy = R_B\frac{x^3}{6} + C_3x + C_4 \quad \text{...........} \quad (4)$$

The constants C_2 and C_4 are eliminated from the condition that $y = 0$ when $x = 0$ in both cases $\therefore$ $C_2 = 0$ and $C_4 = 0$.

The constants C_1 and C_3 are found from the condition that y and $\frac{dy}{dx}$ are continuous at C.

Thus putting $x = a$ in (1) and (2) and $x = (l—a)$ in (3) and (4)

$$R_A \frac{a^2}{2} + C_1 = -\left\{ R_B \frac{(l-a)^2}{2} + C_3 \right\} \qquad \text{..............} \quad (5)$$

$$R_A \frac{a^3}{6} + C_1 a = R_B \frac{(l-a)^3}{6} + C_3 (l-a) \qquad \text{..............} \quad (6)$$

C_1 and C_3 are found by solving the simultaneous equations (5) and (6) and it is in this part of the work that much of the labour occurs.

By Macaulay's method the bending moment equation for the whole beam (referring to Capt. Womersley's article), is equation (7) which, on integration, gives equation (9) for deflection.

As the term within the $\{\ \}$ brackets does not concern the portion AC, it is obvious (from (9)), that when $x = 0$ the second constant is 0.

So that there is only one constant to find, which is easily determined from the condition that $y = 0$ when $x = l$.

In both cases, the constants having been found, the ensuing labour is much the same, but sufficient has been said to show that much labour can be saved by this new method in arriving at this point.

In cases of more complicated loading the saving is proportionately greater; the work up to now is much more easily checked than is possible by the old method, and one can approach the long arithmetical calculation that follows with a greater feeling of security.

In any case, by whatever method it is done, the calculation of deflection in any but the very simplest problems, is a laborious matter; and it is not surprising that the distinguishing feature of such calculations is almost invariably the production of a wrong answer.

To get the right solution, first time, by the old method, needs some luck, as well as great care in avoiding arithmetical errors and such slips in algebra as, say, writing down a + for — sign in one of the many steps; anything that helps to avoid some of this labour, therefore, will also contribute to the chances of arriving at the correct solution.

In some cases it is possible to avoid much of this trouble by use of the "Theorem of Three Moments," but this method breaks down in cases of combined concentrated and distributed loading, owing to the difficulty of finding the areas and centres of gravity of the bending moment diagrams, the boundaries of which are defined by the addition of the ordinates of parabolic and straight line figures.

Macaulay's equation, being of universal application for all systems of loading, supports, or degrees of fixation, provides a short cut through most of the difficulties connected with the determination of deflections and reactions.

THIS very powerful method for determining reactions, deflections, etc., for beams by the use of one omnibus equation was published by W. H. Macaulay, M.A., of King's College, Cambridge, in the "Messenger of Mathematics, Jan. 1919, XLVIII," although it has been in use, through him, in Cambridge for the past two decades or more. The principle may be clearly shewn by considering a simply supported beam with a non-symmetrical concentrated load

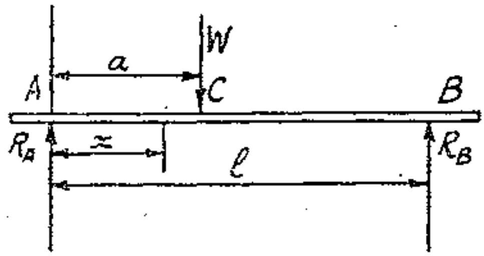


FIG. 1.

as in Fig. 1. Take the end A as the origin and the undeflected centre line AB as the x axis. It is usual to consider the deflection y as positive below AB, that is in the usual negative direction for measuring y, and thus the radius of curvature will be negative and will require a negative sign before being equated to the bending moments producing positive deflections. Thus, from A to C the bending moment equation is :—

$$-EI\frac{d^2y}{dx^2} = R_A.x \tag{1}$$

which gives the slope equation on integration

$$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} + \alpha \tag{2}$$

and the deflection equation on further integration

$$-EIy = R_A\frac{x^3}{6} + \alpha x + \beta \tag{3}$$

where α and β are constants of integration.

From C to B the bending moment equation is :—

$$-EI\frac{d^2y}{dx^2} = R_Ax - W(x-a) \tag{4}$$

and if this is integrated so that the term $W(x-a)$ keeps its own constant of integration with it, the following equations are obtained for the slope and deflection :—

$$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} - \frac{W}{2}(x-a)^2 + \alpha_1 \tag{5}$$

$$-EIy = R_A\frac{x^3}{6} - \frac{W}{6}(x-a)^3 + \alpha_1x + \beta_1 \tag{6}$$

Now when $x=a$, (2) and (5) should give the same value for the slope of the beam, and (3) and (6) should give the same value for the deflection, and thus it will be seen that :—

$$\alpha = \alpha_1 \quad \text{and} \quad \beta = \beta_1$$

Hence the equation (4) can be used as the bending moment equation for the whole beam provided that the term $W(x-a)$ is left out when (x) is less than (a), and the integration carried out in the manner shewn in (5) and (6). It is usual to enclose such terms as $W(x-a)$ in special brackets as a reminder of the necessary conditions, as in (7), (8) and (9).

$$-\mathrm{EI}\frac{d^2y}{dx^2} = \mathrm{R_A}x - \left\{\mathrm{W}(x-a)\right\} \qquad (7)$$

$$-\mathrm{EI}\frac{dy}{dx} = \mathrm{R_A}\frac{x^2}{2} - \left\{\frac{\mathrm{W}}{2}(x-a)^2\right\} + \alpha \qquad (8)$$

$$-\mathrm{EI}y = \mathrm{R_A}\frac{x^3}{6} - \left\{\frac{\mathrm{W}}{6}(x-a)^3\right\} + \alpha x + \beta \qquad (9)$$

The known conditions are, suppose that :—
$y = 0$ when $x = 0$ and l, and thus inserting these conditions in (9)

$$\beta = 0 \text{ and } \mathrm{R_A}\frac{l^3}{6} - \mathrm{W}\frac{(l-a)^3}{6} + \alpha l + \beta = 0$$

also the bending moment is 0 when $x = l$
$\therefore$ from (7)

$$\mathrm{R_A}l - \mathrm{W}(l-a) = 0 \quad \text{or } \mathrm{R_A} = \frac{\mathrm{W}(l-a)}{l}$$

Thus it will be found that :—

$$\alpha = -\frac{\mathrm{W}a(l-a)\ (2l-a)}{6l}$$

and hence the deflection is :—

$$-\mathrm{EI}y = \frac{\mathrm{W}(l-a)x^3}{6l} - \left\{\mathrm{W}\frac{(x-a)^3}{6}\right\} - \frac{\mathrm{W}a(l-a)\ (2l-a)}{6l} \cdot x$$

This example has been worked out completely since the procedure is exactly the same however many concentrated loads there may be and whatever their sign, and this means, of course, that the method is equally applicable to continuous beams.

(In what follows $\frac{d^2y}{dx^2}$ will be written $\ddot{y}$ and $\frac{dy}{dx}$ as $\dot{y}$)

The bending moment equation for the beam shewn in Fig. 2 would be :—

$$-\mathrm{EI}\ddot{y} = \mathrm{R_A}x - [\mathrm{W_1}(x-a)] + [\mathrm{R_B}(x-\alpha)] - [\mathrm{W_2}(x-b)] + [\mathrm{R_C}(x-\beta)] - [\mathrm{W_3}(x-c)]$$

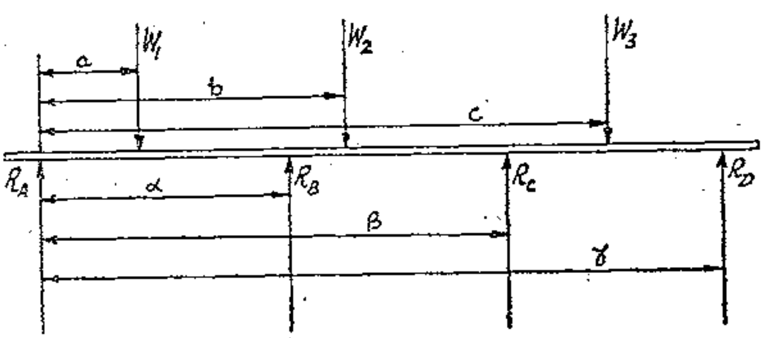


FIG. 2.

Such a case as this would entail considerable labour in its solution and would probably be more easily solved by the use of the Theorem of Three Moments, as the areas and positions of the centres of area of the "free" bending moment diagrams are quite easily obtained, but the example has been given to indicate the method of writing down the bending moment equation in a more extended case.

When a uniformly distributed load (*a*) completely covers the beam (*b*) partially covers the beam but extends up to the right hand support, the treatment is exactly the same and offers no special difficulty.

Fig. 3 is an example.

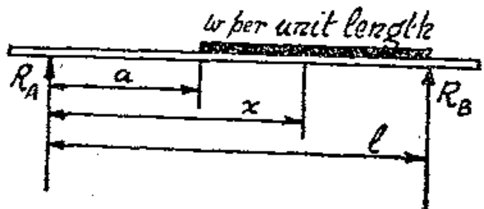


FIG. 3.

The equations are:—

$$-EI\ddot{y} = R_A x - \left\{\frac{w(x-a)^2}{2}\right\} \qquad (10)$$

$$-EI\dot{y} = R_A\frac{x^2}{2} - \left\{\frac{w(x-a)^3}{6}\right\} + \alpha$$

$$-EIy = R_A\frac{x^3}{6} - \left\{\frac{w(x-a)^4}{24}\right\} + \alpha x + \beta$$

If, however, there is an isolated piece of uniformly distributed load, as in Fig. 4, a difficulty arises since the equation (10) would

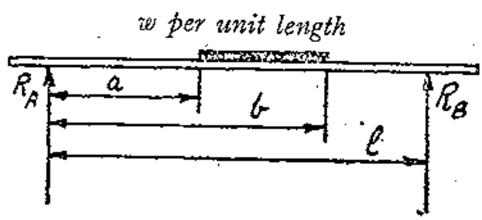


FIG. 4.

not be true for values of (x) between (b) and (l), because ($x-a$) is no longer the length of the distributed load to the left of the section being considered, nor is $\frac{x-a}{2}$ the distance of the centre of gravity of this load to the left of the section and so a special method has to be adopted to overcome the trouble. The distributed load is extended to the right hand support and an extra piece of negative distributed load of the same intensity is introduced under the extended part of the original one as shewn in Fig. 5.

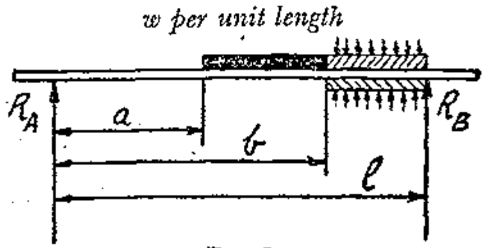


FIG. 5.

It should be obvious that no change has been made statically, as the two extra portions of the loading counteract each other, but the terms which represent the bending moments of the loads are now true to the end of the beam. The solution is as follows :—

$$-EI\ddot{y} = R_A x - \left\{\frac{w(x-a)^2}{2}\right\} + \left\{\frac{w(x-b)^2}{2}\right\}$$

$$-EI\dot{y} = R_A\frac{x^2}{2} - \left\{\frac{w(x-a)^3}{6}\right\} + \left\{\frac{w(x-b)^3}{6}\right\} + \alpha$$

$$-EIy = R_A\frac{x^3}{6} - \left\{\frac{w(x-a)^4}{24}\right\} + \left\{\frac{w(x-b)^4}{24}\right\} + \alpha x + \beta$$

If the conditions are as in the first example, i.e., the deflection zero at the two ends of the beam and the beam simply supported at the ends, then :—

$$\beta = 0\,; \ \frac{R_A l^3}{6} - \frac{w(l-a)^4}{24} + \frac{w(l-b)^4}{24} + \alpha l = 0$$

and

$$R_A l - \frac{w(l-a)^2}{2} + \frac{w(l-b)^2}{2} = 0$$

whence R_A and α may be determined and the completed equation obtained.

One more special case occurs when an intermediate couple is applied to a beam. Under these circumstances it is a little difficult to co-relate the couple and its distance along the beam with the remainder of the equation. The trouble is most satisfactorily

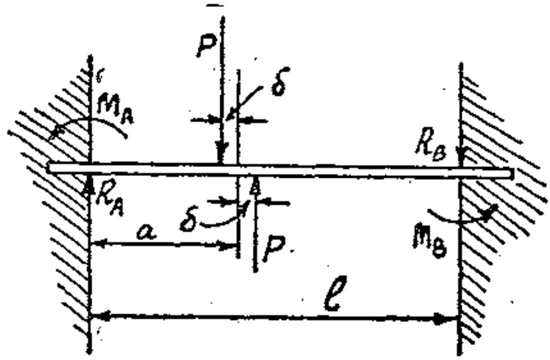


FIG. 6.

overcome by imagining the couple to be produced by two equal and opposite infinite forces acting an infinitesimally short distance apart and such that the product of the force and distance apart is finite and equal to the couple applied. Consider the case of a beam, say *encastré*, at the ends, and with just the intermediate couple M_C applied at C_1, a distance (a) from the left end. Split the couple up into two infinite forces P a distance 2δ apart as indicated in Fig. 6 and such that $M_C = 2P\delta$. Let the end reactions and fixing moments be as shewn. Then the bending moment equation is as follows :—

$$-EI\ddot{y} = R_A x - M_A - [P(x-a+\delta)] + [P(x-a-\delta)]$$

whence

$$-EI\dot{y} = R_A\frac{x^2}{2} - M_A x - \left\{\frac{P}{2}(x-a+\delta)^2\right\} + \left\{\frac{P}{2}(x-a-\delta)^2\right\} + \alpha$$

Since the beam is *encastré* at both ends then :—

$$\dot{y} = 0 \quad \text{when} \quad x = 0 \text{ and } l$$

whence

$$\alpha = 0$$

$$R_A\frac{l^2}{2} - M_A l - \frac{P}{2}\Big((l-a) + \delta\Big)^2 + \frac{P}{2}\Big((l-a) - \delta\Big)^2 = 0$$

and from this

$$2M_A l - R_A l^2 = -4P\delta(l-a) = -2M_C(l-a) \qquad (11)$$

Integrating again

$$-EIy = R_A\frac{x^3}{6} - M_A\frac{x^2}{2} - \left\{\frac{P}{6}(x-a+\delta)^3\right\} + \left\{\frac{P}{6}(x-a-\delta)^3\right\} + \beta$$

Again

$$y = 0 \qquad \text{when } x = 0 \text{ and } l$$

and therefore

$$\beta = 0$$

$$R_A\frac{l^3}{6} - M_A\frac{l^2}{2} - \frac{P}{6}\Big((l-a) + \delta\Big)^3 + \frac{P}{6}\Big((l-a) - \delta\Big)^3 = 0$$

whence

$$3M_A l^2 - R_A l^3 = -6P\delta(l-a)^2 - 2P\delta.\ \delta^2$$
$$= -3M_C(l-a)^2 \qquad (12)$$

since δ^2 is an infinitesimal of the second order.
From (11) and (12) it will be found that :—

$$R_A = \frac{6a(l-a)}{l^3} M_C \text{ and } M_A = \frac{(l-a)\ (3a-l)}{l^2} M_C$$

and the complete equation is :—

$$-EIy = M_C\,\frac{a(l-a)}{l^3}\,x^3 + M_C\,\frac{(l-a)\ (l-3a)}{2l^2}\,x^2 - \left\{M_C\,\frac{(x-a)^2}{2}\right\}$$

A few numerical examples follow indicating the types of problem that may be encountered and shewing the universal applicability of the method.

Example I.

A uniform girder is continuous over two spans of 30 feet and 40 feet respectively, and carries a uniformly distributed load of 2 tons per foot run extending for 20 feet on each side of the intermediate support, which sinks 0.1 inch per ton load on it, the end supports being rigid. The "Moment of Inertia" of the girder section is $\frac{1}{6}$ in foot-units and Young's Modulus of Elasticity for the material is 4,000 tons per square inch.

The beam ready for operation is shewn in Fig. 7.

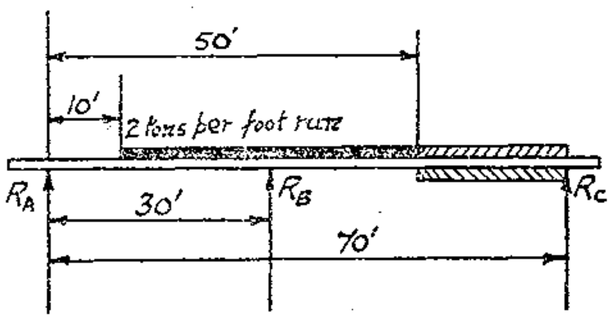


FIG. 7.

The equations are:—

$$-EI\ddot{y} = R_A x - \left\{(x-10)^2\right\} + \left\{R_B(x-30)\right\} + \left\{(x-50)^2\right\}$$

$$-EI\dot{y} = R_A\frac{x^2}{2} - \left\{\frac{(x-10)^3}{3}\right\} + \left\{\frac{R_B(x-30)^2}{2}\right\} + \left\{\frac{(x-50)^3}{3}\right\} + \alpha$$

$$-EIy = R_A\frac{x^3}{6} - \left\{\frac{(x-10)^4}{12}\right\} + \left\{\frac{R_B(x-30)^3}{6}\right\} + \left\{\frac{(x-50)^4}{12}\right\} + \alpha x + \beta$$

The known conditions are that:—

$x = 0$	when $y = 0$		(1)
$x = 30$ ft.		$y = \frac{0.1}{12} R_B$ feet	(2)
$x = 70$ ft.		$\left\{\begin{array}{l} y = 0 \\ \ddot{y} = 0 \end{array}\right.$	(3) (4)

Thus from (1) $\qquad B = 0$

from (2) $\qquad A = \frac{4000}{9} - 150R_A - \frac{280}{3}.R_B \quad (5)$

from (3) and (5) $$350R_A + 31R_B = \frac{23{,}300}{3} \qquad (6)$$

from (4) $$54.25R_A + 31R_B = \frac{7440}{3} \qquad (7)$$

Thus from (6) and (7) $R_A = 17.9$ tons, $R_B = 48.7$ tons, $R_C = 13.4$ tons and any other quantities desired may then be found.

