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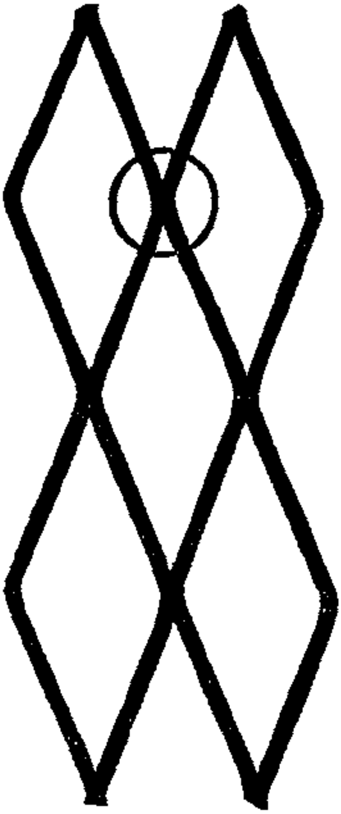

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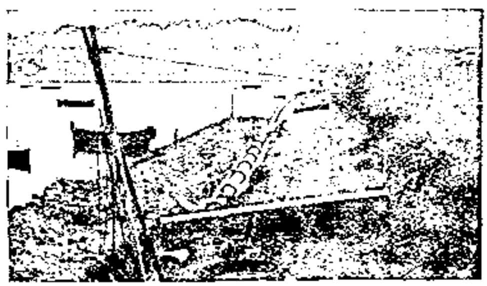

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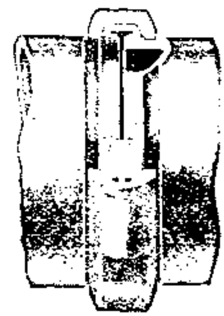

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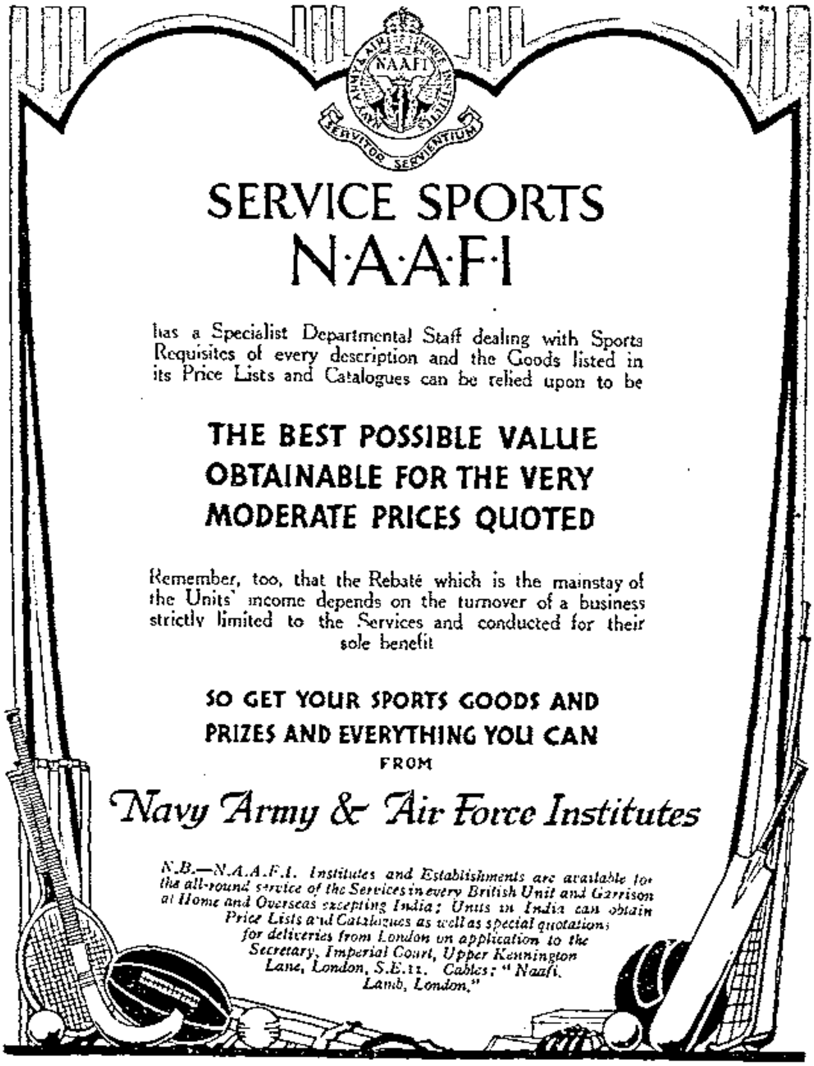
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The primary object of the dam is the storage of water which, on release, will help to maintain a full reservoir, for a greater period of time, behind the Assuan Dam, now that the latter's storage capacity has just lately been increased by the second heightening.

Choice of Site.

The general considerations governing the site have been outlined in the article on Nile Control in the December, 1934, *R.E. Journal.*

No railway runs up the bank of the White Nile, south of Khartoum, so a railway had to be built to the site of the dam. No advantage in natural features is gained by going far up the river, so the site resolved itself to Gebel Aulia, where a small sandstone outcrop on the east bank of the Nile offered material and the possibility of a higher level of rock in the bed of the river.

Description of the Dam. (See Fig. 1.)

The dam can be divided, broadly, into two main parts—a masonry gravity dam across the main bed of the Nile and an embankment dam across a long stretch of silt, only covered for a few weeks at high Nile.

The length of the masonry dam is 1,640 metres, or just over a mile, made up as follows :—

(*a*) Solid dam east, 464 metres long. This is a solid masonry gravity dam running from the rising ground at the foot of the Gebel out to deep water, where it joins

(*b*) The lock, with a total width of 60 metres. The width between walls is 18 metres and the length from gate to gate 80 metres.

(*c*) West of the lock, across the low-water bed of the Nile, is the sluice dam with 60 sluices and a length of 454 metres. Beyond this is

(*d*) The solid dam west, 662 metres long.

The embankment dam is in two parts :—

(*a*) From its junction with the solid dam west it runs for 2,440 metres across ground with an average depth of 7 metres of silt, sand and gravel, covering the rock of the river-bed. Here, two rows of sheet steel piling will be driven, 3 metres apart, down to rock and the intervening space excavated and filled with mass concrete to form the core wall, which will be continued above ground level to the top of the dam.

(*b*) The last 867 metres are across rising ground to the western termination of the dam and here the core wall trench has been partially excavated in the rock (during the 1921 attempt on the dam). No piling is needed for this section.

A short section of core wall, 53 metres long, ties the east end of the solid dam east to the solid rock of the Gebel.

The total length of the dam is thus 5 kilometres, or 3·107 miles. The greatest anticipated depth from foundations to the top of the parapet is about 20 metres.

The height of the water in the full reservoir will be 6·45 metres above the average low Nile and 1·70 metres above average high Nile. These heights may seem small, but the reservoir will stretch approximately 200 miles upstream before the point is reached where the reservoir level will coincide with normal low Nile level.

Solid Dams East and West.

These are identical in design and are gravity structures with a batter of 40 to 1 on the upstream face and $1\frac{3}{4}$ to 1 on the downstream face. The overall top width is 6·30 metres. A " cut-off " trench, 1·50 metres wide and 2 metres deep, runs along the upstream side of the foundations.

The Sluice Dam.

The downstream face has the same profile as the solid dams. The upstream face is wider and houses the sluice gates and the safety shield grooves. The extra weight here compensates for the loss of weight due to the sluice openings.

The sluices are in four groups—one group of ten at each end and two of twenty in the middle. Only fifty sluices will be required at first. The westernmost group of ten will be "blind" sluices and will not be fitted with gates nor will an apron be constructed. Gates can be fitted at a later date if a greater discharge is required.

Each of the groups is separated by a training wall. An apron of masonry, not less than 1 metre thick, extends for 60 metres downstream of the sluices. Sluice openings are 4·50 metres high by 3·0 metres wide, spaced at 7-metre intervals.

The Lock. (See Fig. 2.)

The lock floor is 18 metres wide and 135 metres long from sill to sill. The length between gates is 80 metres. The east wall is prolonged for 35 metres at each end to enable shipping to be warped easily in and out of the lock. From a point 22 metres back from the west wall, two "lay byes" extend 90 metres upstream and downstream. To these shipping can tie up while other shipping is going through the lock. A wall connects these two lay byes, and forms the west reclamation wall. This wall and the west wall of the lock chamber are 29 metres between their outside faces. They are designed as retaining walls and rise in steps on their inner faces. The space between forms the reclamation area which will be filled with "soft" spoil and surfaced with sandstone.

The lock gates are of steel, faced with greenheart at the bottom, where they abut the granite sill-stones, but meeting steel to steel up the vertical joint.

The lock is filled and emptied through two culverts built in the east and west walls of the lock, each communicating through four openings with the floor of the lock. Penstocks, upstream and downstream of these openings, control the flow of water. In addition, two further sets of two culverts and penstocks are provided for flushing out silt from the lock gate recesses.

A subway runs under the floor of the lock to take over the water main and electric light and telephone cables.

A rolling lift bridge crosses the lock.

Abutting the west reclamation wall a series of nine pools forms the fish ladder.

The Embankment Dam. (For section, see Fig. 1.)

Excavation from borrow pits is to be used to form the embankment, which has a batter of 1 in 2 upstream and 1 in 3 downstream and a top width of 10 metres. The core wall is 3 metres wide.

The steel piling consists of 15-in. x 5-in. H-section R.S.Js connected by separate clutches.

The embankment is protected by sandstone dry pitching laid on a bed of sand and crushed sandstone metalling. Large sandstone boulders, from half to one-and-a-half tons in weight, form a wave breaker on the upstream face.

Materials.

The masonry dam (solid dams east and west, lock and sluice dam) is constructed of granite rubble masonry with "mosaic" facing of dressed granite ashlar.

Six to one mass concrete of crushed granite aggregate is used for the core wall and 4 to 1 fine concrete for a variety of purposes, such as linings to the lock culverts and penstock chambers, the arches over the sluice openings and parts of the sluice gate recesses, as a lining and outer covering to the steel subway pipe, for the top surfaces of the roadway, etc.

Sources of Materials.

Granite.—The granite is quarried at Gebel Sileitat, 30 kilometres north of Khartoum, where a few low boulder-covered outcrops of granite are to be found.

Ashlar is dressed at the quarries. Granite aggregate for concrete is crushed at the quarries and also at Gebel Aulia.

Sandstone.—This is quarried from the east side of Gebel Aulia.