Example II.

A beam 40 feet long is *encastré* at both ends and carries a load of 10 tons at a point 10 feet from one end and 10 tons uniformly distributed over the other half of the beam. To determine the reactions and the fixing moments, etc.

(Technical Examination for R.E. Officers, December, 1925).

The beam should be arranged as in Fig. 8.

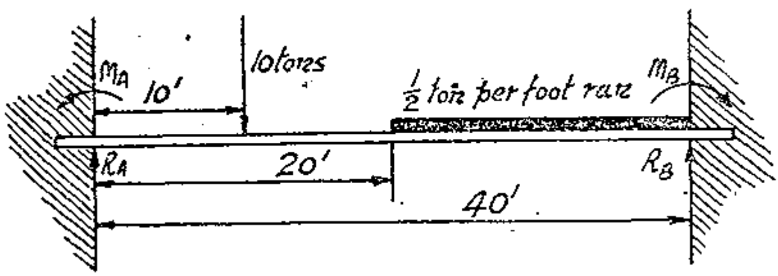


FIG. 8.

$$-EI\ddot{y} = R_A x - M_A - \left\{10(x-10)\right\} - \left\{\frac{(x-20)^2}{4}\right\}$$

$$-EI\dot{y} = R_A\frac{x^2}{2} - M_A x - \left\{5(x-10)^2\right\} - \left\{\frac{(x-20)^3}{12}\right\} + \alpha$$

now $\alpha = 0$ since $\dot{y} = 0$ when $x = 0$

$$-EIy = R_A\frac{x^3}{6} - M_A\frac{x^2}{2} - \left\{\frac{5}{3}(x-10)^3\right\} - \left\{\frac{(x-20)^4}{48}\right\} + \beta$$

also $\beta = 0$ since $y = 0$ when $x = 0$

when $x = 40$ feet $\dot{y} = 0$ and $y = 0$.

whence $60R_A - 3M_A = 387.5$

and $40R_A - 3M_A = 181.25$

from which

$R_A = 10.3125$ tons and $M_A = 77.08$ foot-tons.

The remainder follows at once.

Example III.

A vertical stanchion is *encastré* at the lower end and supported horizontally at the upper end. The length of the stanchion is 10 feet, and 8 feet from the ground level, a crane runway bracket is rigidly attached to the stanchion and may carry a load of 5 tons at a distance of 2 feet from the axis of the stanchion. Effect of direct compression is neglected.

The stanchion and its arrangement for solution are shewn in Fig. 9.

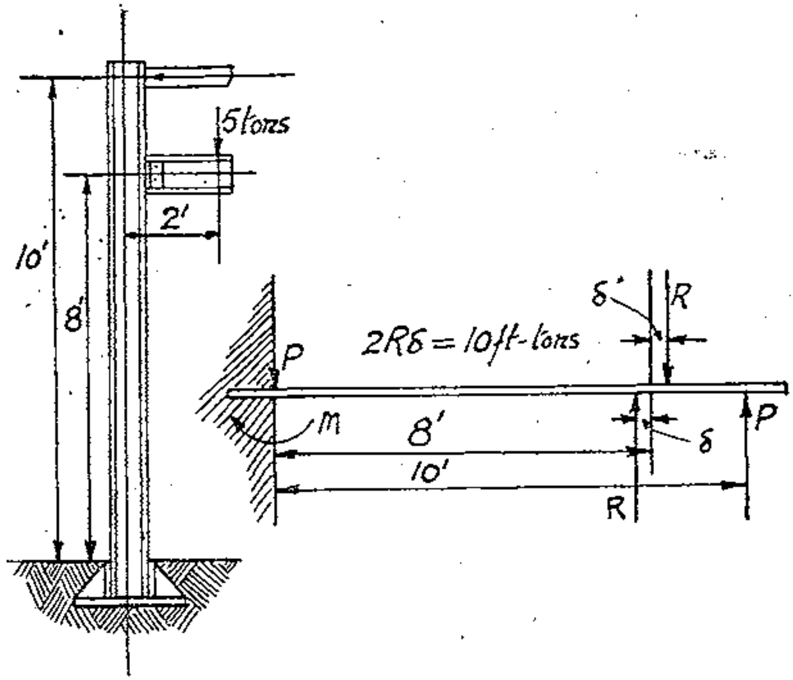


FIG. 9.

$$-EI\ddot{y} = M - Px + [R(x-8+\delta)] - [R(x-8-\delta)]$$

$$-EI\dot{y} = Mx - P\frac{x^2}{2} + \left\{\frac{R}{2}(x-8+\delta)^2\right\} - \left\{\frac{R}{2}(x-8-\delta)^2\right\} + \alpha$$

Now $\alpha = 0$ since $\dot{y} = 0$ when $x = 0$

$$-EIy = \frac{Mx^2}{2} - \frac{Px^3}{6} + \left\{\frac{R}{6}(x-8+\delta)^3\right\} - \left\{\frac{R}{6}(x-8-\delta)^3\right\} + \beta$$

also $\beta = 0$ since $y = 0$ when $x = 0$

Now $\ddot{y} = 0$ when $x = 10$ feet.

Therefore $10P - M = 10$

also $y = 0$ when $x = 10$ feet

whence $50P - 15M = 3$

and thus $M = 4.7$ foot tons and $P = 1.47$ tons.

Any other quantities can now easily be determined.

SYNCHRONOUS ELECTRIC CLOCKS, WITH PARTICULAR REFERENCE TO THE SYSTEM AT THE S.M.E.

By CAPTAIN C. C. S. WHITE, M.B.E., R.E.

Electrically operated clocks are apt to be regarded as a luxury, whereas, in point of fact, in many cases, they are an economy, and can effect an appreciable saving on the system of paying so much a year for "clock winding." In addition to this there is the inestimable advantage that all clocks are in absolute and perfect synchronism with the master clock and with each other.

Before deciding to instal a system of electric clocks there are two main items which require careful consideration:—

(1) The distance between clocks;
(2) Personnel for maintenance.

In theory there is no limit to the distance over which clocks can be operated, but in practice it becomes a question of whether the capital expenditure on line construction is justifiable. The most favourable conditions for their use are either a concentrated area, or where telephone or overhead power lines are already existing, and an extra pair of wires can be run for a very slight extra cost.

With regard to the personnel required for maintenance, no very great electrical knowledge is required, and the work can easily be done by an electric power lineman or a telegraph lineman and an instrument maker or electrician. Electric clocks are not delicate, scientific instruments, needing expert manipulation and attention, but strong, sturdy, substantial and reliable articles; nevertheless it is desirable, except with the smaller sizes of impulse clock, to instal them in a situation which is not liable to jarring or severe shaking. Incidentally the clocks are usually sealed by the makers, and seldom require attention.

Two of the main advantages, absolute uniformity and no winding, have already been mentioned. Other advantages are that the original outlay is no greater than that of installing an equivalent number of clocks in a small area. Extra clocks can be easily added at a small cost. All that is necessary is to run two wires from the nearest point on the existing circuit to the new clock, and add one or two cells to the battery.

The system can be extended to include turret clocks, striking clocks and sound signals, to operate automatically according to any desired programme.

The main disadvantage is that if a break occurs in the circuit, all clocks stop, since the clocks are usually connected in series, but even this can be considered preferable to having numerous clocks out of synchronism. Of course, a short-circuit on the line will prevent those clocks on the loop getting the impulse, and they will consequently drop behind, but such a fault will be of rare occurrence with a well constructed line.

Various Systems.

There are various systems of electrically operated clocks, but the principles are very much the same in each case. The general idea is to have a Master Clock, whose function is two-fold; firstly, to keep accurate time, and secondly, to control the other clocks, usually by half-minute or minute impulses.

The master clock can be sustained either electrically or mechanically. In the "Synchronome" and "Pulsynetic" systems the movement of the pendulum is sustained every half-minute by the fall of a "Gravity Arm," re-setting being effected by an electromagnet operated by the main battery. The magnitude of this impulse depends upon gravity, a constant force for all practical purposes. Direct impulsing by an electro-magnet is not advisable, as the magnitude of the impulse will vary with the strength of the battery, so electro-magnetic sustaining cannot give constant time keeping, except, possibly, under special laboratory conditions.

"Princeps" System.—The "Princeps" electric clock is maintained by an ingenious method; the pendulum receives a small additional impulse from a side contact spring every complete vibration, this spring being returned to its normal position by a movable stop, controlled electrically.

"Magneta" System.—In the "Magneta" system, the master clock is not operated electrically. A release arm is actuated by a pin wheel, and the energy generated by the falling weight operates a magneto, which drives the secondary clocks, and at the same time re-winds a small remontoir spring which maintains the pendulum.

The Pulsynetic System.

Master Clock.—The action of the Transmitter or Master Clock is exceedingly simple. Normally, while swinging with the pendulum, the pallet P of the crutch H passes close under, but does not (and must not) touch the roller R, which is pivotally mounted on the gravity or impulse lever G.

The driving pawl D pushes round the escape or time wheel E, tooth by tooth, with each oscillation of the pendulum. The pawl B prevents the backward rotation of this wheel. At each half-minute, however (one revolution of the wheel), the driving pawl D enters the deep cut tooth E_1, and the extension on D_1 of the pawl D rises, and engages the supporting or stirrup catch at the point S_1, instead of passing freely through the loop as normally. The supporting catch S is then pushed out of engagement with

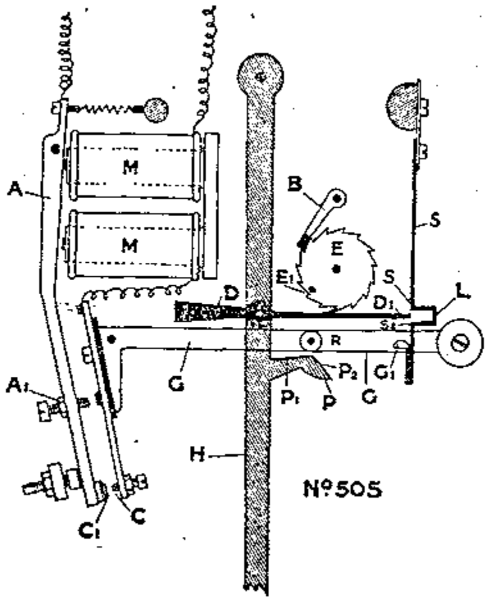


FIG. 1.

the gravity lever G at G1, allowing the gravity lever to fall. The roller R of the gravity lever drops on to the inclined plane P2 during the pendulum's swing to the left, thus imparting to it, mechanically, a gravity impulse of unvarying force. The downward path of the gravity lever is definitely arrested at a pre-determined point by the contact C meeting the contact C1. The circuit being then completed through the electro-magnet MM and the external circuit, which is composed of the battery and impulse clocks arranged as in Plate No. 2, the armature A is attracted, and so throws the gravity lever to its normal position. Whereupon the contact is broken by the breaking screw A1; this arrests the motion of the armature and causes the contacts C and C1 to separate. This contact is self-adjusting in relation to its duration, because the action takes place quicker while the current flowing through the circuit is strong, but when the battery weakens, the duration is prolonged by the action of replacement taking place more slowly, thereby increasing the duration of the contact, and so giving all clocks in the circuit time to operate with the weaker current.

If for any reason it is desired to advance all the clocks on the system, this can be done by holding down the "repeating cord," and so depressing the pawl D1, which will then engage with the supporting catch S at S2 at each vibration of the pendulum, thus releasing the gravity lever G and causing it to make contact every two seconds instead of every half-minute.

In order to retard the clocks, the pendulum may be stopped for so long as is necessary.

It is interesting to note that, in order for the transmitter to work correctly, the gravity lever must be lifted to its correct position by the current the instant the contacts C and C_1 meet. If the gravity lever remains down until it is assisted back by the pendulum, then the duration of the impulse is one second instead of 1/30th, and the warning bell will ring.

Warning Bell.—A warning bell is incorporated in the impulse circuit to indicate when the battery current becomes too weak to work the clocks satisfactorily. It is a single stroke trembler bell with its hammer loosely adjusted, so that it has not time to hit the gong when the duration of an impulse is normal, *i.e.*, 1/30th sec. But when the battery current drops below 0.17 ampere, and the re-setting of the gravity lever (G) is not so rapid, the duration of the impulse is increased; then the hammer has time to hit the gong and so give audible warning that the battery requires attention.

Battery.—The battery can well be either dry or wet Leclanché cells. The load is ideal for this type, being 0.18 ampere for a very short impulse, somewhere in the neighbourhood of 1/30th of a second, and occurring every half-minute. The battery should last for a year or more without requiring attention, and have a useful life of three or four years at least.

Impulse Clocks.—Clocks with dials up to 3ft. 6 inches diameter are usually directly operated by means of a simple electro-magnetic, and are known as impulse clocks. The power taken by these clocks depends upon the size of electro-magnet required—the larger the clock the greater the ohmic resistance, and so the greater the voltage drop and the power consumed in that part of the circuit. Incidentally, the total yearly consumption of energy for all clocks on the S.M.E. circuit is .064 of a unit.

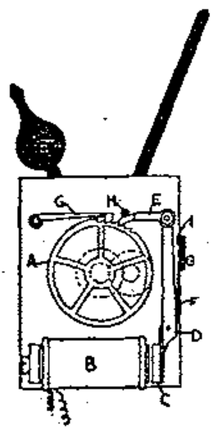


FIG. 2.

Waiting Train Clocks.—Larger clocks, such as turret clocks, and in fact all clocks whose hands are exposed to the weather, are best operated by a "Waiting Train" movement.

Briefly, this is an independent clock, electrically operated by its own battery, but its hands are arranged so as to move through a half-minute space in from 27 to 28 seconds, and then wait for a release caused by an impulse from the master clock.

The "mainspring" of a waiting train movement is an electrically driven heavy pendulum, the function of which is not to keep time, but to drive the hands of the clock. The motor pendulum is energised by an electro-magnet when its oscillations fall below a certain pre-determined arc. Under normal working conditions re-energisation takes place about once per minute, but when heavy work is being thrown on the hands, the motor pendulum becomes energised more frequently—as often as every complete vibration if necessary. On being energised at each vibration, the pendulum develops 30 times its normal power, and it is impossible to stop the movement by hand, even when exerting one's full power on the worm wheel.

The dis-association of the driving mechanism from the time-keeping ensures that the accuracy of a turret clock is determined by the master clock, and an accuracy of one second per week is easily obtainable.

Another feature of electric operation is the entire absence of heavy clock weights, with their attendant troubles due to suspension, possibility of falling, etc. The motive power is provided by a local battery, which can be housed wherever convenient.

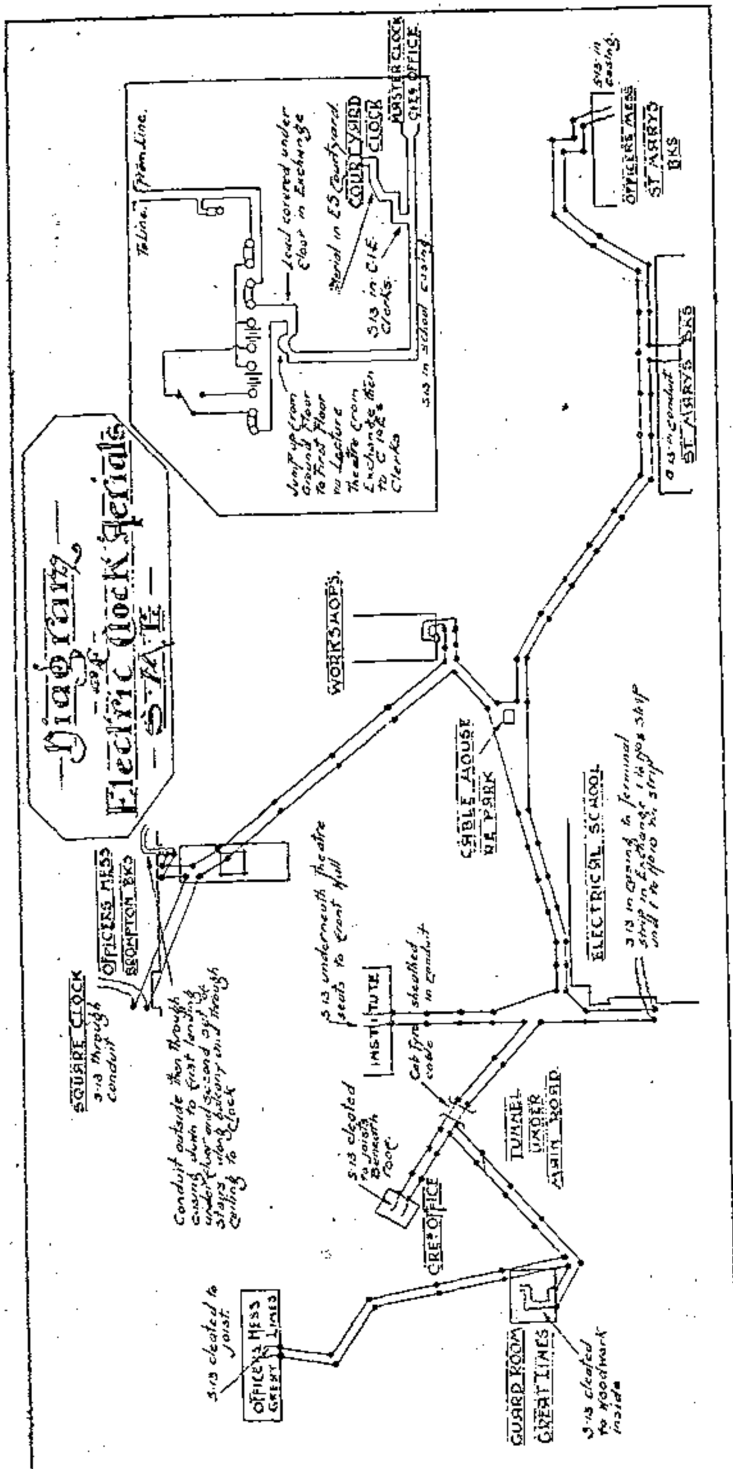
The half-minute control is arranged as follows:—The gear ratio of the turret clock is such that the minute hand is driven through a half-minute space on the dial in from 27 to 28 seconds. The pawl of the motor pendulum is then automatically lifted out of engagement with the ratchet wheel, so that, although the motor pendulum maintains its action, the hands remain stationary for two or three seconds, locked by the worm gear. A current impulse from the transmitter, dead on the half-minute, releases the pawl, and the hands are driven forward for another half-minute on the dial. As a rest of two or three seconds is inappreciable, the hands appear to move with regular progression, and not in half-minute jumps as in the case of impulse movements.

A waiting train movement is recommended for all exterior clocks when the diameter of the dial exceeds 3ft. 6 inches.

Striking or Chiming Clocks.—Clocks can be arranged to strike or chime electrically. In the case of large clocks this is usually done by means of motor-driven gear arranged as in Diagram No. 3, or by a "Waiting Train" movement. The drop hammer, motor-driven method will strike church bells of two tons weight. Chimes for small clocks can be operated direct off the impulse circuit by means of a special instrument.

PLATE 1.

DIAGRAM I.



INSTALLATION AT THE S.M.E.

In August, 1921, it was decided to instal "Pulsynetic" electric clocks at the S.M.E. The scheme adopted was to replace the existing mechanical movements by electrical control in the three main clocks at Brompton Square, St. Mary's Barracks and S.M.E. Workshops. Brompton Square clock was considered too large a clock to be operated directly off the impulse circuit, for which reason a "Waiting Train Movement," with its own independent battery, was ordered. Eight small impulse clocks were installed in the entrance of the S.M.E. Main Building, the Electrical School Courtyard, the three Officers' Messes, Great Lines Guardroom and in the C.R.E's. Office.

A master clock to control all the above was installed in the C.R.E's. office, and a battery in the S.M.E. Telephone Exchange.

An order for the necessary apparatus was placed with Messrs. Gent and Co., in September, but, owing to delays in getting the line stores, it was not until March, 1922, that the main portion of the installation was completed.

The total cost of the whole installation, omitting labour costs, was £189 12s. 9d., made up as follows :—

	£	s.	d.
Brompton Barracks Square.			
Supplying and fitting "Waiting Train" movement clock, 3' 6" dial.	36	10	0
St. Mary's Square.			
Supplying and fitting Impulse clock, 2' 6" dial. ..	7	6	0
S.M.E. Workshops.			
Supplying and fitting Impulse clock, 3' 0" dial. ..	6	18	0
Electrical School Courtyard.			
Impulse clock, 12" dial.	5	0	0
Seven Impulse clocks for interior use, at £3 15s. 6d. each, 9" dial.	26	8	6
Master clock	17	8	9
Warning bell	2	5	0
3½ miles hard drawn copper wire, 1/16—light insulation	23	4	9
Wire, electric, S.13	3	13	4
Wire, electric C.T.S. twin	6	10	0
Insulators, bolts and line stores..	48	6	1
Cells, electric, Leclanché	5	2	0
Sal ammoniac	1	0	4
Total	£189	12	9

It will be seen that a very large proportion, nearly half, of the expenditure is on the line. The total length of wire in circuit is just over $3\frac{1}{2}$ miles.

Brompton Square clock, which has a "Waiting Train" movement, has proved to be most satisfactory. It has stopped only once—in August, 1923—when 4 cells of the local battery were discovered completely dry. This battery is on the roof of the Brigade Major's quarters—a very hot situation when the weather is at all warm.

The two large exterior clocks in St. Mary's Barracks and S.M.E. Workshops, fitted with impulse movements, have not proved to be quite so satisfactory. They are apt to be affected by the wind and weather.

The most satisfactory type of exterior clock, other than the "Waiting Train," is the impulse movement in water-tight cast iron case in the Electrical School Courtyard, which has given no trouble whatsoever, but the dial is too small for a Square clock.

All the interior impulse clocks are in plain air-tight wood cases, and have required no attention.

In order to ensure the aerial line being as safe as possible, it was considered advisable to use insulated hard drawn copper wire, No. 16 S.W.G., and to have the clock wires as cap wires on "cow-horn" insulators on the telephone poles.

Duplicate batteries are installed at the S.M.E. Telephone Exchange to admit of one being rested and refreshed whilst the other is in use. This is really rather more of a luxury than a necessity, as the load on the battery is so small that half-a-dozen spare cells is all that is required for "stand-by" and cleaning purposes.

To calculate the size of the battery required, allow a working current of 0.17 to 0.25 ampere for the impulse circuit. The current must not fall below 0.17 ampere, and should not exceed 0.25 ampere. The battery at the S.M.E. is composed of 28 Leclanché cells, and the total resistance of the circuit is 167 ohms, made up as follows :—

	ohms.
Brompton Barracks relay	16
Workshops clock	18
St. Mary's Square clock	40
8 Impulse clocks at 3 ohms each	24
Master Clock	25
Warning bell	4
Line resistance	40
Total	167

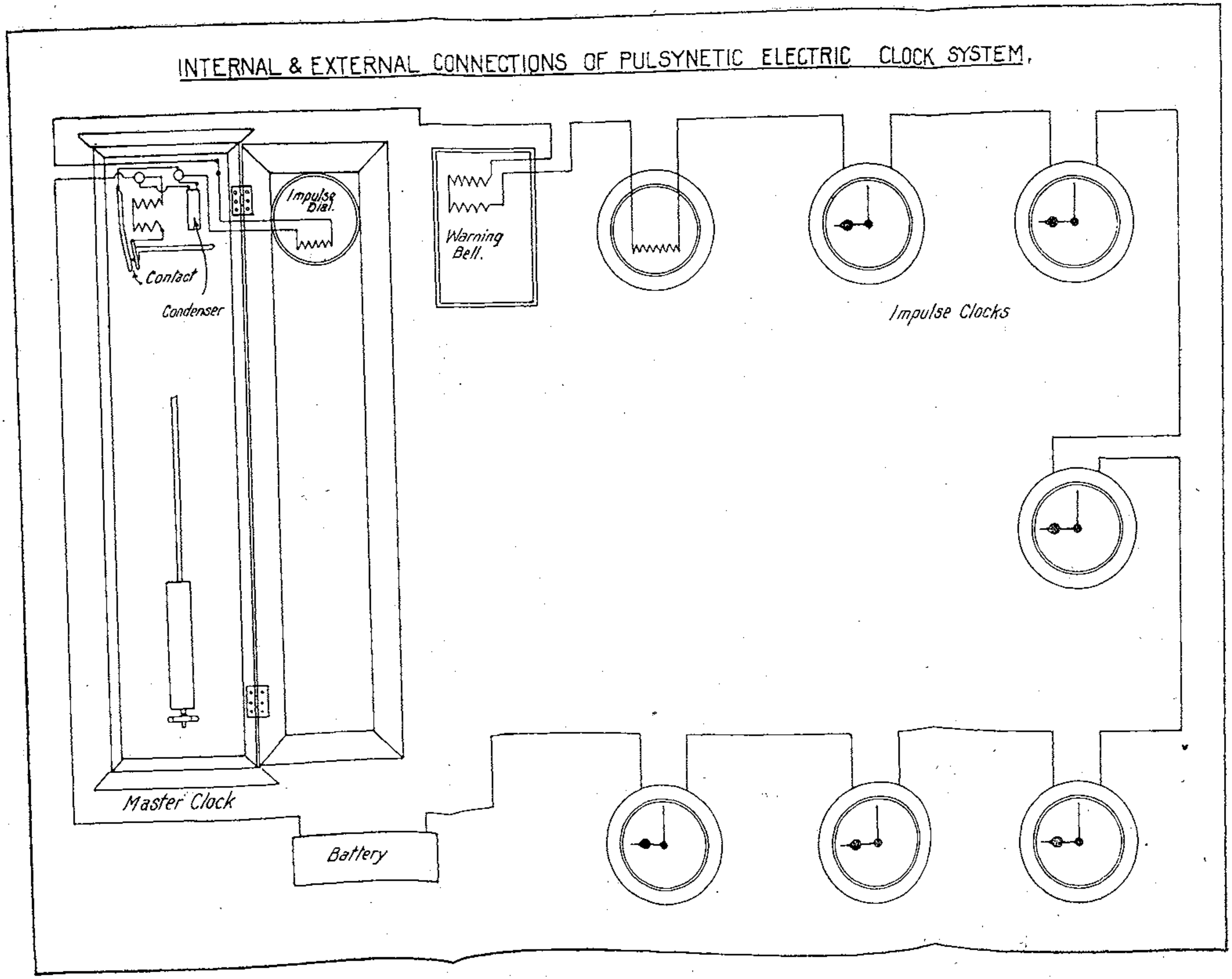
From the date of installation up to June, 1925 (over 4 years), there have been six occasions of complete breakdown; four of these were caused by breaks in the line wires (two occurring in the abnormally high gales experienced throughout the country in December, 1924), and the other two by accidents to portions of the indoor wiring. In addition to the foregoing, a mysterious fault which causes all clocks, except that at Brompton Square with the "waiting train" movement, suddenly to gain from 5 to 10 minutes, has occurred during the winter months each year, and always at night. It is obvious from the results that the master clock must have been giving additional impulses, for such interim impulses would necessarily be ignored by the "waiting train" movement, but the cause has not yet been discovered. The logical conclusion is the presence of an intermittent line fault of moderately high resistance which appears only during the colder hours, causing the line current to fall sufficiently to prevent the re-setting of the gravity arm of the Master Clock, although not enough to affect the action of the impulse clocks.

Too much attention cannot be paid to the careful planning and selection of the aerial route, and when insulated wire is used, particular care should be taken to avoid long spans and exposed positions, as both the weight of the wire and the wind pressure are increased very considerably more than the mechanical strength of the wire.

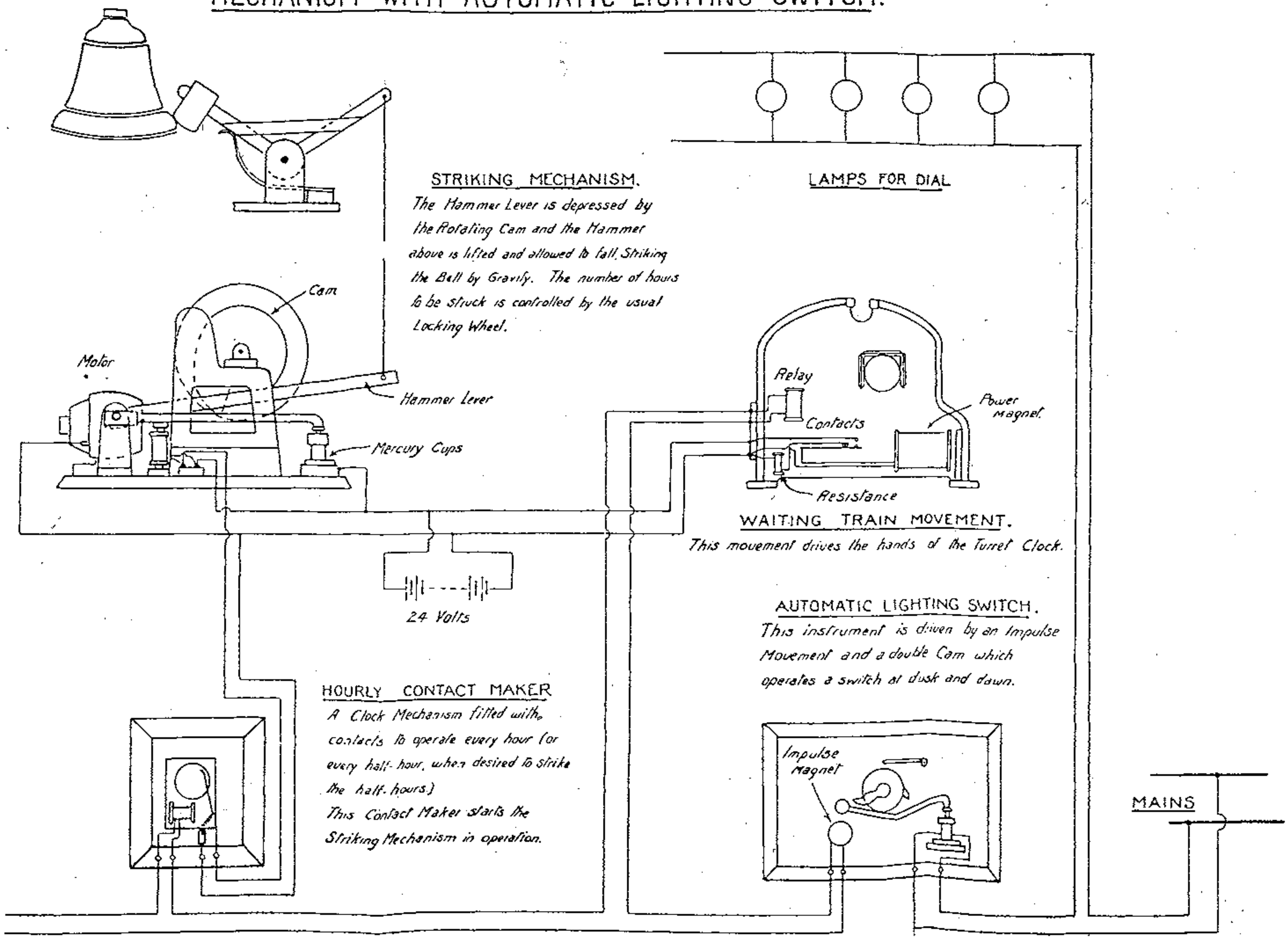
As regards time keeping, the accuracy of the master clock is all that can be desired for all practical purposes. The regulation of the master clock is an extremely simple matter. It is done by adding or subtracting small weights to the pendulum, or by giving a fraction of a turn to the main bob. Temperature appears to make no material difference, as the pendulum is compensated, and it is easy to ensure that the error shall not exceed a second a day.

The author wishes to thank Messrs. Gent and Co. for their kindness in permitting the publication of the diagrams and for the use of their blocks.

Note.—Since this article was written the clocks from the Great Lines Hutments have been moved to the Lower Barracks, Chatham. The aerial line from the C.R.E.'s Office to the Lower Barracks is 40-lb. bronze wire on the telephone poles, and has given no trouble.


INTERNAL & EXTERNAL CONNECTIONS OF PULSYNETIC ELECTRIC CLOCK SYSTEM.
Impulse Dial.
Contact
Condenser
Warning Bell.
Impulse Clocks
Master Clock
Battery

DIAGRAMMATIC ARRANGEMENT AND CONNECTIONS OF WAITING TRAIN CLOCK AND STRIKING MECHANISM WITH AUTOMATIC LIGHTING SWITCH.



TANK OBSTACLES.

By CAPTAIN H. P. W. HUTSON, D.S.O., O.B.E., M.C., R.E.

The Tank a real menace.—The tank and its possibilities constitute a very serious problem for the defence. There is real danger that a superior tank attack will over-run the position, and once the tanks have penetrated amongst the Infantry their effect is locally decisive. How is the menace to be met?

Existing anti-tank weapons inadequate.—The means at present available for engaging hostile tanks are:—(*a*) One's own tanks. (*b*) Artillery Fire. (*c*) Aeroplanes.

Probably the tank itself forms the best weapon, but in view of the limited number it is more than doubtful if sufficient could be spared for the purpose. Certainly, in the opening stages of a campaign, the bulk would have to be retained in reserve for use at the decisive point.

This same difficulty—inadequacy of numbers—arises when the employment of artillery for anti-tank work is considered. Even if we take the field with batteries organised on a six-gun basis, the general opinion is that the army would be under-gunned. To tie up field guns in silent positions, such as successful anti-tank defence demands, would diminish still further the numbers available for their chief function of dealing with the opposing infantry and artillery. Moreover, the question of providing a suitable weapon for anti-tank work is still to be solved. The 3.7 inch howitzer was designed to meet the combined requirements of close support and anti-tank defence. Like most attempts at a compromise the result has failed to give entire satisfaction in either rôle.

We know little about the possibilities of air attack against tanks. It may be assumed, however, that such employment would necessitate low flying and a consequent high proportion of casualties to the aircraft. The normal allotment of army co-operation machines would probably be three squadrons to a Corps of three Divisions. This is not a large number when the reconnaissance and artillery observation duties required are considered. Consequently, any extensive use of this arm for anti-tank defence may be regarded as improbable.