Sand.—This is obtained from *Khors* (dry river-beds). The main source of supply is some 10 kilometres away on the west bank. A light railway has been laid to bring the sand to the stock heaps at the west end of the dam. Sand is also brought up the river in native boats from other smaller sources.

Cement.—In accordance with the terms of the contract with the Egyptian Government, Egyptian cement is used.

Towards the end of the First Season, masonry, with a mortar content of about 40 per cent. of 3 to 1 mortar, was being built at the rate of 1,200 tons a day.

Construction Programme. (See Fig. 2.)

During construction the Nile must remain open for navigation and provision must be made for by-passing the flood waters without causing any undue banking up of the river.

Since the construction railway, colony, offices, stores, etc., were on the east bank, work started from this side. The *sudds*, or temporary dams, were carried out to a point roughly halfway across the low-water Nile.

The solid dam east was built up to its full height for a length of 240 metres from its start. For the remaining 224 metres, the foundations were excavated and filled solid with masonry up to the top surface of the rock. This gap will form the diversion channel for the Nile towards the end of the Second Season.

Beyond the lock, which is now half-finished, masonry of three only of the first ten sluices has been built up to sill level of the sluices. Foundations for the remaining seven have not yet been completed. A gap is thus left between the lock and No. 1 training wall, over the eventual site of the first ten sluices. This will form the navigable channel towards the end of the Second Season.

At the beginning of the Second Season, No. 1 training wall, now half-finished, will be completed, and will form part of the *sudd* round the sluices to the west of it. Work on the first ten sluices will continue till they are built up to sill level.

During this period *sudds* will be in course of construction from the west bank of the river.

Prior to closing the gap between the existing *sudds* round the sluices to the west of No. 1 training wall, and the west bank, the *sudds* east of No. 1 training wall will be removed and the water let through over the sills of the first ten sluices. Shipping will then use this passage.

All railway traffic will cross the diversion channel by a timber trestle gantry running from the east bank to the lock. Westwards from the lock, the trestles will be of steel across the navigable channel with a 60-foot span steel swing bridge. Beyond No. 1 training wall the railway will run off the gantry on to the top of the *sudd* and so over to the west bank.

With the eventual completion of the sluice dam and the lock, the diversion channel will be *sudded* off and the masonry of the solid dam east completed.

The above is only a rough outline of the probable construction programme which is liable to considerable modification depending on the progress of the work.

The Contract.

Work is being carried out under a measurement contract. Payment is made only for the permanent work, and the contractor's prices for this cover the cost of all the temporary works such as *sudds*, gantry, cableways, approach railways, etc. Advances are made in respect of plant, stone, cement, sand and steelwork for the dam, when these are delivered on site.

The following is a rough summary of the quantities :—

Rubble masonry	278,500	metre cube.
Dressed granite	20,000	,, ,,
Concrete	115,500	,, ,,
Sandstone	105,800	,, ,,
Clay filling	336,200	,, ,,
Total ..	856,000	,, ,,
Rock excavation	70,000	,, ,,
Excavation for core wall ..	76,700	,, ,,
Dredging	54,000	,, ,,

Sub-Contractors.

The work is carried out by Italian sub-contractors, with Italian and Greek foremen. Egyptian masons and labourers do the bulk of the excavation and building. Sudanese labour is employed for carrying mortar, watering the masonry, loading and off-loading sand, cement, coal, etc. Stone at the quarries is dressed by Italian, Egyptian and Sudanese stone-cutters.

Supervision.

The work is set out and supervised by the contractor's staff of engineers and foremen.

The work is being done for the Egyptian Government, who are represented by the resident engineer and his staff of Egyptian directors of works, engineers and inspectors, assisted by a small staff of British advisers.

FIRST SEASON.

TEMPORARY WORKS.

Sudds and Sheet Steel Piling.

Before any work could be started it was necessary to make temporary dams, or *sudds*.

In shallow water near the banks of the Nile, these were made of clay, silt or old quarry débris, run out in Decauville skips, tipped and later faced with rock from the excavations, as a protection against erosion.

While work was proceeding on the solid dam east, inside small *sudds* of this description, the main *sudds* were being made.

These were constructed of old quarry débris from the back of the Gebel and rock rubbish from the excavations, carried in 4′ 8½″ gauge trucks, and either side-tipped or off-loaded into baskets and carried forward and dumped by the Egyptian labourers.

While this was in progress, the cutter-suction-dredger, with floating pipe line, was dredging over the site of the lock and discharging the spoil as far as possible on the eventual site of the main *sudd*.

Where the *sudd* was to be more than five or six metres high it was reinforced with a core of sheet steel piling, driven down to rock by the floating pile-drivers. The piling was sometimes done in advance of the tipping parties and sometimes after the *sudd* had been formed. In the former case it was found that the soft dredged bank was not always firm enough to support the piles and driving had to be stopped until the tipping parties caught up.

Pumping.

On completion of the *sudds* round an area to be de-watered, the pumps were installed. At the beginning of the season these were driven by belt from portable steam engines and later, following the completion of the power station, electrically-driven 12-in. and 10-in. centrifugal pumps were used.

During the pumping, soft excavation (silt and clay) was tipped outside the *sudd*. The pressure of water carried this into the *sudd* and closed the interstices in the rock rubble. At points where considerable leakage occurred, sandbags were used.

A balance had to be struck between the rate of de-watering and the rate of settlement of the *sudd*. In a case where pumping was too vigorous, the soft dredged bank started to slip and the piles were forced inwards to an eventual slope of about 45 degrees. Continuous tipping of sandbags and rubble at the weak point stopped any break-through. A few hours of sunshine bake the mud hard and subsidence is unlikely provided the inevitable percolation is kept down to small trickles.

Sumps.

When de-watering was nearly complete, sumps were dug in the soft silt, revetted with sandbags, and the rock excavated to a depth of a metre or two. One or more 10-in. pumps were erected near each sump and their suction pipes connected to the strainers and foot valves in the sump. Drainage channels were cut through the silt to lead in the remaining surface water and the water percolating through the *sudd*.

In the course of two or three days, the strong sun and dry wind hardened off the surface of the silt sufficiently to start laying derrick tracks and railway lines, ballasted with rock from the excavation which by that time was in progress.

Preliminaries to Permanent Work.

Setting Out.

The moment a *sudded* area was de-watered, the limits of the soft excavation were set out. The surface level of the silt and the probable reduced level of the rock surface was known. In the case of the solid dam, a table was prepared showing the foundation width relative to the foundation depth, resulting from the 40 to 1 and $1\frac{3}{4}$ to 1 batters on the U.S. and D.S. faces of the dam. By the specification, foundations were sunk at least one metre into the rock. It was thus possible to predict the dimensions of the trench to be cut in the rock. It was found by experience that a margin of 15 cms. over and above the exact foundation widths was advisable (since this was never cut conscientiously right up to the setting out marks), and also that a berm between half and one metre wide at the rock surface was necessary with a slope of between 2 to 1 and 1 to 1 for the soft excavation, to prevent this slipping down into the excavated trench.

Thus the position of pegs marking the limits of the soft excavation could be calculated, and there followed a mud-bathing party for the chainmen, who floundered about up to their waists putting in pegs, while the engineer directed operations from some temporary control point, with the aid of a theodolite and ranging rods.

As the work on the solid dam east progressed and the main *sudds* were being built, it was necessary to start a triangulation to establish known distances down the length of the dam and to fix the position of the lock. The base was 160 metres long, limited by the relatively high level of the Nile. A 6-in. vernier theodolite was used and four rounds of angles taken at each station.

Two points, on the main *sudds*, upstream and downstream of the main axis of the dam and as nearly as possible on the eventual axis of the lock, were observed and their co-ordinates calculated. Pillars were then built at points in relation to these, to bring the pillars on the axis of the lock and exactly at right angles to the main axis of the dam.

The type of pillar built was a tapering column of concrete, about four feet above ground-level, with a substantial foundation and reinforced with a steel rail driven four or five metres into the ground. At the top were bedded a ¾-in. bolt, with two cross-saw cuts in it, and a triangular steel plate with three legs, with a hole in the middle allowing the bolt to project ½-in. above the top of the plate. A piece of pipe, threaded ¾-in. internally, and one foot long, was screwed on to the bolt and formed a mark to sight on with a theodolite. When working at a pillar the pipe was unscrewed and the theodolite centred over the saw-cuts in the bolt. All these pieces of pipe were eventually stolen by the labourers, who were also very fond of the setting-out pegs, which came in handy for firewood.

Soft Excavation.

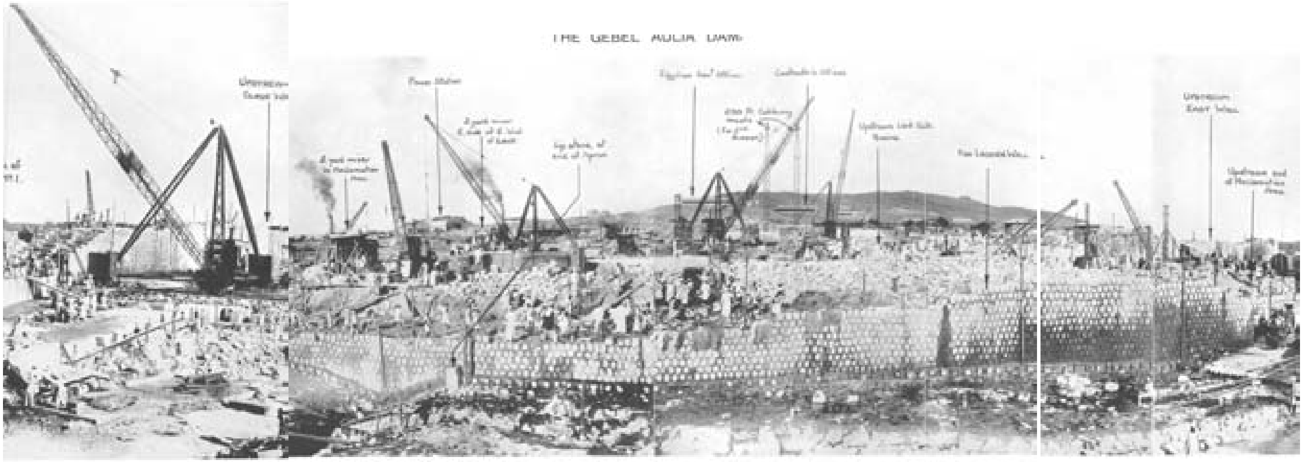
The silt, clay and mud overlying the rock was removed entirely by hand labour. A species of short-handled hoe is used to scrape it into a basket, which is carried away and tipped.