Increase in anti-tank weapons unlikely.—The present urgent necessity for economy throughout all Services and Departments renders any material increase of our anti-tank armament unlikely in the near future. It is true that the Infantry are asking for an anti-tank weapon for themselves. But, apart from the question of expense, it would seem unwise to add further to the battalion's load. It already has as much as it can cope with efficiently and any additional weapon would hamper it and lessen its mobility. Further, it must not be forgotten that tank design is still in the embryonic stage. Hence, changes are likely to be both rapid and far reaching. There is no guarantee that a weapon of the heavy machine gun type, capable of piercing the armour of the present light tank, would be able to engage future models, which we may expect to see more heavily armoured and proof against any weapon manned by infantry personnel. As things are at present, we must recognise that the armament of the army is insufficient by itself to ensure adequate protection against tanks along the whole of a normal front.

Essential to restrict tank approaches.—If, then, the defence is to be able to beat off a tank attack, the approaches open to the enemy tanks must be so restricted that the defenders' weapons can cope with the situation. The cross-country powers of the tank are by no means unlimited. With improved design, increased ability to negotiate obstacles may be expected, but for some time to come there will be many features, natural and artificial, which it can either not cross at all or at which its speed is so decreased that the weapons of the defence will have time to engage it effectively. The problem for the defenders is to so select their positions that they include areas unsuitable for enemy tank movement, and, where such areas are inadequate, to supplement them by artificial means.

Natural obstacles often available.—There will be few theatres of war from which natural tank obstacles will be absent altogether. In most parts of Europe such features are numerous. Woods, rivers, swamps and villages are common objects of the country side, and will usually be impassable for tanks except by defined passages. Elsewhere steep-sided ravines, boulder strewn *nalas* or rocky outcrops may provide what is wanted. Mountainous districts will always limit the tank's possibilities.

Of course, it will be impossible to confine operations to such localities as these, but they occur generally throughout the world and wherever feasible should be utilised to narrow down the possible approaches to a position.

Artificial obstacles required to supplement.—It will seldom be the case, however, that the natural obstacles are sufficient by themselves. Whilst one flank of a position may be in close country passable by tanks along a limited number of tracks only, the other may be in open down land traversable anywhere. Obviously the exposed portion of the line requires some form of artificial obstacle. To what extent and in what form can this be provided?

In permanent defences cost is usually the chief concern, and questions of time, labour and materials are of secondary importance.

Mechanical equipment, too, will be available, permitting extensive excavation and massive construction. Consequently large and elaborate obstacles are possible.

But in mobile warfare conditions are very different. Time will nearly always be the deciding factor, and the supply of labour and tools will be strictly limited. There can be no question of steel or concrete structures. The obstacles will have to be made with such materials as exist on the site or can be brought there with a minimum of transport. Practically, therefore, field obstacles are limited to two types:—(i) earthworks; (ii) mines.

Earthworks usually impracticable.—Earthworks possess the great advantage that no materials are required for their construction. But their drawbacks and limitations are obvious, and were well illustrated at some recent tests. A series of ditches, trenches and craters (see Plate A) were prepared and heavy and light tanks were driven over them. The designs embodied the latest views on this form of tank obstacle, but their efficacy as such can only be described as disappointing. Not one presented the slightest difficulty to heavy tanks of the type used at the end of the Great War. With the exception of the Grid and the Shelled Area they did, however, constitute a serious hold-up for the light tank, and the tests shewed that the Four Foot Ditch is an obstacle which may be relied upon to stop this type of tank. But the light Tank is by no means the final word in tank design. In many respects it is only a glorified armoured car, and future developments will certainly lead to the production of a model with greater power of surmounting obstacles.

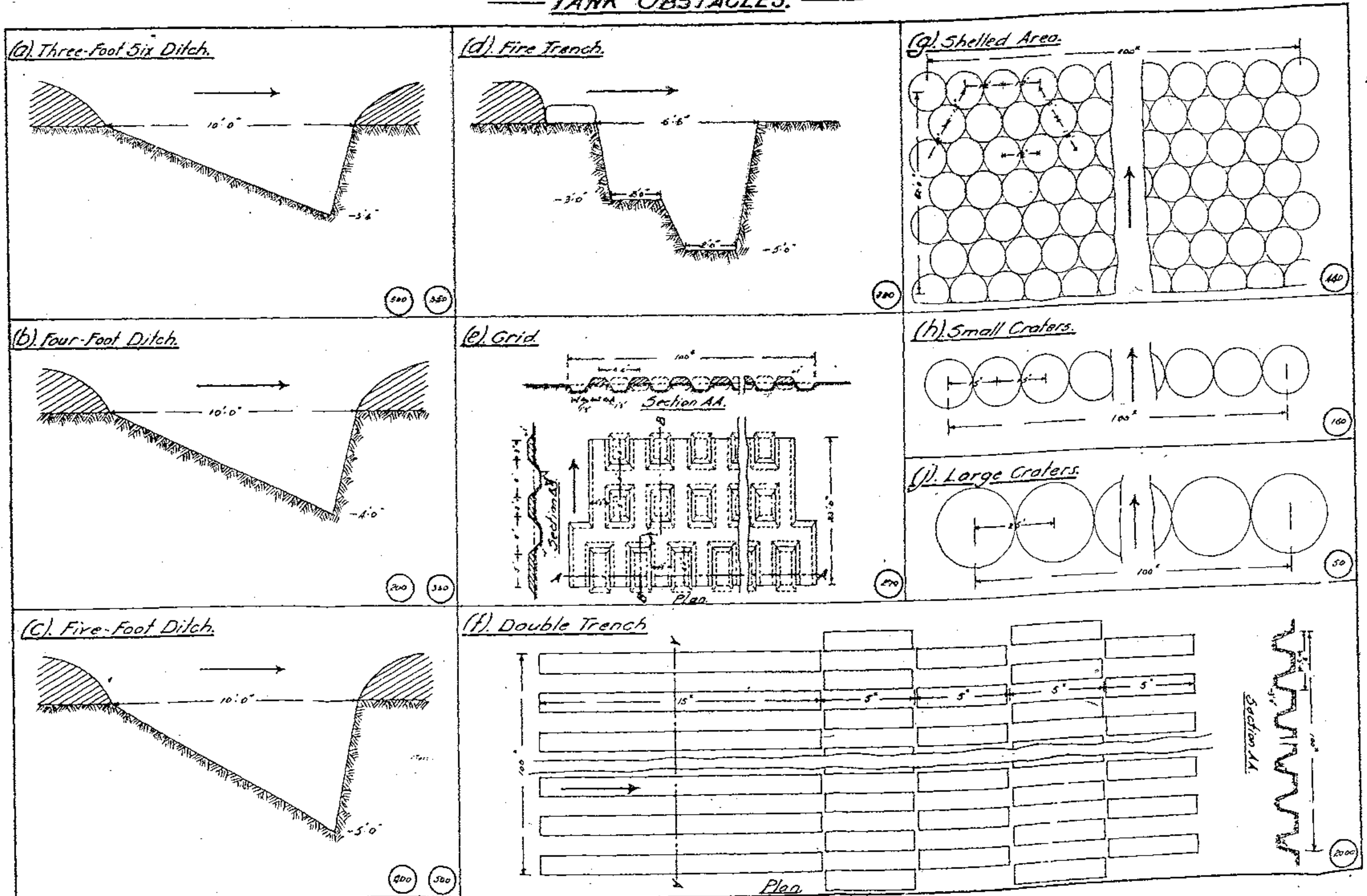
Yet though this was the only type of tank which the earthworks under test were capable of stopping, the labour involved in the construction of even the four-foot ditch would make its general employment impossible. It was found that from 190 to 330 man-hours were required to dig a hundred yards of this ditch, according as the soil was sand or gravel. Now, take the case of a brigade group which has been given a 3,000-yard sector of a position and told that it has four hours in which to complete all defensive arrangements. What men are likely to be available for digging tank ditches? Probably none, but for the purposes of illustration we will assume that a working party of 500 is found from the battalion in reserve. Such a party could, in the four hours available and under the most favourable conditions of soil, dig 1,000 yards of ditch, but for average soils 600 yards would be a fair figure. At first sight this does not seem an inconsiderable length for a 3,000 yard front, but the assumptions upon which it is based are not likely to be realized in war. The 500-strong working party would in all probability be about half that number, and in addition the men would almost certainly be tired. If we take 200 yards as the maximum length of this type of tank obstacle which a brigade group will be able to construct on its front, we shall be nearer the mark for conditions of moving warfare. Consequently, even when the enemy is equipped only with light tanks, the time and labour necessary adequately to protect the front with tank ditches is so prohibitive that this form of obstacle will seldom be feasible during mobile operations. When positions are prepared some time in advance, the time and labour factors will be of less importance and the construction of these obstacles may be possible. But the difficulty of concealing them, both during and after construction, must militate greatly against their efficiency. It will never be practicable to cover the whole front with a continuous obstacle, and if the attacker knows beforehand what portions have been protected he can make his preparations accordingly. We may conclude, therefore, that whilst on occasions earthworks may be usefully employed, they do not provide a tank obstacle capable of general employment in the field.

Mines offer a better solution.—What is the situation as regards mines? The *Manual of Field Works* (*All Arms*) states that mine-laying is a dangerous operation and should be carried out by experts; also that careful records should be kept of the positions of all mines laid. If this is to apply to the tank mine its usefulness will be severely limited. The essential factor of a good tank obstacle is suitability for rapid construction or placing. Laying by experts and careful records do not make for speed. What is required is a small portable mine, weighing about ten pounds, and possessing a simple safety device secure against rough handling. Only a shovel should be needed for placing it, and once laid the mine should be so selective that the weight of a man will not set it off. These considerations should not be impossible of fulfilment. The mine would achieve its purpose if it destroyed the tracks of the tank and so rendered it immobile. A comparatively small charge should ensure this. Safety could be obtained by some form of pin to be withdrawn after the mine is in position. It is only as regards its selectivity that there is likely to be much difficulty. Possibly we shall have to be content if safety against discharge by a man's weight is provided for and risk the possibility of horses or transport firing it. If, then, a mine of this type is produced, and there is no apparent reason why this should not be done, it will certainly form the best, and probably the only really satisfactory, form of tank obstacle. The labour in laying will be small. So will the time, and eventually this may be quickened still more by some device by which the mines are laid by cross-country vehicles. Moreover, the minefield will be inconspicuous, and thus constitute a menace which the attackers cannot foresee, and therefore cannot avoid except by chance.

Should be carried by Divisional R.E.—Assuming, therefore, that a suitable mine can be designed and will be adopted as the standard

PLATE A.

TANK OBSTACLES.



Notes:–

DIRECTION of Tank Attack shewn thus ⟶

Obstacles (a)-(d) were each dug on the LEVEL, on a DOWN slope and on an UP slope (Gradients from 1/3 to 1/5).

Approximate MAN-HOURS to construct 100 yards run of each obstacle, shewn (330); these times are for work in sand or sand and gravel.

The HEAVY Tanks crossed ALL the obstacles without difficulty.

The LIGHT Tank crossed:–
(a) Level and Downhill,
(b) Downhill,
(d) Level and Downhill,
(e), (f), (g), (h) and (j) but failed at the others.

tank obstacle, the question arises as to who is to carry the mines. Though these are not for handling by experts only and can be laid by any troops, it is desirable that " mines " should be the responsibility of one arm. Then the normal procedure would be for this arm to lay the mines, but where necessary to issue to other arms to lay themselves. Such an arrangement would ensure a more economical use of the mines than if they were distributed generally, and would tend to more rapid progress in the methods of mine construction and laying.

The infantry are already overburdened. It would be unwise to hamper them still further. Either the tanks themselves or the Divisional R.E. could better undertake the work. The tank battalions are Corps troops and a division may or may not have tanks allotted to it, but it will certainly ask for mines. If these were carried by the tank battalions it would mean the detachment of their mine carriers throughout the Corps, which is not desirable. Further, it might be essential to lay the mines without advertising their position by the presence of a tank. This would imply that the tank battalion was used merely to transport the mines, as their personnel would only be sufficient to lay the field if the tank could bring the mines to the site.

A better solution would be to make the Divisional R.E. responsible. Some of them would be with practically every detachment the division may make, and will, therefore, always be available. The work is of a type for which they are trained and they have personnel for laying.

Additional transport will be needed to carry the mines. This would be necessary whatever unit was responsible. Where the requirements of secrecy do not prevent it, the actual work of laying would be much quickened if the mine carrier could move over the ground where mines are being laid. This points to a track vehicle of some description. The present transport of the Field Companies is H.T. and the introduction of M.T. would complicate matters. But it is difficult to see how this can be avoided. The trend of transport developments is towards complete mechanicalisation. But the process is one of gradual evolution, and until it is finished the difficulties of mixed transport must be accepted. Presumably the mechanicalisation of Field Companies will be more or less concurrent with that of the infantry, and then the use of a cross-country M.T. vehicle as mine carrier is clearly indicated. For the present we must make the best of what exists. If we use H.T. to avoid mixing the types of vehicles, the resulting effects upon the speed of mine laying must be recognised. If we accept the disadvantages of mixed transport the cross-country M.T. vehicles will enable mine fields to be laid more rapidly.

PROFESSIONAL NOTE.

RAISING WATER FROM DEEP WELLS.

The known methods of raising water from deep wells and bore-holes are described in *M.M.E., Volume VI, Water Supply.*

The Plate shews in rather greater detail how an electric sinking pump equipment might be used with the P.E. Lorry. Outline designs for two sizes of pumps have been prepared by Messrs. Allens of Bedford as follows:

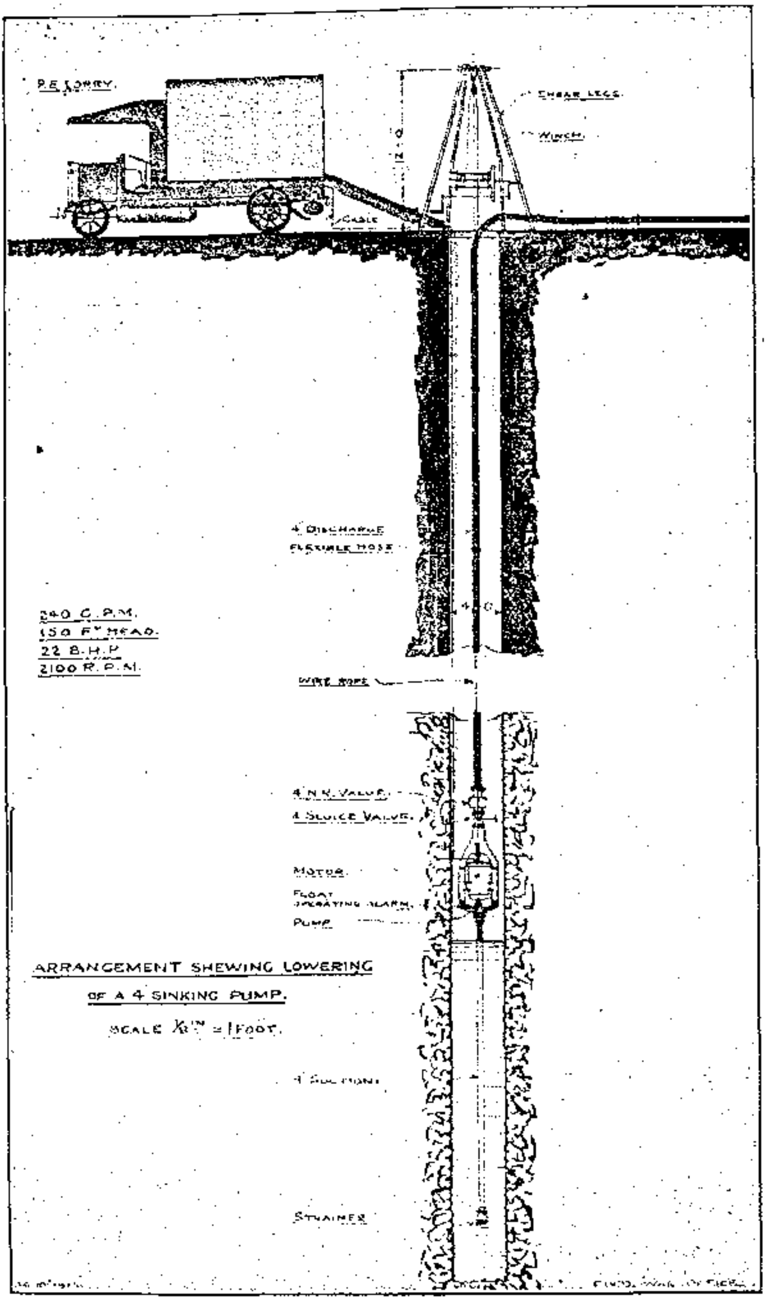
(*a*) ITEM 1. One 5½" "Conqueror" vertical deep well pump with cast iron pump casing, bronze impeller and steel shaft fitted with renewable bronze sleeves.
20 ft. of 5½" Armoured Suction Hose with gunmetal strainer.
Cast iron Pipe Framework and pulley.
One 5½" Sluice Valve.
One 5½" Non-return Valve.
One "Allen" 40 h.p. 110 v., 1800 r.p.m. semi-enclosed drip-proof, vertical motor.
One drum type starter complete with Ammeter.
One alarm float.
Capacity—500 g.p.m. against a total head of 150 ft.

Total price	£465 Stg. nett.
Extra price if pump casing of bronze	£24 Stg. nett.
Extra price if pump motor submersible	£140 Stg. nett.

(*b*) ITEM 2. One 4" "Conqueror" deep well pump with cast iron pump casing, bronze impeller and steel shaft fitted with renewable bronze sleeves.
20 ft. of 4" armoured suction hose with gunmetal strainer.
Cast iron pipe framework and pulley.
One 4" sluice valve.
One 4" non-return valve.
One "Allen" 22 h.p. 110 v., 2100 r.p.m., semi-closed. drip-proof, vertical motor.
One drum type starter complete with Ammeter.
One alarm float.
Capacity—240 g.p.m. against a total head of 150 ft.

Total price	£375 Stg. nett.
Extra price if pump casing of bronze	£18 Stg. nett.
Extra price if pump motor submersible	£80 Stg. nett.

RAISING WATER FROM DEEP WELLS.



ARRANGEMENT SHEWING LOWERING OF A 4" SINKING PUMP.

SCALE $\frac{1}{8}$ IN = 1 FOOT.

Installation would be effected in the field as follows:

Lorry containing gear drives up to well head, wooden skids, shear legs and winch are rigged, pump unit is slid down skids and lift taken by shear legs, pump suction connected, pump lowered down well, rising main being added as necessary and electric cable connected and paid out, lowering ceases on electric float working, pump started.

The arrangement seems to possess advantages for raising comparatively large quantities of water in a hurry in the field. It would have been of inestimable value for Sucrerie wells in France, but although specified and demanded such equipments were never forthcoming.

The advantages of this gear may be explained by stating the impossibility of using other types under certain conditions.

(*a*) CARUELLE OR BELT ELEVATORS.
Cannot be used if there is much obstruction in the well, e.g., effects of demolition.

(*b*) AIR LIFT.
Not enough submersion is available.

(*c*) DEEP WELL OR BORE-HOLE PUMPS.
Not enough time to install or get barrels up for repair.

(*d*) ELECTRIC PUMP OF HORIZONTAL PATTERN FIXED AT BOTTOM.
Not enough room and time to install.

The arrangement shewn on the plate has the very definite advantage in that it can follow the water level. It would also be of value for deepening or aditing wells in peace or war.

H.S.B.

MEMOIRS.

THE LATE SIR MONTAGU OMMANNEY.

As the oldest friend and contemporary of the late Sir Montagu Frederick Ommanney, I have been asked to add a few personal notes to the Memoir of him published in the December issue of the *R.E. Journal.* Sir Montagu was educated for some 4 years at a school in Boulogne prior to joining Cheltenham College, whence, in July, 1861, he passed into Woolwich at the age of 19 as 45th out of 247 candidates. But for his weakness in mathematics he would have taken a much higher place, both on entering and leaving the R.M.A.

In French, he took a very high place, scoring a percentage of 87.4 of the possible marks obtainable, but it was as a draftsman that he excelled all his competitors, gaining the drawing prize on leaving Woolwich in December, 1863, as 13th Sapper out of a batch of 63 cadets. At Chatham his recreations were yachting and boating and he rowed in our "batch four," which greatly distinguished itself on the Medway. On leaving the S.M.E. in 1866, where he was the first recipient of the "Fowke" medal, he was selected, on account of his great ability as a draftsman, for special duty at the War Office and Admiralty. For the same reason he was again selected in 1871 for the post of Instructor of Topography at the R.M.A. In 1874 Lord Carnarvon, the Secretary of State for the Colonies, being on the look out for a private secretary, asked Colonel H. Y. D. Scott, R.E., if he happened to know of any young R.E. officer likely to be suitable. Colonel Scott at once named Lieut. Ommanney, with the result that the post was offered to and accepted by him, thus transferring him to an entirely new sphere of work.

That Ommanney succeeded in gaining his new chief's confidence is shown by the fact that when Lord Carnarvon vacated the Colonial Office in 1877, he appointed him as 3rd Crown Agent in the Crown Agents' Office, where he remained for the next 13 years, until Mr. Joseph Chamberlain offered him the onerous and responsible post of Permanent Colonial Under-Secretary of State.

Sir Montagu was most unwilling to accept the offer and represented that at his age (58) he was much too old to undertake fresh work of such magnitude, and strongly urged that a younger man should be selected.

Mr. Chamberlain, however, would not listen to these arguments and replied that he considered himself a much better judge of what was needed than anyone else could be and insisted on compliance with his wishes.

For the next seven years Sir Montagu worked practically night and day without intermission; the strain unquestionably telling on him and seriously weakening his magnificent constitution. He retired in 1907 at the age of 65, a man worn out in the service of the State. He subsequently devoted himself to sketching, carpentering and gardening, in all of which he excelled.

In an appreciation of Sir Montagu in the *United Empire*, Sir Charles Lucas records that "he was an excellent man of business and combined great business capacity with good temper and great kindliness."

This is indeed the keynote to his character.

"Monty," as he was affectionately called by all his contemporaries and intimates, was never known to lose his temper; whilst he would always go out of his way to do a kindly action or a good turn to anyone. He was beloved by his school mates and his contemporaries at Woolwich and Chatham, whilst his subsequent career shews that he invariably gained the confidence and affection of his chiefs and of all those with whom he was thrown in contact.

As Doyen of the Kings-at-Arms, he was noted for his courtly bearing and his intimate knowledge of all matters of detail of their somewhat intricate procedure. It was with the deepest regret that failing health at length compelled him to resign his connection with the business of the Order of "St. Michael and St. George," with which he had been so long and honourably associated.

Many indeed are the paths of distinction open to Officers of the Royal Engineers, but it is rarely that these lead to such specially distinguished work in the Civil Service as fell to the lot of our old friend "Monty."

He seized the opening when it offered and left a record of which our Corps may well be proud. His services were rewarded by the G.C.M.G., the K.C.B., and the I.S.O., but what I think he loved best was the feeling that he had not an enemy in the world, and that all those who knew him held for him the deepest affection and esteem.

J.W.O.

COLONEL A. R. REYNOLDS.

The initials of Colonel Arthur Reynold Reynolds, who died suddenly at Wimbledon on the 16th September, 1925, will be familiar to the readers of the *Royal Engineers Journal* as those of the very able reviewer, for many years, of the *Revue Militaire Générale* and the *Revue Militaire Française*, whose last contribution appears in the present number of our Journal. Colonel Reynolds was born in 1864 and educated at Lancing College and Brakenbury's. He entered the R.M.A. in 1882 and was commissioned in the Corps in

1884. He served in many stations at home and abroad, including India, where his chief work was the Bangalore water supply. In 1900-1901 he took part in the Boxer Expedition in China and received the medal. Promoted Colonel in 1913, at the outbreak of the Great War he was under orders to proceed to Malta as Chief Engineer, but his orders were cancelled and he was eventually sent to Salonica, where he served in 1915 and 1916. He was afterwards employed at Plymouth until the end of the war and then retired. The Editor desires to pay a grateful tribute to a colleague whose kindly consideration and long-suffering courtesy will always remain a pleasant remembrance.

F.E.G.S.

BOOKS.

HISTORICAL ILLUSTRATIONS TO FIELD SERVICE REGULATIONS (Vol. II).

By BT. MAJOR H. G. EADY, M.C., *p.s.c.*, R.E. (Sifton Praed and Co.) Price 10/6.

Major Eady has compiled a reference book of not too forbidding proportions—which will be of value to all military students, and not only to those young officers who are starting on the study of Military History.

In his preface, he says, "The main difficulty to most people seems to be to know what to read, where to look for a particular type of campaign, battle, or incident, and how to apply the illustration to the manual concerned. This book . . . . . is not intended as a crammer's 'potted history' for the purpose of passing examinations. It is hoped, on the contrary, that by seeing examples from all periods of history, the reader may become interested in the study of the evolution of war as a whole rather in that of a single campaign for examination purposes, and that in this study he may be able to evolve a logical process of thinking as to the future."

The author has read widely, and has had experience in trying to instil into others the knowledge he has gained. He has the gift of being able to condense into a few lines the essence of the examples he has selected for illustration. In some instances, perhaps, he is too brief, due, no doubt, to the limitations he has set upon himself with a view to keeping the book to a reasonable size. It is to be hoped that Major Eady will be encouraged to produce a second edition, and find space to elaborate some of the references. He has done well in recommending his readers to such volumes as Callwell's *Small Wars*, Villiers Stuart's *North West Frontier Fighting*, and the official *Operations in Waziristan*, 1919-1920, if they wish to study "Warfare in undeveloped and semi-civilized countries," and he has therefore omitted all further reference to this subject.

As a case in point, it is not much help (vide p. 89) to say regarding the "Position of Reserves"—"Again note the difficulties of the Allies as a result of the faulty dispositions of the French reserves at the outbreak of war (1914.)" The young officer will not be able to dig out the information for himself: it would be a task of some difficulty even to the experienced student. There are a good many examples of this assumption of knowledge on the part of a reader, and the book would have a greater value if the author always gave the gist of the situation, or a definite reference to some book from which the information can be obtained.

In another illustration, Major Eady has given a certain amount of useful information, but not enough to satisfy a thinking reader. On p. 144 he quotes Callwell's *Small Wars* to illustrate "Disasters due to lack of outpost precautions." Referring to the disasters to small isolated British columns in the latter part of the South African War, Callwell rightly attributes them to the failure of the outposts. It would help the student if Major Eady explained in what way they failed, and suggested the remedy. One of the most successful British Commanders of irregulars in the war—General Rimington—made it a rule never to camp two nights in the same place if there was any likelihood of Boer Commandos being in the neighbourhood. He was fully aware of the shortcomings of irregular troops in outpost work, and never risked surprise. At dusk he moved his column to another previously reconnoitred camp, in some cases only a mile or two away. At first there was much grousing at leaving a comfortable camp to move, generally in the opposite direction to which he would appear to leave the camp if observed, only a mile. But the men soon realized that it was worth it, and it became second nature to them to apply the same principle to their own outpost pickets. The Boers never attempted a serious attack on a halted column unless they had been able to reconnoitre thoroughly in daylight. The disaster to a small yeomanry column in the Harrismith district in December, 1901, was due to its remaining stationary for several days. The Boers were able to reconnoitre it at leisure, and made a night attack on what to all appearances was the safest side of the position, overpowered the picket and got into the middle of the camp before their presence was even suspected.

A concrete example like this would never be forgotten even by one who had not had experience of active service.

There is a note on p. 127 which requires a little further explanation. Major Eady says :—" Note the danger of being caught in march formation, as exemplified by the Battle of Magersfontein." The reader might be inclined to regard this as merely a warning not to risk being caught in march formation. The Highland Brigade at Magersfontein had made its approach march *by night*, and was late in deploying. The incident is more applicable to "Night Operations," p. 208, under the heading, "A night advance and an attack before dawn."

On p. 160 speaking of objectives, Major Eady limits himself to saying: "How many of the battles in the Great War became struggles for some dominating feature," and he gives a list. But he gives no reasons why the struggle centred on these features. The main objects of both sides were generally to obtain artillery observation and cover from view for the reserves. It was not always a case of "Here is a tactical feature! It must be captured." The Germans, especially at the beginning of the

War, were much quicker than we were in recognising such features and were allowed only too often to retain them. Even when they failed to capture them in a general attack they soon realised their importance and were not satisfied till they had captured them. Gradually, we and the French learnt our lesson, and this resulted in the desperate struggles he mentions. He might in this connection have mentioned an occasion on which it was decided that a tactical feature must be surrendered, *e.g.*, General Byng's decision to withdraw from the high ground about Monchy-le-Preux in order to shorten his line during the German offensive in 1918. He had the courage to do this, although he knew well what it meant—loss of observation and the whole slope to Arras in full view of the enemy.

The comparison of the German strategical plan in 1914 (pp. 164, 165) with the manœuvre of Alexander at the Battle of Arbela in 331 B.C. is rather far fetched. It might tend to confuse the young student, struggling with the definitions of tactics and of strategy, and further, the manœuvre of Alexander was only possible in the absence of artillery. Arbela would be a good example to quote for the study of the evolution of tactics in view of modern developments.

In any future edition the Chapter on "Information and Reconnaissance" might with advantage be enlarged. So little is printed on the subject of Information and Intelligence that the student is hard put to it to know where to study the subject. For instance, on page 101 no mention is made about leakage of information from the use of telephones, and the elaborate arrangements for overhearing and countering. The Germans were first in the field, but as usual we probably bested them in the end.

The subject of fighting by the map and not by the ground might be mentioned in this chapter. Two glaring instances recall themselves to mind—the existence, or non-existence, of "Greenland Hill," north of the R. Scarpe in the fighting in front of Arras during the last ten days of April, 1917; and a similar inaccuracy in the formation of the ground as shown by the map which led to several unsuccessful attacks south of Arras, north of the Bois du Vert and "Hook Trench," in May, 1917. In both cases it was a long time before it was realized that the contouring of our maps was wrong.

The importance of forwarding captured documents *immediately* to higher authority was exemplified in the case of "Greenland Hill." A German map, taken from the same source as our map, but corrected, was taken off a prisoner by a medical orderly and kept by him for two days. In the meantime another attack had been made by our troops, again without success. Had the information been available earlier heavy losses would have been avoided, and the probability is that the attack would have been successful, as it actually was in the other case when the true configuration of the ground had been realized by personal reconnaissance.

The more one dips into the book, the more is one tempted to read up the detailed accounts of the incidents referred to. That is the intention of the author, who is to be congratulated on achieving the object with which he set out on his work.

A useful list of reference books is included. It is not quite complete even for the young student, and a notable omission is Wood's and Edmond's joint history of *The Civil War in the United States*, 1861-5, a standard work on that campaign.

The maps, always a difficulty because of the effect on the price of the volume, are adequate, but it would facilitate reference if those in the pocket were each numbered *on the outside* when folded. The paper might also be a tougher quality.

It is to be regretted that there is no index. Even an index on the headings of *F.S.R. Vol. II*, with references to the pages of the book on which they are discussed would be useful, because Major Eady's work is one which the student will constantly have to refer to.

H.B-W.

AN ACCOUNT OF THE BATTLE OF LIAO-YANG.

By Major-General Sir W. D. Bird, K.B.E., C.B., C.M.G., D.S.O. (Gale and Polden.) 3s. 6d.

This little book has been produced for examination purposes, and will prove of very great value to those working for promotion examinations or the Staff College. The operations of the two rival forces are dealt with separately. In this way the author presents a very fair view of the situation as it appeared to the opposing commanders at various times during the battle. Essential details of topography, strength of armies, moral factors, are all given, and the courses open to the commanders fully considered. In discussing alternative plans frequent references are made to *Field Service Regulations*, and the principles laid down in those regulations form the basis of suggested plans, and of the criticism of the action taken. The various situations as they presented themselves to the commanders at the time are illustrated by ten sketch maps, which have the great merit of shewing fairly well what is essential, and leaving out superfluous detail. The elimination of topographical detail may, perhaps, have been a little overdone, but no one will be sorry that the author has reduced the difficult place names to a minimum. Read in conjunction with the author's earlier strategical study of the whole war, the book may be confidently recommended to all students of military history, especially those preparing for examinations.

About 50 questions on the application of *F.S.R.* to the events of the battle are added, and the student is left to work out solutions for himself.

R.P.P-W.

LETTERS OF A ONCE PUNJAB FRONTIER FORCE OFFICER.

By Colonel J. P. Villiers-Stuart, C.B., D.S.O., O.B.E. (Sifton Praed.) Price 5s.

This eminently readable little book is in the form of a series of letters from an uncle to his nephew, who, writing from the great frontier town of England, has asked to be told all about fighting on the North West Frontier of India.

The nephew is fortunate in his parent's brother, as few people know more about the subject than Colonel Villiers-Stuart, formerly an officer of one of the most distinguished "Piffer" regiments, Coke's Rifles.

The first letter deals with the characteristics of the Pathan, the nature of the country he inhabits and the distribution of the various Afghan and Frontier tribes. Our control of the inhabitants of the Independent Territory which forms an ineffectual buffer between Afghanistan and British India is discussed. Our influence is at present exerted in a minor degree through the personality of Political Officers and in a greater degree through the grant of periodical subsidies.

The difficulties of extending our frontier up to the Durand Line are represented. There are some 500 miles of it, practically roadless, and the cost of making frontier roads is enormous.

The alternative policy, of withdrawing to the Indus and abandoning of all the British subjects to the west of it, who look to us for protection, is dismissed as unthinkable. Yet such a step has been advocated by at least one popular daily paper.

The two standing menaces to peace on the frontier are from the Independent Tribes and Afghanistan.

Danger from the former increases as the power of combination grows. In the old days we seldom had more than one sub-tribe to deal with at a time, but now conflict with one sub-tribe may entail hostilities against the whole tribe.

Afghanistan is a small country of about five million inhabitants, yet past history shows that war against it is not to be undertaken lightly. The first Afghan War was a military disaster relieved by one ephemeral success at the end, it was also a political failure. The second was a military success qualified by at least one bad defeat and again a political failure. The third was a doubtful military success, and is indeed regarded as a victory by the Afghans, but it had at least one important political result in that a successor to Cavagnari has been established at Kabul.

The forces we may have to face in a war against Afghanistan are the regular army of ten to fifteen thousand men, about one hundred thousand Afghan Irregulars and about one hundred and fifty thousand Independent tribesmen, who can always be counted on to throw in their lot with their co-religionists.

Colonel Villiers-Stuart recommends the study of the history of frontier warfare, and makes frequent reference to *Frontier and Overseas Expeditions from India, Vols. I. and II*, and to *Operations in Waziristan*, 1919-20.

The second letter deals with the conduct of military operations carried out in hill country, and the use of aeroplanes, artillery, machine guns, Lewis guns and tanks is discussed. No mention is made of the possibilities of using gas. In operating against tribesmen we have two objects in view:—To kill as many as possible; and to destroy villages, food and livestock.

The inhabited parts of the frontier are the valleys, and each valley or part of it represents the area occupied by a sub-tribe. The invasion of one valley may attract the assistance of the inhabitants of neighbouring valleys, hence it is often good policy to invade an area by several columns operating along different valleys.

The danger of carrying out an act of military routine, such as setting a picquet, or sending out a reconnaisance party, in the same manner and at the same time day after day is insisted on. Punishment always follows sooner or later.