Rock Excavation.

Agreed Sections.—Once the surface of the rock has been bared, sections are taken and agreed with a Government engineer. These sections are five metres apart and spot levels are taken approximately every metre. From these original rock levels and the final rock levels, taken over the same sections, at the completion of the excavation, the cube of rock excavated is calculated.

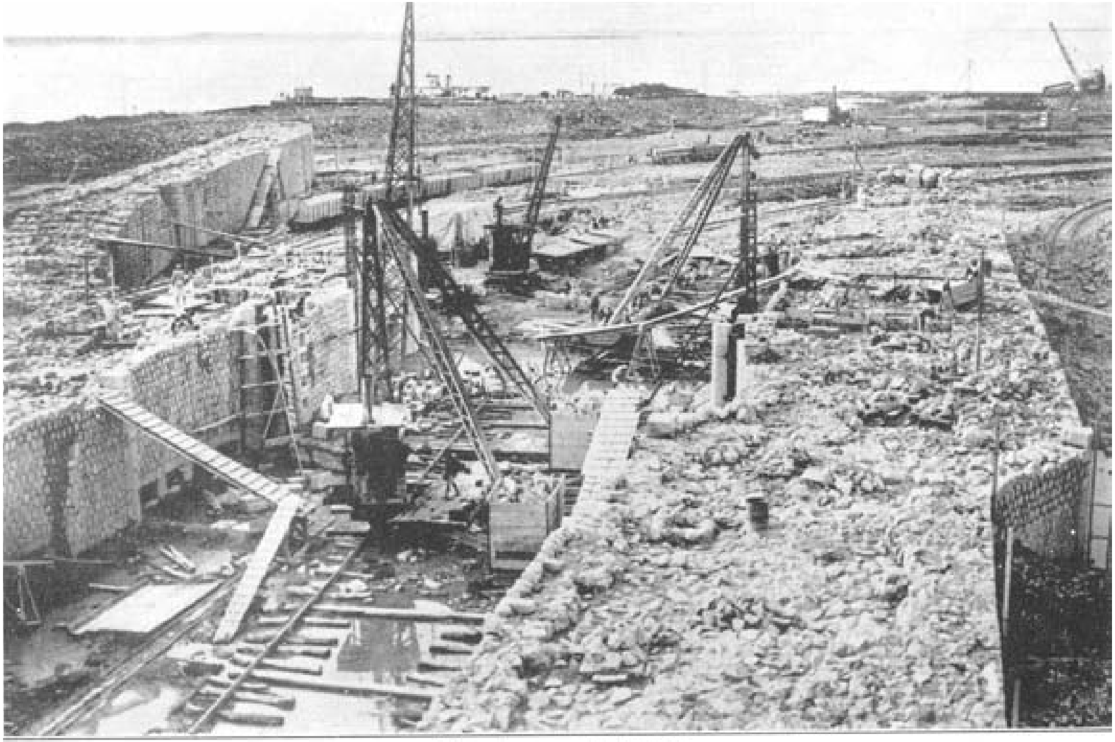
Marking Out.—It was found by experience that the best way to mark out rock excavation was to drill holes (by compressed air or by hand), if possible to a greater depth than the final foundation level, and then insert a steel bar or piece of pipe about six feet long.

Dog spikes are useful in soft rock, but after blasting are inclined



Panorama of west side of Lock.

Gebel Aulia Dam



Downstream end of Lock.

(By permission of Resident Engineer, Gebel Aulia Dam.)

Gebel Aulia Damdownstream end of lock

to disappear. A bar or pipe may get bent but is seldom blown completely out of position.

Bright blue paint, or preferably enamel, is useful in giving a preliminary line before there is time to insert bars, or for marking rock where the full width has not been properly taken out. Bright red enamel was used for all marks for level. The reason for using enamel is that when it is applied direct to rock surfaces it remains visible for a far greater time than oil paint. In the complex foundations for the lock, red and blue enamel was found to be invaluable for marking the final dimensions when trimming off the rock after the bulk of the excavation had been done.

Excavation.

Practically all the holes for the gelignite cartridges for the blasting were drilled by hand. The soft nature of most of the rock, which was sandstone or mudstone, caused choking of the central air blast hole of the compressed air drills. These were used only occasionally in hard mudstone. Holes were normally drilled to a depth of 60 to 90 cms. Two Sudanese rock drillers could produce four to six holes in an hour. Holes were spaced from one-and-a-half to two metres apart—the soft sandstone requiring closer drilling since the force of the explosion was cushioned by the soft stone. The mudstone, being laminated, was more easily shattered. As a general rule, the softer the rock the greater the quantity of explosive required for blasting.

After blasting, all loose rock was either carried out by hand or loaded into skips and removed by derrick. Picks, wedges and crowbars were employed to dig out the shattered rock and for removing the last 30 to 40 cms. above the actual foundation, within which limits no blasting was permitted.

One Ingersoll-Rand air-compressor, driving six paving-breakers, was employed chiefly on the cut-off trench, two metres deep and one and a half wide where no blasting was possible. The paving-breakers were also useful for trimming up the edges of the foundation trenches.

PERMANENT WORK.

Rubble Masonry.

This consists of pieces of granite from 6 to 60 kilograms in weight bedded in 3 to 1 mortar, except for the first 60 cms. in the foundations, where 2 to 1 mortar is used. The average production of one mason was three cubic metres a day. On piecework, a pair of masons are capable of building up to eight cubic metres a day.

The "mosaic" face work consists of picked stones, hammer-dressed on site, to roughly an hexagonal shape.

Profiles.

The facework is built to a string line, as in brickwork. The string is attached to "profiles" of timber (size about 3 in. x 1 in. with one edge " shot ") fixed 5 cms. outside the intended face of the masonry. The masons have small 5-cm. cubes which are placed at the desired point on the profile before attaching the line.

Profiles are first supported from 4 in. x 4 in. posts bedded in masonry on the rock. Later, as the wall rises, flat bars of cast-iron with a slot down the middle are built into the facework and the profiles bolted to them. When no longer needed they are broken off and pointed over.

Masonry in Cut-off and Foundations, and Pressure Grouting.

On completion of the rock excavation, two small channels, approximately 25 cms. wide and 15 cms. deep, were cut at each side of the bottom of the cut-off trench. These channels were graded down to sumps 1½ metres square and half a metre deep in the cut-off trench. The sumps were about 50 metres apart. A similar channel was cut at the downstream toe of the foundations. These served to carry off the water that seeped through the fissures in the sides of the excavation.

Masonry was started in the cut-off trench and built to a height of about one metre, leaving a gap of 25 cms. between the masonry and the sides of the cut-off. One-and-a-half-inch pipes were placed vertically at intervals along the channels. Small stones, or " spalls," were then thrown into the channels, to a depth of about 30 cms. and covered with a piece of sacking. Masonry was then built above the sacking to fill the gaps solid. Water was thus able to drain away, under the masonry, to the sumps.

Water seeping in above the level of the top of the cut-off was led to the sumps by small channels cut in the face of the sandstone and lipped with puddled clay.

Masonry round the sumps was stepped back. When the masonry had been built to a height of two or three metres round the sumps, a plain pipe was substituted for the suction pipe and foot valve of the steam ram pump used for de-watering the sump. While the pump continued to work and keep down the water-level, masonry was rapidly built into the sump, grout pipes being inserted at the same time. On completion of the masonry filling to the sump, the suction pipe was disconnected, and the pump removed for work elsewhere.

Once the masonry had set, the pipes were grouted with neat cement till a pressure of 100 lbs. sq. in. was obtained. The grout filled in the interstices between the spalls in the small channels and was also forced up the fissures in the rock.

In the construction of the lock, seepage water was led to sumps outside the foundations and these were similarly dealt with.

Boring and Pressure Grouting.

On account of the fissured nature of the foundation rock, 6-in. pipes were built vertically into the masonry at frequent intervals down the solid dam and over springs in the foundations. After the completion of the masonry to the full height, a boring rig was erected over each pipe and the rock bored to a depth of four to six metres below the foundation level. The bore holes were then grouted under pressure.

Ashlar.

Dressed granite is set on full beds of 2 to 1 mortar and beaten down into place with heavy mauls. Grouting is only permitted in the case of sill stones.

All joints in the face work are raked out and pointed with 1 to 1 mortar, using fine sifted sand.

Steelwork.

Glenfield & Kennedy have the contract for the steelwork for sluices and penstocks, and Sir William Arrol that for the lock gates, the temporary dam pontoons for the lock and the rolling lift bridge.

Electrical and Mechanical.

Power Station.

A temporary power station—D.C. dynamo, belt-driven, by two portable steam engines in tandem—was used to supply current for the colony lighting during the erection of the main power station. During this period no electrical plant was used on the work.

At the end of February the main power station was ready. This consists of two "6 V.K." type 600-h.p. Ruston diesel engines direct coupled to D.C. dynamos.

The voltage is 500. A three-wire system is used for the colony supply.

Plant.

For the first four months Ruston portable steam engines were used for driving all main pumps, shafting in the workshops, water-supply pumps and the stone-crusher. Stationary boilers supplied steam to the smaller pumps, used throughout the season, for de-watering the sumps in the masonry.

Small petrol-driven centrifugal pumps with single-cylinder Lister and four-cylinder Aster engines were also used.

The Butter's derricks and Smith cranes are all steam-driven.

With the completion of the power station, motors were coupled direct to the 10-in. Allen centrifugal pumps. These and the Gwynne centrifugal pumps, with Crompton Parkinson motors, were used for de-watering all the large *sudded* areas. The Gwynne pumps, with 10-in. delivery and 12-in. suction, had a capacity of 2,700 g.p.m.

The workshops, water-supply pumps and stone-crusher were later converted to electrical drive.

The main mixers for mortar were two-cubic-yard Stothert & Pitt steam-driven concrete mixers.

Small Winget portable mixers were used at places where a supply of mortar from the main mixers could not be arranged conveniently.

The pile-driving frames, when working on the *sudd* piling, were mounted on old hulls of stern-wheel steamers. The hammers are No. 7 McKiernan-Terry double-acting hammers, working at 100 lbs./sq. in.

Workshops.

The metal workshops are equipped for undertaking heavy repairs to the broad-gauge locomotives and all heavy plant. A small cupola furnace is installed and good quality iron castings are made, except when ants make their nests in the moulds on the foundry floor. Brass and alloy castings can be made from a crucible.

The carpenters' shop is equipped with a steam-driven circular saw. A planer and band-saw have been recently installed and will be electrically-driven through shafting and belts.

All the contractor's trucks, 4′ 8½″ gauge and 5-ton capacity, were built at Gebel Aulia.