In the third letter the principles laid down in *F.S.R. II., Chapter XI.*, which have been derived from the concentrated experience of about 80 years of frontier warfare, are dealt with in some detail, and examples are given of the results of their observance and neglect. The great advantages which have sometimes been gained from night operations are described.

The fourth letter deals with "Protection in Movement," and the procedure evolved from years of experience for obtaining flank protection and security in front and rear is fully described.

"Camps and Protection at Rest" form the subject of the fifth letter. A diagram is given of the layout of a typical perimeter camp. Nowadays the site of a camp should, if possible, be in close proximity to an aeroplane landing ground. The questions of the distribution of the various arms in the camp, action in case of attack, camp picquets, etc., are very fully discussed.

Letter No. VI. is headed, "Attack, Defence and Destruction." A peculiarity of hill warfare is the dispersion to which any operating force is necessarily subjected. For example, a force operating from a camp against a distant village must provide picquets for camp protection and picquets for flank protection during the advance and retirement.

In operations against an enemy in the hills dispersion is necessarily entailed by the fact that all advances must be made up spurs, so that an attacking force is split up into small parties separated by ravines.

The most important duty on the line of communication is the protection of convoys. The vulnerability of a convoy depends upon the nature of the transport of which it is composed; it may consist of camels, pack mules, A.T. carts, light or heavy lorries. One three-ton lorry carries about the same load as 17 camels.

Defence on the frontier can only take the form of defence of camps and picquets, "it is impossible to picture taking up a defensive attitude, in the European sense, on the border." The destruction of villages is dealt with in great detail. The advance, covering troops, working parties, method of procedure and subsequent retirement are all fully dealt with.

The last letter is concerned with "Lines of Communication, Stratagems, etc." The lines of communication usually lie in two areas, a strip inside our border and the remainder in enemy country. In the first case the defence usually consists of regular posts with an outwork for transport, the garrison being sufficient to provide for the defence of the post and to furnish transport for convoys as far as the next post. Somewhere on the line there is a mobile force for aggressive operations. But in the hill country beyond our border, defence of convoys becomes much harder. The camps used by the striking force are adapted to take convoys, and are provided with garrisons sufficiently large to picquet the hills along the route and to provide an escort, there being central reserves at selected points. This method has the disadvantage of leaving the country between the posts open to the enemy during the night and leads to "repetition" and the inevitable regrettable incidents.

A better method is to establish permanent picquets along the route with self-contained garrisons relieved every week or ten days, with central reserves as before.

Aggressive defence, however, is essential, the posts must be made so strong as to enable the garrisons to be reduced to a few men by day, leaving the rest of the men available to take part in small aggressive enterprises in co-operation with the garrisons of neighbouring posts.

Examples are given of the sort of stratagems which the enemy are likely to employ.

The book is illustrated by diagrams and by rather indifferent photographs of examples of the Khaibar, Kurram and Waziristan areas.

Any R.E. Officer whose work lies on the North West Frontier would do well to study this book.

A.H.B.

LES ENGINS D'ACCOMPAGNEMENT EN FRANCE ET A L'ETRANGER.

Par COMMANDANT BISWANG. (Berger-Levrault.) 3f. 50.

THIS book is an attempt to discover what is the weapon which the infantry should have under immediate control in order to overcome resistance which has survived the fire of the artillery and which they cannot subdue with their own arms.

The author proceeds logically to show that a weapon is required over and above the artillery proper and he deduces that this should be the "infantryman's own gun."

He then examines the arms which are available in the French Army to support the infantry, namely, the 37mm. gun and the 81mm. Stokes mortar. Their characteristics and failings are very fully set out so that the succeeding chapter, on their tactical employment, is the easier to follow. The doctrine of this employment is worked out with copious quotations from the manuals. The author divides it into two main parts, the "doctrine de bataillon" and the "doctrine de feu," which he considers to make it imperative that the weapon of the future should be at the disposal of the battalion commander and of sufficient power to be able to deal with any resistance met, including tanks.

The next chapter is devoted to the examination of the infantry support weapons in use, or under test, in Russia, Japan, England, United States, Italy and Germany. Special attention is paid to the two last named. The decision of Italy to use field guns is thought to be unwise. The German plan of using *minenwerfer* is admired, especially that part which lays down that the brigade commander should be able, by keeping some mortars under his own hand, to make his personal influence felt in the fight.

There follows a chapter devoted to the weapons of the future. The author concludes that two are required, (i) a heavy machine-gun, firing an armour piercing bullet for anti-aircraft work, and (ii) a gun-howitzer of at least 65mm. bore. The former he considers essential for defence against the armoured aeroplane. The latter should be a close support and anti-tank weapon for the infantry, very mobile, capable of rapid laying, accurate, powerful, ranging up to 2,500 metres, with 90° traverse, etc. This arm should be manned by artillerymen permanently attached to the infantry battalions. It is suggested that, in order to simplify the supply of ammunition, the bore should be 75mm. like the field gun. It is acknowledged that such a weapon is going to be heavy, and mechanical traction is given as the solution. Experiments are proceeding satisfactorily in France with a view to replacing the Stokes mortar by a more accurate light howitzer, and to adding a 13mm. machine-gun for use against aeroplanes and tanks. The author regrets the complication of having two types of gun with the infantry, viz., the 37mm. gun and the new howitzer.

The book is a thorough examination of the problem from the French point of view ; it is interesting that the necessity for an anti-tank weapon is not stressed, and that the idea of saving casualties to personnel is ever present.

N.W.N-C.

LE MODERNISME AMERICAIN. L'ARMEE. LE MATERIEL.

By Colonel G. Becker. (Berger-Levrault.) 2f. 50.

This book is a reprint of a garrison lecture given at Bordeaux in November, 1924. The author enumerates six lessons from the Great War, and goes on to show how they are being applied in America. The first half of the book deals with the principles followed in the organisation of the Army, the second half with the design of new weapons and material. This part of the lecture was obviously out of date as soon as it was delivered, and seems hardly worth producing in book form.

The author insists that the Army must be fashioned in the likeness of the Nation. The severe test of war strained to breaking point the relations between the aristocratic German army and the partially democratic German people.

The conditions of a future war are likely to apply a still more severe test. From the very outset the nation will be attacked directly, and not indirectly through its armed forces, as heretofore. To the increased strain of modern battle will be added in the soldier's mind the anxiety as to what is happening to his family at home.

Is our army in close touch with the nation ? If not, how can the relation be improved ? Any advance will have to come from the army, as the nation sees no necessity for it. The onus for making the advance appears to lie on the officer.

Another lesson of the Great War is that the industrial mobilisation is just as important as the military mobilisation. America is extremely favourably situated in this respect. Except for a war with Mexico, for which her regular army should suffice, she would almost certainly have time to mobilise efficiently before embarking on military operations. Moreover, she can raise an army of four million men without calling upon more than one twenty-fifth of her population. Thus, for her, the difficulty of adjusting the military to the industrial mobilisation hardly exists. It is very different for the nations of Europe and one of the most important problems in front of us is to find the correct formula for the most efficient utilisation of our man (and woman) power.

A large part of the second half of the book is taken up by the consideration of the use of gas. The author claims for aerial warfare and chemical warfare the peculiar characteristic that preparation for them does not entail purely non-productive expenditure. One may disagree with his statement that gas is a weapon capable of playing a decisive part but it is difficult not to believe with him that gas will be used. If sufficient people could be convinced of this, our policy with regard to gas might be reconsidered. Education is our first weapon of defence, but we deprive ourselves of its use by pretending the danger does not exist.

E.H.C.

EXPOSE SCHEMATIQUE DU FONCTIONNEMENT DES ARMES DE PETIT CALIBRE.

By CAPTAIN G. H. MULLER. (Berger-Levrault.) 5 fr.

THIS small book contains detailed information of the workings of the various patterns of rifle, light automatic and Hotchkiss machine gun, pistol and revolver, in use in the French Army.

It is intended for the use of Instructors of all grades of classes, from the regimental to the technical expert. The information in the case of each weapon is arranged in identical synoptic, almost tabular, form, the most important points being emphasised in black type. Every operation, feed, closing the bolt, firing and extraction is separately illustrated in very clear line diagrams. The book forms an excellent handbook for the Instructor, who can, without difficulty, extract such detail as may be suitable for his purpose.

The matter is very technical and of little general interest to others than those for whom it is written. It is, however, worth noting that the rates of fire which can be developed by the various weapons are given as follows:—Rifle, 8 to 10 rounds a minute; light automatic, 120 rounds a minute; Hotchkiss machine gun, 250 a minute. The two latter weapons can both be fitted with anti-aircraft sights; these are described in an appendix.

R.L.B.

A PRACTICAL TREATISE ON FOURIER'S THEOREM AND HARMONIC ANALYSIS FOR PHYSICISTS AND ENGINEERS.

By ALBERT EAGLE, B.Sc., A.R.C.Sc., Lecturer in Mathematics in the Victoria University of Manchester. (Longmans Green & Co.) Price 9s.

As some of the readers of the *R.E.J.* may not have heard of Fourier's Theorem, I propose to explain this theorem shortly, following the author as closely as possible.

Such expressions as x^n, $\sin x$, $\log x$, e^x, and others, or a combination of these, are "analytic" or natural functions, whereas "artificial" functions (a new term) are those which are arbitrarily defined as being equal to one analytic function in one part of their range and to another in some other part; there are also "empirical" functions possessing an irregular discontinuous graph. Fourier's theorem states that any periodic function, analytic or artificial, of period 2π can be expressed by the series.

$$f(t)=\frac{A_0}{2}+A_1\cos t+A_2\cos 2t+\text{etc. } ad\ inf.+B_1\sin t+B_2\sin 2t, \text{etc.}$$

$$\text{Where } A_n=\frac{1}{n}\int_0^{2\pi} f(t)\cos nt\,dt \quad B_n=\frac{1}{n}\int_0^{2\pi} f(t)\sin nt\,dt.$$

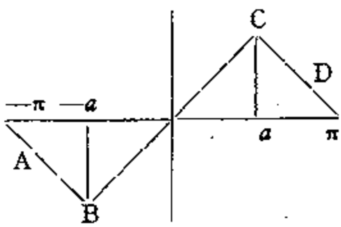
the various terms, such as $A_1\cos t$, $B_1\sin t$, etc., are termed "harmonics," and the process of expressing a defined function by a Fourier series is termed "analysing."

In the treatise under review the author applies Fourier's theorem to the analysis of many artificial functions met with in physics and engineering, for instance, the analysis of an odd function of t represented by

$$f(t)=\frac{bt}{a} \text{ from } t=o \text{ to } t=a \text{ and by } b\,\frac{\pi-t}{\pi-a} \text{ from } t=a \text{ to } t=\pi$$

is given by

$$f(t)=\frac{2b}{a(\pi-a)}\left\{\sin\frac{a}{1^2}\sin t+\frac{\sin 2a}{2^2}\sin 2t\ ad\ inf\right.$$



The true graph of the function as defined is represented by ABCD, whereas that of f(t) would consist of a number of convolutions converging in general shape more and more nearly to the given figure, the greater the number of the terms of the series included in the graph. The treatise concludes with a formal proof of Fourier's theorem and with a chapter explaining how periodicities in observed data, not essentially periodic, are to be searched for.

Fourier's theorem is of great use in many physical and mechanical problems, *e.g.*, in the transmission of pulses along a wire, the flux of heat, the motion of a slide valve actuated by a set of linkages or by a cam, primarily the nature of the problem in such cases is that of the resolution of a motion known to be periodic or of the function which expresses it into its simple harmonic constituents.

Mr. Eagle's treatise is reasonably clear, requires no great knowledge of the Integral Calculus to be understood, and should be of use to physical students.

J. M. WADE, *Lt.-Col.*, B.SC., LONDON.

THE STRENGTH OF MATERIALS.

A treatise on the theory of stress calculations for engineers. By JOHN CASE, M.A. (CANTAB.), F.R.AE.S. (Edwin Arnold and Co.) Price 30s.

CONSIDERING the number of works dealing with stress calculations and Applied Mechanics in all its branches, which are already available, and which, collectively, deal with every aspect of the subject, there would not at first appear to be any place for this new book to fill; but a cursory reading of it provides its author and publishers with ample justification, and a more careful examination deepens the first impression of its great value.

The author has collected within one cover every kind of usual and unusual stress problem likely to be met with in structural and workshop practice, and deals with them in a distinctive fashion.

In a short notice of this nature it is not possible to do more than to point out what appear to be the most noteworthy features of such a comprehensive work, such as the chapters on combined stresses; beams under lateral and longitudinal loads combined; bending combined with torsion and thrust; and stresses on curved beams. Also, there is published for the first time in a standard work, Macaulay's method of estimating the deflection of beams.

Concrete-steel construction is only briefly mentioned, as it is affected by the particular argument under consideration in each chapter, and its treatment is not always fortunate (as, for instance, the paragraph dealing with long R.C. struts, which is by no means clear). The author makes it clear that he had no intention of dealing fully with R.C. construction; and it is, perhaps, asking too much to expect the general high level of the work to be maintained in this branch of the subject; but it is made unnecessarily confusing by the use of notation differing from that now regarded as standard in most books on reinforced concrete.

There are a great many examples (some worked out in full and all having the answers given), which form a very valuable feature of the book. It was the author's design to give such "examples as would make some demand on the thinking powers of the student," and the selection given contains a large number of very interesting problems, which, however, never degenerate into mere mental gymnastics, but have all a definite connection with the argument in the preceding text.

The book is designed for the use of the student reading for an honours degree, and it postulates a grounding in the subject and a sound mathematical training. It is eminently suitable for the young officer, and particularly for private reading by those taking the Cambridge Course, whom it will help considerably in digesting such points as are not immediately grasped during lectures.

A.M.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

(*August*, 1925).—*The Turco-German Command during the War*, by Commandant Larcher. The achievement of harmonious relations between allied commanders in time of war is one of the most complex problems connected with the conduct of operations, and the case of Turkey and Germany is not without interest and instruction. Commencing with an intimate co-operation induced on the one hand by Turkish admiration and respect for German methods, as exhibited in the 1866 and 1870 campaigns, and on the other by German interests in Asia Minor, as evidenced by the Baghdad Railway, relations between the two nations were gradually changed during the war, by German ambitions and interference, to dislike and ultimately to active obstruction from the Turkish side. Conditions were favourable for unity of command, but the Germans confused this principle with that of direct command, which, owing to the opposition of Turkish nationalist sentiment, it was impossible to impose without friction.

A Second Lesson of the War of Secession. Lt.-Col. Daille's article is continued, describing the battle of Spottsylvania and some of the cavalry raids, mainly Federal, and including Sheridan's march to Atlanta. The last is illustrated by a sketch, and the conclusion drawn is, that in spite of the powerful resources which large formations of cavalry may hope to have at their command at the present day, it is legitimate to conclude that distant missions attempted in enemy territory, on difficult ground, far from the support of the main body, are more than ever operations which involve the greatest risks in return for merely limited results. Such raids would only be justified when adopting a strategical attitude which is purely defensive. (*To be continued*).

Concerning a German Opinion. The conclusion of the article. Chap. VI calls for few remarks, as the opinions expressed more or less coincide with those of the writers of this article. It deals with French military criticisms of the proposed *loi des cadres*, many of which, to von Taysen's surprise, express a fear that the Bill is unfair to the infantry, tending to reduce its strength, overload it with apparatus, and impair its mobility. Chap. VII is, generally speaking, a recapitulation of arguments already advanced. A tribute is paid to von Taysen for the good faith which inspires his pamphlet. His reasoning is based on the spirit of the German regulations, and stripped of its mistakes and exaggerations, contains much matter which is worthy of consideration and application in France. The book is no doubt written, as already remarked, with a view to encouraging the German infantry under the enforced limitation of their material resources, and for this reason is none the less valuable as an indication of the German doctrines of war at the present time.

Schemes for the Employment of Artillery, by Colonel Picot. Before the war, ideas on the employment of artillery were vague and often incorrect, such as the statement in the 1913 regulations, "artillery does not prepare the attack, it supports it." The war showed that regularly thought-out plans were necessary, and up to 1917 these plans gradually became longer and more complicated, with tables, maps and sketches decorated with the most varied colours. Fortunately in 1918 want of time for preparing such plans proved that many were unnecessary and could be replaced by general rules. German experiences and methods closely approximated to those of the French, and Lt.-Col. Bruchmuller has published a most interesting book on the subject in which he clearly demonstrates the necessity for considered schemes, but the point is that they ought to be generalized and simplified. Known methods of action would simplify the tasks of commanders, staffs, troops of other arms and of the gunners themselves; it must be remembered that many of them on the outbreak of war will not be well trained regulars. Col. Picot makes proposals for such general plans as he advocates for the attack and for defence, and concludes with some general remarks. His arguments are not without interest.

The Battle of Courcelles-Mary, 9th to 11th June, 1918, by Col. de Ripert d'Allauzier. This battle is interesting not only from its success, but also because here, for the first time, was systematically applied the organization of the "army battlefield" as conceived by French G.H.Q. in December, 1917. During the period of stabilization it had been customary to hold the first line at all costs, reserves being frittered away by filling up gaps in the front line as local circumstances demanded. The new scheme was to organize a position of resistance some kilometres from the enemy which he could not reconnoitre like the front line trenches, and to hold the space between this and the enemy as a covering zone with as few troops as possible carefully disposed with a view to breaking up the enemy's attack before he reached the main line of defences. A further advantage of thus retiring the position of resistance, would be that the enemy infantry would arrive before it, poorly supported by artillery, owing to its distance from the original position of their guns. Again, some kilometres in rear of this a second position was to be organised, to act as a dam in case of a breach of the first, and to be held by entirely different formations. It was essentially an organization of all arms in great depth. The position of resistance was to be held by the greater portion of the first line troops with their reserves intact and ready for counter-attack from behind, or exceptionally in front, of the position, in fact the elements of surprise and manœuvre could again be made use of in the defence. These principles had been fully grasped by the commanders of the Army group and of the 10th Army, which was attacked, also by the G.O.C's, the 36th Division (in first line of one sector of the defence) and 11th (The Iron) Division (in second line of that sector). In neighbouring sectors equally good disposition had not been made, and the enemy broke in, forming a large cavity in the French line. On the west flank of the base of this salient the resistance of the 36th Division was so firm that the 11th Division was not called upon to aid in the defence proper, and was able to effect a wheel to the east facing the flank of the German salient, into which it penetrated and recovered most of the captured ground. (*To be continued*).