Railways.

All the contractor's rolling-stock and locomotives are 4′ 8½″ gauge, while the gauge of the Sudan Government railways is 3′ 6″. All the stone from the quarries arrives in 35-ton steel bogie trucks, which necessitates a third rail to practically all the construction roads. The sleepers are of Sudan timber, hardwood logs sawn in two. The rails are flat-bottomed, dog-spiked to the sleepers.

Curves, as far as possible, are not less than 100 metres' radius, but curves down to 50 metres' radius were necessary where space was limited. Gradients of 1 in 50 are possible for short stretches.

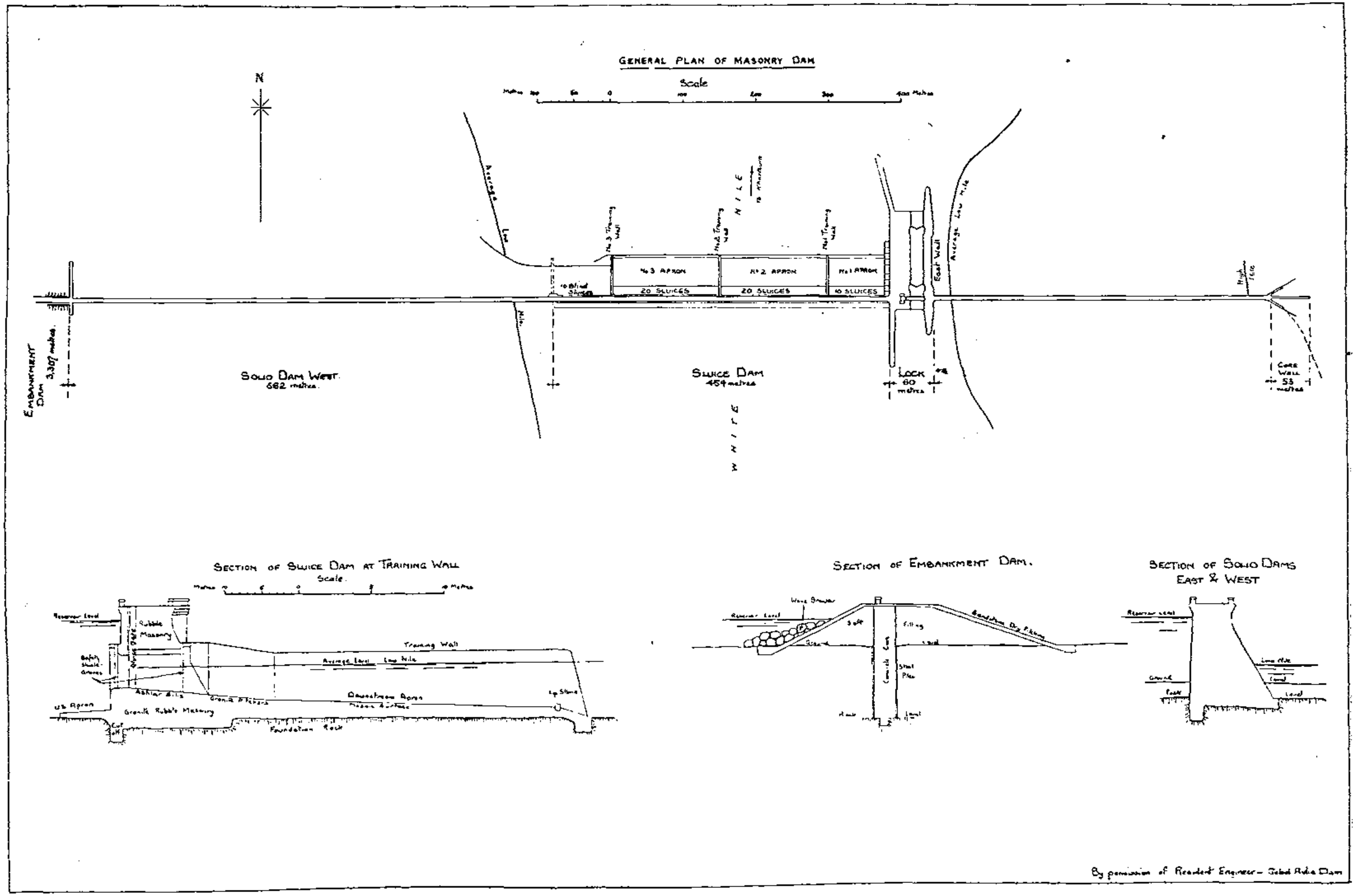
Subsidiary Works.

The colony contained a few houses, offices, stores and a hospital, built for the 1921 attempt at the dam. Further accommodation had to be provided for the contractor's and sub-contractor's staff, artisans, checkers and Egyptian masons and labourers. Sudanese labourers find accommodation in a local village.

The floating population in connection with the work together with their families numbers roughly 7,000.

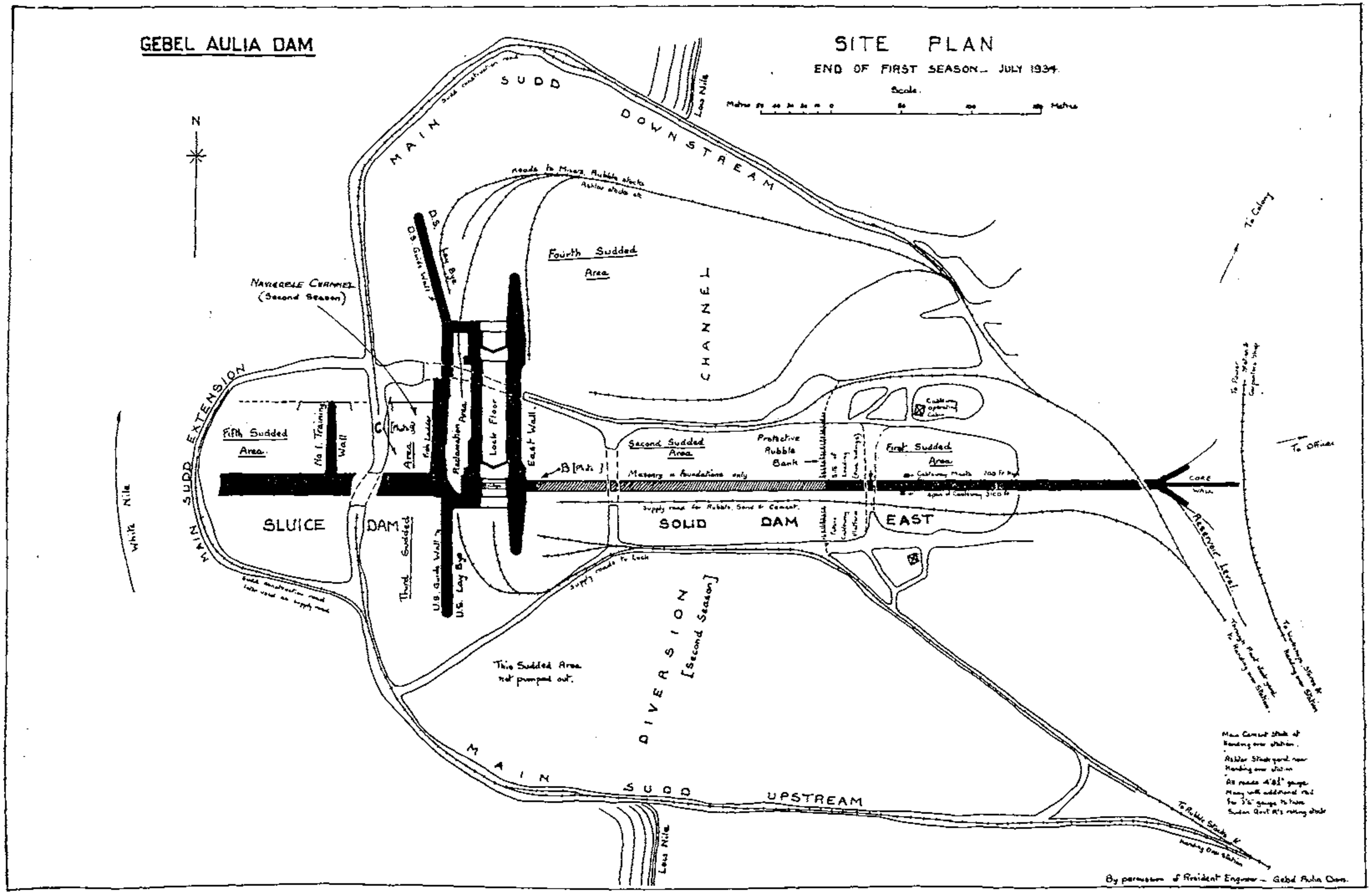
Electric light is provided to the quarters in the colony and a piped supply of chlorinated water is laid on.

FIG. 1



By permission of Resident Engineer – Jebel Aulia Dam

FIG. 2.


GEBEL AULIA DAM
SITE PLAN
END OF FIRST SEASON – JULY 1934.
Scale.
N
MAIN SUDD DOWNSTREAM
Low Nile
To Colony
Fourth Sudded Area
CHANNEL
Navigable Channel
(Second Season)
D.S. Lock Bye
D.S. Guide Wall
MAIN SUDD EXTENSION
Fifth Sudded Area.
No. 1. Training Wall
C
Area
Reclamation Area
Lock Floor
East Wall.
B
Second Sudded Area
Protective Rubble Bank
First Sudded Area
Masonry in foundations only
CORE WALL
To Offices
SLUICE DAM
Third Sudded
SOLID DAM EAST
U.S. Guide Wall
U.S. Lock Bye
Reservoir Level
White Nile
DIVERSION
[Second Season]
This Sudded Area not pumped out.
MAIN SUDD UPSTREAM
Low Nile
By permission of Resident Engineer – Gebel Aulia Dam.

WATER-SUPPLY IN A DESERT COUNTRY.

(Winning Essay for the Cooper's Hill War Memorial Prize, 1935.)

By LIEUTENANT H. P. DRAYSON, R.E.

Subject.

1. *Discuss the water-supply problems that will confront a small mechanized force operating in a desert country, and give your views on the organization and equipment of the engineer units that should accompany such a force.*

Background.

The force is of all arms, entirely mechanized and motorized, consisting of 4,000 *men and* 700 *vehicles with water-cooled engines. It is to be concentrated at Port " A," and its role is to relieve as rapidly as possible a force besieged in the town " B,"* 400 *miles distant.*

There are well-watered strips of country round " A " and " B," separated by 300 *miles of desert. Water exists at two oases, " X" and " Y,"* 100 *miles apart in the desert.*

Each of these oases is known to be able to supply a concentration of 1,000 *tribesmen and their flocks. Oasis " X " consists of a series of shallow wells, whose rest level is about five feet below ground level. Oasis " Y " consists of a few deep wells, whose rest level is* 100 *feet below ground level.*

No serious opposition is expected from the tribesmen, who are besieging " B," until the fertile area round that town is reached.