The Exhaustion of the German Effectives. The continuation of Col. Pacquet's article embracing the period from mid-July to the end of August, 1918. This period coincides with the loss of the initiative by the Germans, who up to then had been able to husband their reserves by attacking only when prepared to do so. From the beginning of August the fatigue of their troops and diminution of their strength rapidly increased. (*To be continued*).

Foreign Military News. Holland. The 75 m.m. field gun is about to be improved by lengthening the barrel and modifying the carriage so as to obtain a range of at least 10 kilometres. Preparation for economic warfare has been initiated by the Minister for War, who has called for a return from all military commanders concerned of stores and munitions required on mobilization and for their replacement as required. Once in possession of this information he will approach the larger manufacturing concerns with a view to adapting their industries to supply the needs of the army.

The draining of the Zuiderzee, commenced in 1920 and estimated to take 35 years to complete, has raised new problems of defence which are now under consideration by the Government.

Books and Reviews. L'Armée indigène nord-Africaine, by Col. Paul Azan. (Charles Lavauzelle et Cie). Col. Azan is now in command of a native regiment, and having passed the greater part of his service in Algeria and Morocco is well acquainted with Mahomedan questions. He points out the unpopularity and uselessness of conscription in Algeria; the idea of a native reserve seems to him utopian. The presence of native units in France has many and great inconveniences. He advocates a return to long service voluntary engagements with pension as a means of introducing favourable propaganda into the villages.

September, 1925. *The French Command in Western Thrace.* By Commandant Armingeat, with two maps. From October, 1919, to May, 1920, Western Thrace was administered by the Alliés under the orders of a French general and then handed over to Greece in accordance with the treaty of Neuilly. As an example of what can be done in a short time to restore a distracted country, inhabited by representatives of three distinct races of different religions, and each hating the others, with customs, tax-collecting posts and telegraphs, public works, etc., utterly disorganised, the account is interesting and instructive.

A Second Lesson of the War of Secession. The conclusion of Lieut.-Colonel Daille's article. After briefly touching upon the political and economic situation and the anxiety which defeatist propaganda, introduced by the Federals into the South and among the negroes, caused to Jefferson Davis, the writer proceeds to draw his conclusions. The ruthless measures taken by Grant in devastating the country, destroying roads and industries and burning houses, combined with a rigorous blockade, slowly diminished the resistance of the Confederates. Grant's orders to his commanders were to attack at all costs. President Lincoln and the Federal Government kept him abundantly supplied with troops and stores, so that he could always rely on numerical superiority, and successive battles wore out Lee's reserves, which the possession of interior lines enabled him to utilise to advantage so long as they lasted. Grant took no risks in regard to his communications; instead of using the open roads to the west of the Wilderness he depended on the sea and navigable rivers, constantly changing his base as the advance progressed. Grant's and Sherman's tactics are contrasted, the latter depending on manœuvre for dislodging the enemy, but always failing to bring him to battle. J. Johnston's conduct of the retreat on Atlanta is commended. The Confederists' knowledge of the forests of Virginia, their individual resourcefulness, and Lee's personality, prolonged the unequal struggle. The Federal losses were enormous, but were stoically borne for sake of the Union. It was Lee's misfortune that he was faced by a Grant, but the latter cannot claim the whole credit; he was merely the chosen and trusted instrument of the Northern Government which accepted full responsibility.

A.R.R.

Les Transmissions des Grands Unités. By Colonel J. Langlois. An exercise in the organisation of Signal communications between a mobile column and its supporting division during an attack, testing the resources of the latest French equipment in wireless, telephones, cyclists and pigeons. "Signals can only give satisfaction if their arrangements are in strict agreement with the tactical situation and the decision of the commander; thence the absolute necessity of intimate connection and incessant collaboration between the Staff and the Signals commander."

The account of the battle of Courcelles-Mery is continued and describes how the 36th Division occupied and held the forward zone in considerable depth, and the 11th Division took up a second line in rear; but when the enemy broke through in the adjoining sector the 11th Division, on the staff of which the writer, Colonel de Ripert D'Alauzier, was serving, took up a line on the flank, which extended, toward the rear, the flank of the 36th Division. (*To be continued*).

In this number Lieut.-Colonel Paquet concludes his article on the *Exhaustion of the German Effectives in* 1918.

F.E.G.S.

REVUE DU GENIE MILITAIRE.

October, 1925.—*Permanent Fortification.* By a Foot Soldier. A proposal for a form of permanent fortification specially applicable to an extensive frontier, based on inferences drawn from field fortification in the late war. The writer suggests "*points d'appui*" spaced (with due regard to the terrain) some 1,000 to 2,000 metres apart with a second line 1,200 to 1,500 metres in rear dividing the intervals. Each such point to consist of a concrete work, covered and flanked by a ditch and/or barbed wire and containing command and observation posts with two or more each of machine guns and trench mortars all protected from direct fire. Occasional "strong points" at suitable intervals—enclosing a group of similar works. Artillery positions may or may not be prepared in advance, or be on rail and a mobile reserve be sheltered in deep dug-outs in rear of the position. The writer would so fortify the higher and more important points in peace time, leaving gaps—flanking defences (*positions transversales*) and rearward lines to be made on mobilisation.

The Fortification of Metz. Notes on certain uncompleted projects for various works.

A Drawbridge in a Bridge on Piles. Description of such a drawbridge built by the 2nd/6th Génie in April, 1925.

A Scheme with Troops carried out by the 11th Génie in April, 1925. Involving the construction of various bridges for an attack by a corps of two divisions.

A Further Note on the Drowning of Eighty German Soldiers (see June number). A detailed description of the type of raft used and suggestion that the disaster was caused by lack of longitudinal rigidity and bad watermanship in inclining the raft at too large an angle to the current.

November, 1926.—*Inauguration of the War Memorial at the "Ecole Polytechnique."* Speeches by Marshal Foch and by General Thomas (the Commandant).

An Engineer Officer on a Mission to Turkey in the 18th Century. His letters describing a visit to the fortifications in the Black Sea. The institution of a School of Instruction for Military Engineering for the Turkish Army, and his efforts to get the fortification of Otchakow brought up to date.

The Work of the Engineers in Algeria. A summary of the public works carried out by the Military Engineers since the first occupation of Algeria in 1830.

A New Method of Gabion Revetments. For high revetments involving two or more gabions—the author claims that the insertion of a horizontal row of hurdles under each row of gabions ensures stability and avoids the necessity of anchoring back into the parapet which is often impossible A considerable economy of labour is claimed.

"*Données Numériques.*" Particulars of personnel, tools, material and time taken in executing various bridges.

December, 1925.—*Motorisation des Unités du Génie.*—Général Camon. A consideration of certain important operations in the past involving large movements of Engineer Equipment and Stores—mainly bridging—instancing from analagous operations in the Great War the increasing importance of all branches of military engineers.

The writer goes on to argue that the "automobile divisions" which he hopes will shortly replace cavalry divisions, will be accompanied by engineer units suitably organised—their duties being essentially to

(1) Maintain the roads and as far as possible the railways;

(2) Organise bridge heads and any holding position;

(3) Undertake demolitions.

He holds that engineer units should possess lorries for collection of local materials in preference to loading up their transport with bridging equipment or stores. The latter should be held well in rear, but organised for very rapid despatch as required. The engineer units will have plenty to do in preparing approaches, etc., while awaiting the material.

The system of Wireless Communication with and between the French Colonies.

A summary of the existing stations and history of their development. A non-technical statement of the plant installed and wave lengths used. Short wave systems are under trial, and a 5-k.w. installation maintains good communication by night (not by day) on 75 metres with Djibouti. The author goes on to discuss the future of long and short wave and cable communication and their respective advantages.

A mass production factory for ferro-concrete blocks.

A description of the blocks—used for bursting layers in dug-outs, etc.—and the lay out and organisation of the factory.

A Map Exercise.

A map exercise for the Corps Engineers in preparing a plan for destruction of communication in rear of an army, worked out in detail as regards one division.

H.G.K.W.

REVUE MILITAIRE SUISSE.

(1925, Nos. 7 to 12 inclusive).

M. Jean Fleurier's article entitled *Une légende. La faillite de la fortification permanente* is concluded in No. 7 of the *Revue* under notice. This part of the contribution opens with a consideration of the question as to whether the defence works of Antwerp successfully played their rôle as the constituents of a great fortress. The view of the author of the original article is that the defence of Antwerp will not, in the history of siege warfare, rank as a model worthy of imitation—the same may be said of the attack on the fortress. The statesmen and leading military men in Belgium were alike disappointed in the part played by the most important of the fortresses in their country; they felt that the damage inflicted on the attacking force sent against it by the enemy was altogether incommensurate with the effort and money spent in providing the considerable armament and large quantity of munitions accumulated in the famous *place d'armes* at the outbreak of the Great War. Again, the defence put up at Antwerp had nothing like the same encouraging effect on the Belgian Army and people as had the resistance to the German advance offered at Liège. M. Fleurier accepts, however, the claim that the stand of the Belgians at Antwerp, which passed through two phases—the first an offensive and the second a defensive—had far reaching effects on the early operations in the Western Theatre. To the offensive strokes of the Belgian Army was it mainly due that German troops, which might have been utilised in the fighting on the Aisne, were retained at Brussels and in the neighbourhood of Antwerp for the purpose of guarding against an irruption of the Belgian Army from its citadel which might have jeopardised the safety of the German right wing. And to the fact that the Germans detached a considerable part of their heavy artillery for the bombardment of Antwerp was it due that they were handicapped during their outflanking movement when racing for the sea-coast. The existence of even the old detached works, provided in Brialmont's time, beyond the ramparts designed and constructed by him, produced an "intimidating effect" on the besiegers, and made them extremely cautious in their advance against Belgium's important stronghold. The slowing down generally of the German advance in the Western Theatre was of immense benefit to the Entente Powers, one of the most important of the advantages accruing therefrom to them being that the arrival of the German forces on the Yser was delayed, it is estimated, by at least 12 days. M. Fleurier's final conclusion on this subject is that, had the situation been properly handled, Antwerp could, and should, have held out longer; he thinks that, had this been the case, the reinforcements which were available could then have been moved up in time to establish the left flank of the Western Allies solidly at Antwerp, and the Germans would thus have been denied access to the coast-line. M. Fleurier next gives an interesting comparison of the sieges of Liège, Namur and Antwerp, in an abbreviated form, under 14 heads, which deal, *inter alia*, with the strategic rôle of each fortress, the resistance of the forts, the defence of the intervals between the forts, the part played by the Governor of the place, the initial plan of the enemy's attack, the action taken by the Germans against the forts, the rôle of the super-cannons, the investment, etc. The article concludes with an account, in some detail, of the measures taken by the enemy, after the capture of the three Belgian fortresses, to convert them into German strongholds. Before the value of this reconstruction work could be put to a test, the Entente Armies made their halt on the Armistice Line, the left of which rested near Ghent.

BULLETIN BELGE DES SCIENCES MILITAIRE.

(1925—Tome II. Nos. 3 to 6 inclusive.)

Operations of the Belgian Army, 1914-1918. Art. 26 of the Hague Convention (1907) provides that a commander of a besieging force shall, before shelling of a defended city or town commences, give due warning to the authorities therein that its bombardment is imminent. The manner in which the Germans complied on October 7th, 1914, with the provision in question in connection with their attack on Antwerp is set out in No. 3 of the *Bulletin* under notice: it is suggested therein that although the terms of the articles were observed to the letter, yet, as shelling began almost immediately after the receipt of the bombardment notice by the Belgian authorities, the Germans really failed to give effect to the spirit of the regulation.

The position of affairs as they appeared in the light of the information available at the Headquarters of the Commandant of Antwerp's "Second Line of Defence" during the night of October 7-8th are set out (No. 3). Some of the information which reached these Headquarters was distinctly of a disturbing character; for instance, reports of the Commander of Fort No. 1 indicated that the Germans were attacking this work, and that the bulk of its garrison had, in a panic, fled therefrom after putting the guns there out of action; it was stated that only the officers and 20 O.R. still remained in the fort. However, the information now available shows that Fort No. 1 was not even threatened at this time; indeed, no part of the "enceinte de sûreté" was really attacked, or even bombarded, during the night of October 7-8th by the enemy, who was content to feel his way forward cautiously by pushing out reconnoitring patrols. No attempt appears to have been made to confirm the accuracy or otherwise of this disheartening news, but measures were at once taken to send reinforcements to Fort No. 1 and also to meet the situation which would arise should the enemy break through the line of forts; these are given in some detail in the original article (No. 3). The Commander of Fort No. 2 was directed to send reinforcements to Fort No. 1, and selected for this purpose a detachment of artillery which had fallen back from Namur; he acted thus in spite of the fact that he was fully aware that these men were in an extremely depressed frame of mind and had come to the conclusion that any further resistance to the enemy's advance was useless. In these circumstances, the transfer of these broken-spirited gunners from Fort No. 2 to Fort No. 1 was a step hardly of a nature to improve matters at the latter work. It is evident from the narrative of the operations that the troops defending Antwerp, both the Belgians and the R.N.D., were in a highly "nervous" condition, no doubt largely owing to physical exhaustion brought on by their severe bodily exertions coupled with the deprivation of sleep for an abnormal period.

On the evening of October 7th, the Commandant of the "génie de l'enceinte" had officers standing by at the several gateways of the old ramparts in readiness to destroy the bridges over the wet ditches. Arrangements were also made by him the same evening for placing obstacles on the approaches to the old ramparts; the Boom, Malines and Turnhout roads, however, were to be kept open in order to allow the troops on the "Second Line of Defence," to retire by them into the city. The Germans began to bombard Antwerp at 0.25 on October 8th; their fire was directed chiefly against the southern suburb of the city and points of military importance in proximity to the old ramparts. The shelling, although not violent, was responsible for the outbreak of a number of fires which created anxiety; the failure of the water-supply and the fact that the majority of the inhabitants abandoned their dwellings and streamed into the streets aggravated the situation considerably.

A short account is given in No. 3 of the *Bulletin* under notice of the work carried out by the engineers in view of the contemplated abandonment of the entrenched camp on the right bank of the Scheldt. This work was concerned, *inter alia*, with the dismantling of temporary bridges and also of a boom across the river (at Perle); the destruction of pontoons and also of a second boom (at Steendorp); the destruction of a submarine-torpedo installation and also of two German steamers which had not been able to clear away from the port before the declaration of war.

At Hoboken, situated between the second line of permanent works and the old ramparts, there existed an immense installation of storage reservoirs containing very considerable supplies of motor spirit, petrol, and oil. The measures taken by the military authorities with a view to the removal of these supplies to the new base at Ostend are given. However, before the work of removal could be completed, the reports reaching Fortress Headquarters led the authorities to believe that the situation had become extremely critical; in consequence, the greater part of the motor spirit, etc., in the storage reservoirs was emptied into the ditches of the adjacent Polders. About mid-day of October 8th one of the sluices connecting the ditches in question with the Scheldt was maliciously opened and the motor spirit, etc., thus escaped into the river, where it was accidently ignited and continued its course towards the military bridge at Burght, the destruction of which by the burning liquid seemed to be imminent. Fortunately, when the flaming liquid was still about 100 yds. from the floating piers of the bridge, the tide turned and the structure was saved.

W. A. J. O'M.

To be continued.

HEERESTECHNIK.

(*October, November, and December* numbers.) The first two articles in the October number, "The Motorization of the Army" and "Types of Tanks in the Light of Foreign Expert Discussion" consist chiefly of extracts from articles already published. The former is taken from Gen. Camon's article in the *Revue Militaire Française* (see *R.E.J.*, Sept., 1925) and from Col. Hemelryk's article in the *Journal of the Royal*

Artillery, April, 1925. The second article, which quotes from many sources, mentions the Italian 5-ton tank, and Col. Velpry's proposed 600-ton tank (*Revue Militaire Française*, April, 1924, and July, 1925), as extremes of modern opinion. Summing up, preference abroad is given generally to light (6-8 ton) and medium (13-18 ton) tanks. Col. Velpry's demand for a shell-proof tank is logically sound: whether it is necessary, practicable, and useful, is another matter. Neither article is rich in new ideas.

In the October and December numbers are two articles dealing with the geological and chemical aspects of petroleum and coal. They give a good general idea of the subjects, as far as this is possible in the space.

Extracts from the Yearly Survey Report are completed in the October number. In certain parts of Germany, extensive areas of the earth's surface have subsided, owing to the dissolution of subterraneous deposits of salt. In one such area, in the Harz Mountains, stereoscopic photography was successfully employed, but no details are given as to methods, instruments, or calculations.