1. INTRODUCTION.

THE advent of mechanization in the Army has simplified many of the problems of a force on the move, and one of those, which have been helped most, is that of water-supply. Particularly when a force is operating in a desert country, the question of water-supply is of paramount importance, and the plans of a commander are entirely dependent on his ability to obtain sufficient water at comparatively short intervals of time for his men, animals and vehicles. The replacement of animals by vehicles has reduced the consumption of water to a large degree, and mechanical appliances have speeded up the time required for preparation and issue of the water considerably. More important still is the fact that the increased speed of a force on the march has reduced the times taken to travel between existing sources of water to about one-quarter of those which obtained previously. The importance of the water-supply problem, however, is in no wise minimized, although the solution is simplified.

In any operation in desert country there are many factors, which will influence its execution. The nature of the country will regulate the rate of movement ; the time of year and temperature will influence the scale of water to be supplied. The sources and quality of water available, the composition of the force, the types and capabilities of the vehicles, and the water-supply equipment available all play their part in modifying the course of the operation. Some of these factors will be known to the commander before he leaves his base, but some will be wholly or in part unknown, and allowance must be made for the unforeseen happenings, which might otherwise jeopardize the success of the operation.

In this essay assumptions have had to be made with regard to the composition of the force and the intentions of its commander. Other necessary assumptions as to the nature of the country, weather conditions, rate of progress, and quality of water have been based on average conditions, as experienced by the author in the deserts of north-east Africa and south-west Asia at various seasons of the year. In cases where the commander of the force would not himself know the conditions to be encountered, allowance has been made in most cases for the worst possible eventualities.

The question of equipment is not entirely straightforward, as the Army at the present day is in a transition stage, pending complete mechanization. Accordingly, two situations have been visualized. In the first, only such vehicles and equipment, as are at present included in the *War Establishments* of the units concerned, have been included. As an alternative, some vehicles and water-supply plant, which are at present in the experimental stage, have been introduced into the scheme, as they will in all probability become standard equipment at some future date.

The factors influencing the water-supply problem of a force operating in a desert country are to a great extent interdependent, but in the following paragraphs they have been dealt with, as far as possible, in a logical sequence.

2. NATURE OF THE COUNTRY.

One of the features of desert country is the infinite variety. Though there are few types of desert that will actually prove a barrier to suitably equipped modern vehicles, the rate of progress of such vehicles will be materially affected, as was exemplified by the War Office Experimental Convoy, 1933, whose daily mileages in the Libyan desert varied between such wide limits as 14 and 144 miles per day. The flat gravel plains of Iraq enable M.T. vehicles to travel at speeds up to 50 m.p.h. at all times of the year; the undulating gravel and mud plains of Transjordan are easily passable in dry weather, but after rain they may be impassable for two or three days; the soft or crusted sand of the Libyan desert is often more compact and easier to cross after rain; sandstone and limestone outcrops which are common to most deserts may necessitate détours being made, with consequent loss of time; soft sand-dunes, such as are found in North Africa, and belts of large basalt boulders, such as the lava belt near Kasr el Azrak in Transjordan, are not normally passable by M.T. vehicles and will not be considered; where the desert is scrub-covered, hummocks of sand, which form round the scrub, reduce the speed of vehicles in varying degrees, but such country is seldom impassable. It may be assumed that in 300 miles of desert travel, at least three of such types of country will be met, and that a convoy of 700 vehicles will not normally average more than 60 or 70 miles per day, as night driving is not likely to be possible. In the case under review there is a well-watered strip of country for a distance of 50 miles round "A," then 100 miles of desert to oasis "X," where water is next obtainable. There is then 100 miles of waterless desert to oasis "Y," and a further 100 miles before reaching the well-watered area, which stretches for 50 miles round "B."

It has been assumed that the relieving force will be able to move 100 miles from a water point, to be established on the edge of the cultivated area round "A," to oasis "X" in one day, but that two days will be required for each of the succeeding 100-mile stretches of waterless desert.

3. Effect of Temperature.

The time of year when the operation is to take place will affect the scale of water required. British troops can be trained to manage on two pints of water per day in the cool season, whereas for untrained troops in the heat of summer one gallon per day is barely sufficient even for short periods. Vehicles, too, will need more water in hot weather, though modern vehicles, complying with the W.D. specification for tropical cooling, should lose little if any water through boiling, and only about one pint per day through surging. Boiling losses in vehicles, not complying with this specification, might be considerable in the summer in difficult country. Also, it must be borne in mind that occasions arise, when a following wind with a velocity of about 20 m.p.h. will neutralize the draught of air through the radiator, which the movement of the vehicles produces. In such circumstances a convoy of vehicles may become temporarily immobilized, owing to excessive boiling.

Assuming average conditions, a reasonable allowance of water for a force on the march would be one gallon per man per day and one gallon per vehicle per 100 miles. This scale would allow for excessive wastage in a proportion of the vehicles, due to mechanical troubles. For the detachments remaining at the water points (see paragraph 6) an allowance of two gallons per man per day should be made.

4. Sources of Water-Supply.

(*a*) *Port " A."*

The distance from Port " A " to oasis " X " is 150 miles, of which the first 50 miles lies through well-watered country, which will in all probability be cultivated land intersected by a network of canals, with mud roads running along their banks. It has been assumed that the relieving force will assemble at a starting-point near the edge of this cultivated area, and will have all water containers filled at this point, leaving only 100 miles to traverse to oasis " X," and it is expected that this stage will be completed in one day. Accordingly a water point will have to be established on the edge of the cultivated area, unless one has been previously prepared by the garrison at Port " A," or the local P.W.D. Wells of clear water may or may not be available, but the usual sources of supply in such localities are the irrigation canals. The canal water generally contains a quantity of suspended matter, and is used by men and animals alike for bathing purposes. Sedimentation and chlorination will therefore be necessary before the water is fit for human consumption. Water for the vehicles will need sedimentation but not chlorination.

(*b*) *Oasis " X."*

This consists of a series of shallow wells, which supplies 1,000 tribesmen and their flocks. The yield should therefore be sufficient for the needs of the relieving force. The quality of water from shallow wells varies considerably. At Selima oasis, in the Libyan desert, the water is soft, clear and pure. At El Sheb, 80 miles away, it is dirty and somewhat brackish. In the wells along the Red Sea littoral, it is often salt or highly purgative. But it may be assumed that if the tribesmen can drink the water, it will be potable, though possibly not very palatable. Owing to the possibility of the water being fouled by the flocks, it should be chlorinated for drinking purposes, but there should not be any need for sedimentation.

(*c*) *Oasis " Y."*

There are a few deep wells, whose rest level is 100 feet below ground level. Here again the quality is probably variable; for example, at Maatul, in the Sudan, the Arabs would drink the water of only two of a group of three deep wells. In general deep well water should not require sedimentation, though chlorination will probably be necessary. As at oasis " X," the quantity available should be sufficient for the needs of the force.

(*d*) *Cultivated Area Round " B."*

After 100 miles of desert from oasis " Y," there is well-watered country for the last 50 miles to town " B." Here opposition may be expected, and it will probably be necessary to establish a water point on the fringe of this cultivated area, where the conditions will be similar to those in the country round Port " A." Sedimentation and chlorination will be necessary. In town " B " itself, there must be an existing water-supply, though its degree of purity will be doubtful.

5. Composition of the Relieving Force.

The force, which is entirely mechanized and motorized, consists of 4,000 men and 700 vehicles. Without detailing the composition of the various units, in some of which the transport arrangements are largely conjectural, it has been assumed that the force consists of the following units :—

One infantry brigade, less one battalion.
One cavalry armoured-car regiment.
One field battery, R.A.
One light battery, R.A.
One field company, R.E.
One brigade signal section.
A proportion of the divisional ammunition column.
One section of a divisional baggage company, R.A.S.C.
One section of a divisional supply company, R.A.S.C.
One field ambulance.
One divisional ordnance workshop.

The commander of the infantry brigade will command the force.

6. Probable March Table.

It has been assumed that Port " A " is already garrisoned, that the whole of the relieving force is therefore available to march towards " B," and that existing watering arrangements at Port " A " will be able to supply the needs of the relieving force as far as water point No. 1 on the edge of the cultivated area round " A."

The water points, which must be established at oases " X " and " Y," will need protection from raiding parties, and the assumption has been made that the force commander will leave one company of infantry at each of these points, together with a water detachment R.E., and possibly small detachments of R.A.S.C., R.A.M.C. and

R.A.O.C. These detachments will be kept down to a minimum, as the striking force at " B " should be as large as possible. There will inevitably be slight variations in the strengths of the detachments left at the various water points, so that average figures of 50 men and 10 vehicles at W.P. No. 1 and of 250 men and 25 vehicles at each of W.P's Nos. 2 and 3 have been assumed.

The role of the relieving force on arrival at " B " has not been clearly indicated. Is the whole or part of the relieving force to remain at " B " and hold the town, or is the town to be completely evacuated? If so, what is the strength of the besieged force, which will be returning with the relieving force, and is it motorized? The most difficult case will be assumed, *i.e.*, that town " B " is to be completely evacuated and that the besieged force consisting of 1,000 men and 150 vehicles can be motorized entirely.

The probable march table will then be as under :—

Z − 1 day	Water point No. 1 will be established on the fringe of the cultivated area round " A." Relieving force will be concentrated at W.P. No. 1 that evening.
Z day	Force, less 50 men and 10 vehicles, will move to oasis " X." W.P. No. 2 will be established at the oasis that evening.
Z + 1 / Z + 2 } days	Force, less 250 men and 25 vehicles left at W.P. No. 2, will move to oasis " Y." W.P. No. 3 will be established at oasis " Y " on the evening of Z + 2 day.
Z + 3 / Z + 4 } days	Force, less 250 men and 25 vehicles left at W.P. No. 3, will move to the edge of the cultivated area round " B." W.P. No. 4 will be established at this point on the evening of Z + 4 day. It is possible that opposition may be met at this point, and that W.P. No. 4 cannot be established until the following day, or even that the force may have to retire on oasis " Y." In either of these eventualities, the day's reserve and the " iron ration " will be available.
Z + 5 day	Operations will commence in the relief of " B." The duration of these operations is an unknown quantity, and the relieving force will probably be based on W.P. No. 4 during this period. The evacuation will be assumed to commence on ZZ day.

Night ZZ − 1/ZZ ..	W.P. No. 4 will close down and be dismantled.
ZZ, ZZ + 1 days ..	The relieving and besieged forces will move to oasis " Y."
Night ZZ + 1/ZZ + 2	W.P. No. 3 will be dismantled.
ZZ + 2, ZZ + 3 days ..	Combined force, including detachment at W.P. No. 3 will move to oasis " X."
Night ZZ + 3/ZZ + 4	W.P. No. 2 will be dismantled.
ZZ + 4 day	Combined force, including detachment at W.P. No. 2, will move to W.P. No. 1.
ZZ + 5 day, *et seq.* ..	Combined force will be based on W.P. No. 1 which will be dismantled when no longer required.

7. WATER REQUIREMENTS.

The quantity of water, which each water point must be capable of producing, can now be worked out.

The scale of water-supply (see paragraph 3) is to be :—

- 1 gallon per man per day for each day's march.
- 1 gallon per man to be carried as a reserve throughout the operation.
- 2 gallons per man per day at rest.
- 1 gallon per vehicle per 100 miles.

In addition an " iron ration " will be carried on each vehicle for use in case of dire necessity only. This will consist of :—

- 1 *fantasse* (12-gallon camel tank) of drinking-water per lorry or truck carrying personnel.
- 1 2-gallon tin of drinking-water per other vehicle.
- 1 gallon of unchlorinated water per vehicle. This will be carried in a 2-gallon tin together with the gallon of water issued for the 100-mile run.

Each water point should produce a surplus of about 20% of the anticipated requirements to make good wastage during delivery to units, and to cope with unforeseen calls for water.

The following table shows the daily requirements of water at each water point. Subsequent events may cause some alteration in the actual quantities required, but the scale of equipment suggested (see paragraph 9) will enable the output of the various water points to be increased if necessary.

TABLE SHOWING DAILY WATER REQUIREMENTS.

1	2	3	4	5	6	7	8	9	10	11	(d) 12	13	14
		Size of force.		Gallons of water required. (c)			(a)	1,500 gallon tanks required.					
Day for which water is required.	Location.	Men.	Vehicles.	Chlorinated.	Unchlorinated.	Total including spare.	Pumps required	Sedimentation.	Chlorination.	Total.	Hours required for pumping and purification.	Time water will be available.	Remarks.
Z	W.P.1	4000	700	14000	1400	18000	4	12	12	24	11½	Evening Z−1	Water-supply includes that for one day's march, one day's reserve, and iron ration. Only 6 tanks will be left behind when the force moves away from W.P.1.
Z+1	W.P.1	50	10	100	—	150	1	1	1	2	†	Morning Z+1	Two gallons of water per day for men at rest.
Z+1 / Z+2	W.P.2	3700	665	7400	665	9750 }	3	—	7	7	1¾	Night Z/Z+1	Two days' supply for march to W.P.3. Only 6 tanks will be left behind.
Z+1	W.P.2	250	25	500	—	600 }						Morning Z+1	One day's supply for detachment left at W.P.2.
Z+2	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening Z+1	
Z+2	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening Z+1	Six tanks will, however, probably be kept at W.P.2.
Z+3	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening Z+2	
Z+3	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening Z+2	
Z+3 & 4	W.P.3	3450	640	6900	640	9000 }	2 (b)	—	6	6	2	Night Z+2/Z+3	Two days' supply for march to W.P.4.
Z+3	W.P.3	250	25	500	—	600 }						Morning Z+3	One day's supply for detachment left at W.P.3.
Z+4	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening Z+3	
Z+4	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening Z+3	
Z+4	W.P.3	250	25	500	—	600	1	—	1	1	†	Evening Z+3	Six tanks will probably be kept at W.P.3.
Z+5	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening Z+4	
Z+5	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening Z+4	
Z+5	W.P.3	250	25	500	—	600	1	—	1	1	†	Evening Z+4	
Z+5	W.P.4	3450	640	3450	640	4500	2	3	3	6	10	Morning Z+5	
Z+6 *et seq.*	As for Z+5, unless a fifth water point has to be established.												Extra water can be made available at W.P.4 if required, for washing, etc.

ZZ	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening ZZ−1	
ZZ	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening ZZ−1	
ZZ	W.P.3	250	25	500	—	600	1	—	1	1	†	Evening ZZ−1	
ZZ ZZ+1	W.P.4	4450	790	8900	790	12000	2	4	8	12	12½	Night ZZ−1/ZZ	W.P.4 is dismantled early on ZZ morning.
ZZ+1	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening ZZ	
ZZ+1	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening ZZ	
ZZ+1	W.P.3	250	25	500	—	600	1	—	1	1	†	Evening ZZ	
ZZ+2	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening ZZ+1	
ZZ+2	W.P.2	250	25	500	—	600	1	-	1	1	†	Evening ZZ+1	
ZZ+2 ZZ+3	W.P.3	4700	815	9400	815	12000	1	—	8	8	4½	Evening ZZ+1	9,000 gallons in 6 tanks will have been previously stored and purified and will be ready on arrival of force at W.P.3. 3,000 gallons will have to be pumped and purified subsequently.
ZZ+3	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening ZZ+2	
ZZ+3	W.P.2	250	25	500	—	600	1	—	1	1	†	Evening ZZ+2	
ZZ+4	W.P.1	50	10	100	—	150	1	1	1	2	†	Evening ZZ+3	
ZZ+4	W.P.2	4950	840	4950	840	7500	1	—	5	5	3	Evening ZZ+3	Stored and purified previously. Ready on arrival of force at W.P.2.
ZZ+5	W.P.1	5000	850	5000	—	7500	1	1	5	6	45	Evening ZZ+4	Stored and purified previously. Ready on arrival of force at W.P.1.
				5000	850	9000	4	6	6	12	10	Morning ZZ+5	Pumps and tanks from incoming force used to give extra water-supply.
ZZ+6 if required	W.P.1	5000	850	10000	—	12000	4	8	8	16	10½	Evening ZZ+5	This scale of water will be available until the force leaves Port "A."

Notes.

(a) Col. 8. It is assumed that each pump can deliver 3,000 g.p.h. against 100-ft. head.
(b) Col. 8. Either two submersible pumps, or else two water elevators, and two centrifugal pumping sets.
(†) Col. 12. Several days' supply will be pumped and purified at one time.
(c) Cols. 5–7. The quantities of water shown are minimum quantities. Proper water discipline will have to be maintained to ensure that all containers are full at the start of each day's march, and that the water is correctly used.
(d) Col. 12. It has been assumed that chlorination will always take place before delivery to units; this is a simpler and more satisfactory method than relying on the units' water trucks or trailers for this purpose.

The use of chlorine gas on the lines of the "Sparklet" bulb might lessen the time required for purification, but investigation of such a method would be necessary.

8. EQUIPMENT AVAILABLE.

(*a*) *Transport Vehicles.*

Experiments and trials have up to the present shown that for general cross-country transport purposes the 6-wheeled lorry is the most suitable type for the carriage of 3-ton and 30-cwt. loads, although 4-wheelers can carry 30-cwt. loads over most types of country that a 6-wheeler can cross. (*Vide R.U.S.I. Journal*, February, 1935, p. 6.) But for loads of 1 ton or less, a 4-wheeled lorry or truck is not only equally serviceable, but is also considerably cheaper in both initial and running costs. Tracks, of course, have their own scale of cross-country performance, but are outside the scope of this essay.

At the present day the transport vehicles of mechanized units consist of :—

- 3-ton 6-wheeled lorries for the carriage of stores and equipment.
- 30-cwt. 6-wheeled lorries for the carriage of personnel and equipment.
- 4-seater touring cars for unit commanders.
- 2-seater touring cars for reconnaissance purposes.
- Trailers for carrying field kitchens, water tanks, bridging gear and air-compressor sets.

These trailers have certain disadvantages in that they limit the performance of the towing vehicles, increase very considerably the turning circle of the combined unit, and are difficult to manhandle over rough ground.

Recent developments make it probable that a 1-ton 4-wheeled truck will shortly be introduced in the scale of military equipment. This vehicle will not replace but will supplement the 6-wheeler, and will be available for a variety of purposes. It will probably replace the trailers at present in use, except for certain bridging loads, and it will also be used for the carriage of personnel. One truck will then carry either a field kitchen, a 200-gallon water tank unit complete with purification plant, or eight armed men with their equipment. In this last respect it will be inferior to the 30-cwt. 6-wheeled lorry, which carries 14 armed men with their equipment, but its performance both on the road and cross-country will be comparable with that of the 6-wheeler, at less than half the cost.

If the operation under discussion is assumed to take place at the present day, it is probable that the personnel will be carried in light 6-wheelers. The water for vehicles will be carried in a 2-gallon tin on each vehicle ; this allows 1 gallon per vehicle for the 100-mile journey between water points together with 1 gallon in reserve.

The drinking water will be carried partly in the 180-gallon water-tank trailers, with which units are now equipped, and partly in special water vehicles. These latter may consist of lorries carrying *fantasses* (12-gallon camel tanks) or having special tanks mounted on them, or possibly they would be 600-gallon "Scammel" type petrol tankers, a few of which could be obtained in Syria and Palestine. A medium 6-wheeler can carry a cross-country load of about 500 gallons of water in containers, and a light 6-wheeler about 250 gallons.

If the 1-ton 4-wheeler trucks, mentioned above, are eventually included in unit equipment, it is probable that they will be used for the carriage of personnel and of water, and in the latter case will be fitted with special 200-gallon tanks, complete with purification apparatus. These standard water trucks will have to be supplemented with improvised water vehicles, in order to provide carriage for the three days' water-supply, which the force carries at the outset of each two days' march.

Another very important development is the use of vehicle engines as a source of power for tools and machines. A new flexible drive will probably eliminate the necessity for separate prime-movers for these tools and machines, which can then be driven from any vehicles fitted with a power take-off from the gear box. This will apply equally to a 2-seater car as to a 3-ton 6-wheeled lorry.

(*b*) *Water-supply Equipment.*

At present a mechanized field company carries the following water-supply equipment :—

One pumping set, centrifugal, No. 1, with a delivery of 3,700 g.p.h. against a head of 100 feet.

One water elevator, No. 1, with 250 feet of chain, which can deliver 3,000 g.p.h.

One tank, water, canvas, (S), portable, of the self-erecting type, with a capacity of 1,500 gallons.

Six pumps, lift-and-force, Mark V.

These are carried in a light 6-wheeled lorry.