The New German Manual of Field Fortification, Part II, is reviewed by Major Klingbeil. "As all fortification begins fundamentally with camouflage, this occupies the first part of the Manual." While it is easy to camouflage positions from ground observers, it is much more difficult, and much more important, to conceal them from aeroplanes. The efficacy of the camouflage should, therefore, be controlled by aerial photographs taken from a height: these must be forwarded as quickly as possible to those responsible for the work, so that mistakes may be rectified. Study of aerial photographs is the practical method of studying camouflage, and accordingly the manual is liberally illustrated with them. Axiomatically, all positions must be made to blend with nature: the disfiguration of the landscape must be reduced to a minimum by a reasoned limitation of earthworks: unnatural shapes (straight lines, sharp angles, and the formation of shadows) must be avoided. Camouflage must be frequently renewed and changed according to weather and season. In open warfare, the simplest material for camouflage is tent-canvas.* By covering it over with grass, leaves, straw, or twigs, or by sprinkling it over with sand or snow: also by stretching it loosely, or by covering the edges irregularly, it can be made to match the surrounding ground. Another method is to paint it over with a gruel of mud or chalk. In the matter of dug-outs stress is again laid on the importance of constructing small rather than large ones—at most for five or six men.

As a result of experience on the Western Front, revetment of trenches is considered a disadvantage, because the materials, broken by shell-fire, block the trench. Boards or long poles should, therefore, never be used; at most, stakes not more than a metre long; above that, turf or sandbags.

In the modern system of zones defensive in depth, the parados is of

* Every combatant German soldier carries a square of tent canvas, about four feet square; cords are attached to the corners, and with the help of a few bamboo rods five or six German soldiers could at any time erect a tent. In marching order, the canvas is carried over the great coat, which is itself folded over the top of the pack.

greater importance than formerly, as protection against "shorts" from one's own artillery. As communication trenches cannot be camouflaged, they must be so constructed that they do not betray the position of the fire trench. For example, they may be extended beyond it to a dummy position, or led alongside it, or may be connected with it by short shallow ditches. Camouflage and digging always go hand in hand, *first* camouflage, *then* dig.

Particularly important is the question of drainage. All preparations must be made at the commencement of the work. In low-lying districts, where the saturation level is near the surface, these preparations may have to be very extensive; under certain conditions the whole district must be drained and the saturation level be lowered by pumping with powerful electrical pumps.

The whole article is interesting and well worth study.

Mr. Weyl contributes a long article, *Observations on the Evolution of the Military Aeroplane Abroad*, to the November and December numbers. It is interesting as giving a general idea of the difficulties of aeroplane design, but loses some of its value through being out of date.

Extracts are given in the same numbers from the British *Manual on the Use of Smoke*. The summing up is interesting. "Almost the whole of the Manual is reproduced here, as it is very instructive. Of the Manuals yet published it is the best. The smoke candles give out a dangerous smoke, whence the remark that they will completely clear out a dug-out if lighted and thrown in. They are in fact not intended for smoke screening, but as poison gas producers. With reference to our conditions, many an opportunity in defence, particularly in minor wars, is offered for the use of smoke screens, for the protection of small units against an enemy in superior numbers, or against an enemy recklessly advancing, who possesses *every* material for war."

In the November and December numbers, reports of the German Wireless Exhibition in Berlin, and of the Motor Show at Olympia, are given. The former contains nothing of interest. As to the latter, innovations of the greatest interest from a military point of view are balloon tyres, the front axle drive, and the rapid development of the light commercial vehicle. Between them they make cross-country motor traffic a possibility.

Major Klingbeil reviews the new German manuals on *Searchlights* and *Bridging, Part III*. In the latter, particular stress is laid on the importance of the Sappers' estimate for the time required for the construction of a bridge. Difficulties in the building of heavy bridges are unavoidable; to a great extent the decisions of the higher command depend on the accuracy of the estimate, and so excessive optimism may result in the disorganisation of the whole army. Generally speaking, these two manuals do not seem to contain as much that is new as those previously reviewed.

T.H.B.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*November-December*, 1925).

Heinz Zatschek completes his article "Moltke or Schlieffen?" He gives an interesting summary of the whole argument. "Schlieffen's plan, which Moltke took over on his appointment, had two defects—it reckoned with forces which would not be available, and exposed the left wing of the Army to considerable danger." (According to Schlieffen's plan, the left wing would be compelled to retreat before the French, under the assumption that no vital spot could be reached before the success of the operations on the right wing.) "Moltke, who from the first reckoned on a mass attack on German territory by the enemy, had for the moment no choice but to adopt Schlieffen's plan, to conform to which all war preparations had been more and more modified. But there is no doubt that even then he did not expect a decisive result from the German advance through Belgium, and soon was at work on a plan of his own. In 1908/09 the effects were already seen in the mobilisation orders. In 1910 the first stage of its development was complete; arrangements for transport of troops from the left to the right wing were no longer part of the programme. The remaining pre-war years formed a second stage in the developments of his plan, which, however, was never brought to conclusion. He recognised two distinct possibilities. Either the enemy's main attack was on Lorraine—he expected this, and wanted entirely to abandon Schlieffen's plan—or the enemy's main forces were directed against the German right or centre. In this case they would also be met by sufficiently strong forces to leave no doubt as to the issue. The German mobilisation orders were so arranged, that the Army could equally well be employed for a decision in Lorraine, as in Moltke's plan, or for a great envelopment, as in Schlieffen's plan. In any case, German movements were independent of the enemy's measures. Possibly Moltke's plans, even at that time, did not stop at the driving of the attack as far as the Moselle and the Meurthe, but contemplated a German break-through, in the event of the French failing to make an attack on that front. His manœuvres of 1913, in which the general idea was an attack on a line of fortresses flanked by two neutral states, shows that a break-through did not seem impossible. In 1914 Moltke tried to crystallise his thoughts into facts; it seems that up to then he had shared his ideas with no one. So it came about that even Moltke's chief of staff, Lt.-Col. Tappen, opposed certain of Moltke's measures on the ground that they represented a divergence from Schlieffen's plan. So we conclude: We should not criticise the Supreme Command on account of the changes they made in Schlieffen's plans. We must give them credit for thinking out a plan of their own, and we must regard their actions as a definite policy and not as helpless fumbling. Furthermore, we must not overlook the fact that two diametrically opposed views were represented by Moltke and Tappen, who, as an upholder of Schlieffen's plan, had to give way in everything to Moltke."

The Question of a Decisive Victory East of the Tagliamento in October, 1917, is discussed by Lt.-Col. Schwarzleitner, in answer to an article by General Krauss on the same subject (see *R.E.J.*, September, 1925). Krauss says that no attack to the south was made, as the intention was to drive the Italians into the sea. Actually, on October 29, the Austrian 1st and the German 5th and 117th divisions received orders to advance in a southerly direction, and they took no small part in the fighting on the next day, which brought in 60,000 prisoners. The whole offensive was based on the natural assumptions that the Italians would fight as well in defence as they had in attack on the Isonzo, and that they would utilise their reserves; both assumptions were wrong. The Germans took little interest in the Italian theatre of war, and would only sanction the employment of German troops there for a limited offensive. The sector tactics were not rigidly conceived, and were modified to suit the occasion.

As matters stood, a decisive victory was out of the question. It would even have been impossible to compel the surrender of the Italian third Army.

Lt.-Col. Wuczkowski contributes a very interesting article on *Practical Exercises for Officers.* He points out that in the small armies of to-day even a company commander seldom gets an opportunity of exercising himself in tactics with a full company; a battalion commander is very fortunate to get such a chance; for a brigade commander it is practically out of the question. And it is only by gaining confidence in such exercises that one's powers can be perfected. At present, for many officers the yearly manœuvres form the only field practice of the year, and they are too much of an examination and too little of an instruction. The author examines the possibility of finding a good substitute, and concludes that the practical method must be to instruct certain regimental and all staff officers in the conduct of tactical exercises, which should combine indoor and outdoor work, and be held at least once a fortnight. The specially trained officer works out a scheme, and then gives instruction to at most eight or ten officers, who work together to produce a solution. In the more ambitious schemes, officers of all arms should be included.

The conclusions reached are fairly obvious, yet the article is well worth reading, as it is full of the common sense and elementary psychology so frequently neglected by instructors.

The same author works out Tactical Exercise No. 3 in this volume.

Dr. Kobis contributes an article, *Practical Military Psychotechnics.* Classification of soldiers by simple tests is of value in mass recruiting for war.

The translation of the "Next Great War," by Capt. Liddell Hart, is completed in this number.

The Review of Military Science. I. *Tactics.* Under this heading are three short articles—one uncompleted—on Tanks. Capt. Fritz Heigl points out that the so-called Death Rays, which are supposed to stop motors by magnetic interference with the magneto, even if perfected, will not solve the problem of defence against aeroplanes and tanks, as magnetos are not essential to the design of internal combustion engines.

II. *Commissariat.* A long article, partly historical, on the working of the supply departments of the Austrian army, is given. It is not of particular interest to British readers.

III. *Engineering.* A short notice of a bridging experiment is given. For building a pontoon bridge across the Danube, a motor boat was used for towing the rafts into position, the rafts being constructed down stream from the bridge line. It was considered that where strong or cross currents are encountered, the method will cause a considerable saving of time.

T.H.B.

THE MILITARY ENGINEER.

(July-August, 1925).—*Engineer Combat Troops as Infantry.* After stating that "The Engineer combat regiment of the Infantry division has dual functions; first and most important, as engineers for the division and, second, as infantry in case of emergency" the writer discusses a problem in which an engineer battalion has to take over the front of an exhausted infantry battalion during the course of an attack. In the suggested solution of the problem, owing to the fact that the engineer battalion is about half the strength of an infantry battalion, in order to take over the latter's front the engineer battalion has to obtain reserves from some other infantry unit. In the discussion following the article a writer points out that, with an infantry reserve available, the question whether an emergency of sufficient importance to justify the employment of engineers has arisen, must be considered.

Use of Planks in Floating Bridges. The writer gives two examples of floating plank bridges. The advantages claimed are that of rapid construction and that material can usually be found on the site by demolition of buildings.

C.G.M.

(September-October, 1925).—*Hydraulic Mining Problems in California.* Though of no military interest, this article on gold mining is a striking example of the harm which can be done to the community by a small section of people whose sole object is the acquisition of wealth. It is a strong argument for a measure of State control of industry. The gold-rush to California started in 1849, bringing a stampede of a hundred thousand men to that State. The first mining was done by the "panning" process, in which the silt from the river bed was washed by hand. It was soon discovered that rich deposits of gold were to be found not only in existing rivers, but also in the beds and banks of dried-up streams, and those liable to flood only at certain times of the year. To extract the gold from these localities, the hydraulic process was introduced, consisting of the application of high pressure jets of water. The sludge was directed into wooden troughs, in which the gold remained in sediment. This process proved extremely successful and developed to such an extent that up to the year 1923 something like 1,600,000 cubic yards of gravel had been worked. Open pits half a mile wide and a mile or more in length had been excavated, some to a depth of 400 feet. The bed of one stream had been raised 250 feet by gravel washed into it. By this time, the damage inflicted on river channels had caused serious interference with agriculture and navigation, and it became necessary to pass an Act

appointing a Debris Commission, and limiting the granting of licenses to firms who undertook to arrange to impound their debris behind suitable dams. These restrictions have severely curtailed the industry, which is now in a somewhat serious plight. The Commission is at present engaged in collecting information with a view to improving matters.

Topographic and Geologic Maps. An interesting, though somewhat elementary, treatise on map reading. The Geological Survey Dept. issues four types of maps: geographic, topographic, geologic, and mineral resource. Each of these is described in turn. Illustrations of various types of terrain and their geological explanation accompany this article.

Emergency Dams at Seattle Canal Lock. This lock connects Puget Sound with Lake Union, the difference in level being 26 feet. To provide against possible failure of the gates, emergency dams have been provided. The up-stream dam takes the form of a 70-ft. span steel girder bridge carrying the sluice gates and winding gear. Normally the bridge lies alongside the edge of the lock, where a 75-ton derrick is available to pick it up in emergency and lift it bodily across the lock. The sluice gates are then lowered to engage in a concrete groove at the bottom of the lock.

Zenith light for hill-shaded maps. The Corps of Engineers is experimenting with a hill-shaded map, showing relief entirely by vertical projection. The method adopted is to project a vertical light on to a relief model of a contour map and photograph the result. It is claimed that this process gives a truer impression of the shape of the ground than the more popular method of shading a map in relation to an oblique source of light, assumed to come from some arbitrary direction. Four specimen maps, produced by this process, accompany this issue.

New "Ways" for Old in New England. Reveals the interesting fact that the Boston and Maine Railroad are seriously considering the scrapping of 1,000 miles of track, in face of competition from the automobile. The writer discusses the advantages and shortcomings of both types of transport, and concludes with a suggestion that the track, if scrapped, should be pulled up and a road surface substituted. A possibility by no means remote in this country.

What about Reserve Instruction? There are three principal ways in which officers of the National Guard and Reserve can keep in touch with military affairs. They may attend camp with regular units; they may take correspondence courses, and in some areas branch schools have now been established in the principal cities, where instruction is given by regular officers. The response has so far been disappointing.

(*Nov.-Dec.*, 1925.) *Work of the Bureau of Standards.*—Standardisation is the essence of mass-production. One is not surprised, therefore, to learn that America is provided with an unusually complete government department, whose duty it is to maintain and develop working standards of all kinds. Even so, one is scarcely prepared for the vast and elaborate organisation which is described in this article. Apart from the numerous science and research laboratories, the equipment includes model factories, representing many of the principal industries of the country, where problems of manufacture may be investigated on a commercial scale. The value of such an institution is self-evident. No doubt similar establishments are to be found in this country. If so, it would do one good to read about them.

Electric Power during the World War.—Owing to the heavy demands for munitions and war stores in general, the power services in many of the industrial centres proved inadequate. The inflation of prices made it impossible for the power companies themselves to embark on the construction of additional stations. State assistance became necessary, not only to finance new undertakings, but also to straighten out existing contracts which were hindering the even distribution of power. As a result of the lessons learnt during the war, there now exists in the office of the Assistant Secretary of War an agency charged with the duty of keeping in touch with the resources of the power industry, and the amount and probable location of the power needs of the country in time of war.

India and the Grand Trunk Road.—A descriptive account of a famous road and its place in Indian history from the time of Alexander the Great.

Transmission of Pictures over Wires.—Describes the methods by which photographs may be transmitted by telegraphy. Remarkably clear results can now be obtained at comparatively low cost.

Brock Development of Aerial Mapping.—Conic projection effects, altitude variation, camera tilt. These are the three causes of inaccuracy in aerial survey. The Brock Company has been experimenting in the field since 1914 and here describes some of its latest types of instruments, and the methods by which errors may be eliminated.

Synchronous Torsional Vibrations.—An explanation of these phenomena with special reference to the design of Diesel crank shafts.

R.I.M.

THE DRAGON.

As "Men of Kent" we offer our congratulations to the County Regiment on the appearance of its regimental journal in a new and attractive cover, which shows, besides the famous dragon crest, the battle honours of The Buffs from "Blenheim" to "Baghdad." The cover has been designed by Mr. Graily Hewitt, who also designed the Roll of Honour of the Regiment, which rests in Canterbury Cathedral. The February number of *The Dragon* contains, among other matter, a review of Lieut.-Colonel W. A. J. O'Meara's recently published book *Kekewich in Kimberley*, the proceeds of the sale of which are to be devoted to The Buffs' regimental charities. F.E.G.S.

CORRESPONDENCE.

British Legation, Belgrade,
December 16th, 1925.

To The Editor, *The Royal Engineers' Journal*.

SIR,

Having just read the article in the December number of *The Royal Engineers' Journal* on the "Life and Work of Colonel Clarke," by Colonel

Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., it strikes me that the following sidelight on Clarke's activities in Russia in his early days may be of sufficient interest to warrant insertion in your next number.

In the month of October, 1925, a venerable and nearly toothless old gentleman, wearing Dundreary whiskers and the dilapidated uniform of a Russian General, came into my office and explained in very fair English that he was the Editor of a Russian Military Journal which is distributed quarterly throughout Europe to all officers of the late Russian regime by the organisation of which General Wrangel is the moving spirit, from his headquarters at Novi Sad, north of Belgrade.

My visitor introduced himself as General Ekk, and said that he had been following in the *Times* the description of our manœuvres held in England last Autumn, and confessed that, though he had been able to make a digest for his paper, there were certain terms and expressions used, which, although he had searched diligently for their meaning in a dictionary, did not appear to have much connection with modern military methods.

He had come, he said, to beg for my assistance in his difficulty, and at once asked what was a "Dragon," a "Hathi," and several other similar terms which have been coined in the post-war mint of British Army nomenclature.

Looking at his poor worried old face, which reminded me of nothing so much as Tenniel's illustration of the old man sitting on a gate in Lewis Carroll's classic, it was easy to picture what the confusion and bewilderment must have been to him whose last experience of active service was probably about the time of the Russo-Turkish war.

After I had explained away his difficulties as best I could, he began a pæan of praise on the English and more especially the English Army, and then went on to say that before the war (he did not specify which, so I was not prepared for what was coming) he had had a great friend who was an officer in the British Army by the name of Clarke, and did I know him? I replied that the name was not an uncommon one in England, and asked him where he had known him. He answered "In Russia." Some subconscious impulse prompted my next question, "Was he doing survey work?" "Yes," came the answer, "he was working on calculations for the shape of the earth."

Obviously the old gentleman was referring to Colonel Clarke, whom he must have known before the days of Plevna and the Schipka Pass.

And this confirms the story at the end of Colonel Sir Charles Close's article that Clarke's name bore a greater reputation in Russia than in his own country.

And this was a reputation worth having in a country whose Geographical Service employed continuously 300 Triangulators and 1,100 Topographers, in Eastern Siberia and Manchuria alone, from the end of the Russo-Japanese to the outbreak of the great World War of 1914.

I am, Sir, your obedient Servant,

F. GILES, *Colonel, British Military Attaché.*