9. Organization and Scale of Equipment of the Engineer Units.

(*a*) The duties of the engineer units on the line of march from Port "A" to town "B" will consist almost entirely of water-supply. But on arrival at the cultivated area round "B" many other problems will arise, probably involving bridging operations, demolitions, road blocks, etc. For this reason it has been assumed that a field company will be needed. The subject of this essay is water-supply, so that the scale of bridging equipment, etc., to be carried will not be discussed here.

(*b*) It is not considered desirable that any one section of the field company should be detailed for water-supply duties, but it would be preferable to detach personnel for each of the four water points from different sections. Thus No. 1 section would be detailed to erect No. 1 water point. The section commander would utilize his section to erect the water point, and deliver the necessary amount of water on the evening of Z — 1 day. He would leave a detachment of, say, 1 N.C.O. and 3 sappers to maintain the water point until the return of the force, and he and the majority of his section would move on with the force to " B." Similarly, No. 2 section would be responsible for No. 2 water point, with the result that the field company commander, on arrival at the cultivated area round " B," would have four sections, almost at full strength, available for work.

(*c*) The number of tanks and pumps required at each water point on any given day have been shown in the table in paragraph 7. In arriving at these figures it has been assumed that the water at W.P's Nos. 1 and 4 will need sedimentation, and that it will need chlorination at all four water points. On the outward march, when it is not possible to prepare water points prior to the arrival of the force, the number of sedimentation tanks will be the same as the number of storage tanks, so that the time of purification can be reduced to a minimum. On the homeward march, where ample time is available for purification of the force's requirements of water, the number of tanks can to some extent be reduced. It has been assumed that eight hours will be needed for sedimentation, half-hour for chlorination, and that each pump will be able to deliver 3,000 g.p.h.

It will be seen from the table that on Z — 1 day 24 tanks and 4 pumps will be required at W.P. No. 1, but that not more than 6 tanks and 1 pump will be required until ZZ + 5 day, when the whole force will be back. The situation at the other water points is similar. Accordingly, to avoid having an excessively large amount of equipment, some of it will have to be used at more than one water point. For instance, when the force leaves W.P. No. 1 on Z day, 12 of the 18 water tanks and three of the four pumps in use at W.P. No. 1 can be taken on with the force. The field company commander must decide on how he will arrange this pooling of equipment. The scale suggested in the sub-paragraph (*d*) below is sufficient to meet the needs of this operation at any period, and moreover allows for either a small submersible pump or a lift-and-force pump to be held as a reserve at each water point.

(*d*) A suitable scale of water-supply equipment to be carried by the field company is then as follows :—

(1) *Using Existing Equipment.*

	H.Q.	*No. 1 Sec.*	*No. 2 Sec.*	*No. 3 Sec.*	*No. 4 Sec.*	*Total.*
Pumping sets, centrifugal, No. 1, complete with 100-ft. hose	1	1	1	1	1	5
Pumps, lift-and-force, Mark V	2	1	1	1	1	6
Horrock's water-testing box	1	1	1	1	1	5
Water elevators, No. 1, 250-ft. chain	2	–	–	–	–	2
Tanks, water, canvas, (S), portable	6	6	6	6	6	30
Light 6-wheeler (in addition to the derrick lorry) ..	1	1	1	1	1	5

Notes.

(i) The two water elevators will be allotted to No. 3 Section for this operation.

(ii) On the outward march the pumping sets and canvas tanks will have to be pooled to some extent at each water point, as previously outlined.

(iii) On arrival at the cultivated area round " B," the equipment of H.Q. can be used to form a fifth water point if required.

(2) *Using Equipment which is likely to be Available in the Future.*

	H.Q.	*No. 1 Sec.*	*No. 2 Sec.*	*No. 3 Sec.*	*No. 4 Sec.*	*Total.*
Pumps, submersible, No. 1 (3,500 g.p.h.)	1	1	1	1	1	5
Pumps, submersible, No. 2 (1,000 g.p.h.)	1	1	1	1	1	5
Hose, feet	150	150	150	300	150	900
Tanks, water, canvas, (S) portable	6	6	6	6	6	30
Horrock's water-testing box	1	1	1	1	1	5
2-seater car, with power take-off, in addition to section commander's car	1	1	1	1	1	5
1-ton 4-wheeled water truck, with power take-off	1	1	1	1	1	5

Notes (ii) and (iii) of the previous equipment list apply to this list equally.

(3) *General.*

No mention has been made of such articles as alum, bleaching powder, spare parts for pumps, timber, sandbags, etc. The scale of these must be decided by the field company commander.

10. CONCLUSION.

In this essay the author has assumed a probable course of the operation under such conditions as are likely to be encountered on an average. Unforeseen events will in all probability alter this course, but it is considered that with the organization and equipment suggested, the field company commander will be able to cope with such eventualities as may arise.

As regards the organization, the most important point is that each section will detach a small party, complete with its equipment and transport, so that on arrival at the final objective there will still be four sections of the field company available for work.

The proposed new vehicles and equipment are still in the experimental stage, and their possibilities would need to be investigated before they were included in a force, with a role to perform, comparable with that under review.

The scale of equipment, which has been suggested, is considerably in excess of that normally associated with a field company, but as the success of the operation depends on an adequate supply of water, it is preferable to have a reserve of water and pumps at each water point than to run the risk of failure in the main issue.

THE BRITISH TRANS-GREENLAND EXPEDITION, 1934.

By LIEUTENANT A. S. T. GODFREY, R.E.

THE late Mr. Watkins, the leader of the British Arctic Air Route Expedition, when flying near Kangerdlugsuak Fjord on the east coast of Greenland, saw range upon range of mountains stretching to the north and east towards Scoresby Sund.

Lieut. Martin Lindsay of the Royal Scots Fusiliers, who was a member of the B.A.A.R.E., decided to lead an expedition to explore these unknown mountains. He considered that it would be impossible to reach these mountains from the east coast; first, owing to the pack ice which always lies off this coast; secondly, even if a boat got through, owing to the steep and badly crevassed glacial ascent from the seaboard. His decision entailed preparing to sledge some 400 miles across the ice-cap from the west before expecting a landfall in these mountains, and then some 600 miles home. The depoting of food on the ice-cap is not practicable over the winter, as the precipitation is so great and depots get drifted over with snow, so his expedition would have to be self-supporting. It was vital, therefore, to have the best possible dogs and to start the journey with them in the finest possible condition.

To secure this advantage Andrew Croft was chosen for the expedition and went off to the west coast of Greenland in the autumn of 1933. His job was to choose the best forty-two dogs in Jacobshavn and sledge them into three teams of fourteen dogs and also to choose the best place of ascent to the ice-cap and put a dump of dog food and pemmican on the edge of the ice-cap.

I had the great good fortune to meet Martin Lindsay when we were both enjoying a gas course. He told me about his projected expedition which was then well in train. I asked him to remember me if ever he was leading another expedition and later I had the luck to be asked to go to Greenland with him as surveyor and navigator. Having done the survey course, I imagined that I could survey. When it came to the point, I could not even remember the jargon, so began frantically to study the subject. Fortunately a special survey course was very kindly arranged for me at the S.M.E.

We crossed to Copenhagen and started our journey in the Danish vessel *Gertrud Rask*, a four-masted auxiliary schooner of some 400 tons. The journey to Jacobshavn on the west coast of Greenland should have taken some twenty days. It took us double that.

First, there was storm after storm off the south of Greenland and we never seemed to round Cape Farewell until we thought we were with another Flying Dutchman. Then, when we were a day's run from our objective, a northerly storm got up and drove the pack-ice down on us. For eighteen days we could not go to the north. Though we saw many seals and great quantities of walrus, and also put into several settlements, which gave us an idea of the Greenlander's life on the west coast, we were very restive and were thankful when we finally met Andrew Croft at Jacobshavn on May 19th.

We were three weeks late and the spring thaw had set in. Owing to this we just missed the chance of sledging to our starting-point on sea ice. This was a very great blow to us as, instead of two days sledging, it meant sledging some hundred miles overland, relaying our stores, and it might take any time. Actually it took us eight days, even with the help of the Eskimos; they were the eight most strenuous days I have ever spent. I had never seen a sledge dog, let alone try to drive a team of fourteen who seemed to sense before I started that I was a tyro. The snow was melting off the hills and we had to haul and shove to help the dogs pull the sledges over rocks and grass, and were reduced often to pack-carrying, sledging up the hillsides later with empty sledges. Now, as for the whole journey, we sledged at night until it became too cold and dark, for it was better for the dogs to sleep in the warmth and sledge in the cold. They got less hungry and out of condition; later, when we had to sledge by day it was pathetic to see how quickly it affected them. The midnight sun made colourful sunsets and sunrises to merge into one another, and on our approach to the ice-cap these and the rugged grandeur and wildness of the scenery made an unforgettable impression on us.

We reached our depot at the edge of the ice-cap on June 2nd. Here the Eskimos left us and we three were on our own. We spent a week re-sorting our stores, resting the dogs, and relaying one and a half tons of stores to a depot a few miles inside the ice-cap. We had hoped to depot half our stores some fifty miles in, on the ice-cap. This would have saved the dogs pulling full loads up the steep slopes at the edge of the ice-cap, but owing to having had to sledge overland we had not sufficient dog food for this.

We planned to start the journey proper on June 10th. Two days before this we had a rainstorm. In thirty-six hours all the snow in sight was washed away, exposing blue crevassed ice ridges, and the intervening valleys were full of snow slush. The bad weather continued for another week and in this week, working all out, we only managed to get forward fourteen miles. We lost five dogs down crevasses. Several more went down but we recovered these by lowering a member of the expedition after them at the end of an alpine rope.

Our morale was now very low as we had spent a thoroughly depressing week. We had made two miles a day where we had hoped to make twenty, we had lost precious dogs, and had spent most of our time wading sometimes waist-deep in the ice-cold slush and thaw water. However, on June 18th, we reached a height beyond the spring thaw and were able to travel really fast. Our spirits rose accordingly. The surface melted in the daytime and froze hard during travelling hours, so we glided along on our ski while the dogs trotted all out.

After five days' travelling, in which we covered 108 miles, we lay up for an observation. Navigation during the crossing was very simple. We were on the 70th parallel and we went due east. All we had to do was to take a meridian altitude occasionally to see that we were on our course.

During the next period of five days we covered 91 miles and at the end of them were at a height of 8,000 feet. The temperature here dropped to minus 20° Fahrenheit during sledging hours. At about this temperature the texture of the snow seems to change and to lose its glide, so we changed over to day travelling. We used to travel for nine hours every day, which we now think was too long. For starting in the mornings took roughly four and a half hours; from the time we stopped to the time we were ready to sleep was two and a half hours. Time for any unforeseen delays, for sewing of clothes or writing of diaries, had to be taken out of sleeping hours. This was a mistake, a hard travelling party ought to be allowed eight hours clear for sleep, plus one for make and mend.

Four and a half hours may seem a long time to get moving, but it took us a week or two to work down to that. The cook, on being waked by the alarm clock, would light the Primus and then open the tent and reach out for the pots which had been filled with snow overnight. As the snow in the pots melted and shrank, he would open the tent again, reach out for the lumps of snow also put near overnight. Meanwhile the others would be busy fishing in their sleeping bags for their dry socks, blanket slippers, etc., and dressing themselves.

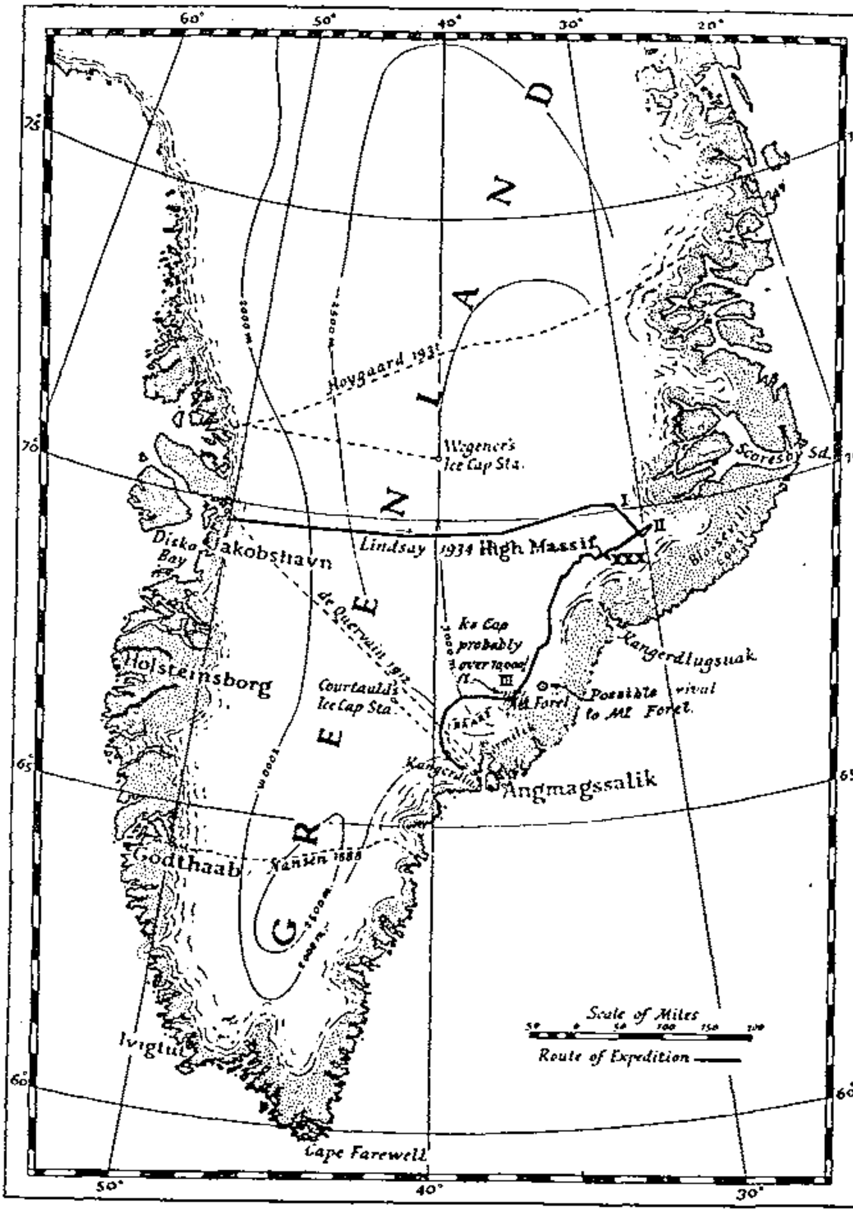
After breakfast two would go out and look round the teams, while the cook packed up the inside of the tent, rolling up the sleeping bags and putting them in a kit-bag, tying the lot well up to prevent drifting snow entering, packing the Primus, plates, cups, etc., into a special kitchen box and dressing himself. Boxes had been put the night before all round the snow flaps of the tent to keep the tent in position in case a sudden blizzard got up. These had to be carried to their proper sledges. Then the snow was dug away from the tent flaps and the tent struck.

Now came the job that took most time. Each day before starting the sledge runners had to be scraped. That meant unlashing each sledge, taking off perhaps twenty boxes each weighing 50 lb., putting them on one side, turning the sledge over, scraping it with the back of a knife, turning it back again, replacing all the boxes and lashing up carefully again. At the beginning of the journey each man had his sledge and his job took well over two hours. Later we got over this by digging an inspection pit in front of each sledge, dragging the sledge over it bit by bit and scraping the section of runners over the pit. Not having read of this dodge in any polar book, I think it was new technique. Lashing up took a long time, as this is a two-man job for each sledge and has to be done with the very greatest care. One cannot afford the chance of anything falling off. In sledging one's values have to be readjusted somewhat, for untidiness and forgetfulness, in ordinary life just a nuisance, are, in sledging, major crimes. Last, before setting off, there was the last look round the camp site in case a spare whip or a knife had fallen in the snow and been overlooked.

On July 20th we made a welcome landfall. We had had a three-day blizzard and several days of overcast sky just before this and in consequence found ourselves some miles north of the 70th parallel. We made our first survey station in 70° 10′ north, and turned south by east to follow the trend of the mountains. When we started to survey we felt a marvellous exhilaration. We had had the fear that we should come back from the west coast with a hard-luck story. Then we had been told that we should never make the journey but from halfway across the ice-cap would have to cut and run for it to Angmagssalik, so it was a great joy to feel that the shortest way home was now on our projected route.

The survey was carried out under difficult conditions. The weather was definitely bad. We had hoped to map on a series of astronomical bases, but finally we made a compass traverse checked frequently by astronomical observations. One cannot have the luxury of a reconnaissance officer, and frequently there was the disappointment of wasting a day sledging to a likely-looking station only to find that it was a bad one. We were always up against the difficulty that where the ice-cap was flat and the sledging good the mountains were too far off; and when we were near the mountains the sledging was up and down precipitous slopes with which the dogs could not compete.

It must not be forgotten that in survey in cold regions the niceties of survey go by the board. Whether one has a 3¼ Baby Watts or the latest Zeiss theodolite makes little odds except in so far as one may be easier to adjust and use than the other. The difference between accurate and inaccurate survey is made by considerations such as the amount of pemmican one had the night before, or how cold one's fingers are, or the fitness of the party. Sometimes navigational observations have to be made with drift snow sweeping



I. First Survey Station.
II. Leg-off to the East.
III. Last Survey Station.

over the sledge handlebars. It is surprising how accurate results can be under such conditions.

At each astronomical station we took a morning azimuth and L.M.T., mid-day latitude, and balanced the morning observations with afternoon ones. There was no possibility of balancing the latitudes. The time in between the observations was taken up in making a sketch and taking rounds of angles while Croft took panorama photographs. All his photography was magnificent and has lately been on exhibition at the Royal Photographic Society. At each station we could not take rays to more than a dozen or so peaks, as we had to keep them in mind to the next station. It was astonishing how their character altered as we travelled past them, so all we could hope to do was to delineate the inside border to the mountains.

The map is being made by the Royal Geographical Society. It would have been interesting had we tried some form of photogrametry, using a small and portable photo-theodolite. A form of principal point traverse akin to the Arundel method in aerial survey might be possible, and if successful would be ideal for exploratory survey. Not only would work in the field be reduced to a minimum, but a very much fuller map produced. We could not take a plane-table as we had not the time, and have in consequence brought back only a few spot heights. Some form of photogrametric survey would enable a contoured map to be made.

Soon after the start of the survey we climbed to the top of a high ice hummock and had a wonderful panoramic view of mountains to the south-west, south and south-east, with particularly high ones to the south. These we hoped to fix from three astronomical positions on the ice-cap. At this station we had to wait during a two-day snowstorm before we could get an observation. Then Lindsay decided to depot most of our food and make a leg-off to a high ridge to the east. Luckily at this time we had eaten through a third of our food and were ready to jettison a sledge, so we dug this upright into the snow to make a landmark visible for some three miles.

We made our leg-off but no sooner had we pitched our new camp than a blizzard started, which lasted for three days. We were thoroughly disgusted; our high hopes of making a map seemed doomed to disappointment. Looking back on it the bad weather at this period was a blessing, though a mixed one. We needed the rest we were forced to take. During these blizzards we lazed and argued and read, and got to know each other. It was astonishing the length of time one was alone on the ice-cap. During the nine hours of sledging one was dog-driving a hundred yards or so behind or in front of the next man. In camping and decamping we had quickly evolved a drill and each did his own job. Really almost the only time we talked was when we were eating. After these blizzards, though they involved several hours' digging, for the sledges, tent and boxes would get drifted up to a depth of two or three feet, we started off refreshed mentally and physically.

We could not afford the time for a third astronomical position in this region, and had to push on to skirt the basin of Kangerdlugsuak Fjord. The Kangerdlugsuak glacier is practically the only drain for the ice-cap between Scoresby Sund and Mount Forel, and as we expected, we found enormous crevasses, some as wide as London streets. They involved wide detours, but apart from the beginning of the journey we had very little trouble with crevasses. At this season of the year the snow bridges had sunk several feet, so we had plenty of warning of crevasses ahead.

In the last week of August we reached the region of Mount Forel, which had been fixed by de Quervain and surveyed by the B.A.A.R.E. North of Forel we travelled for several days with the hypsometer giving our height as over 10,000 feet. This height has been borne out by our aneroid traverse. The Meteorological Office is working on our results, comparing our pressures with those of the meteorological stations at Jacobshavn, Scoresby Sund and Angmagssalik. We hoped to have proved that the Greenland ice-cap is over 10,000 feet, and thus the highest ice plateau in the world.

Having tied our map to Mount Forel we were free to run to our food depot in Kangerdluar Fjord. We had perfect conditions, a hard windswept surface and a wind behind us. We started off gaily, counting the days and revolving menus in our minds against our return to London. Food was a continual fixation, and one used to long passionately for astonishing meals like very underdone beefsteak with hot chocolate and cream to drink, and hot buttered toast with masses of butter.

The wind behind us increased in strength to a blizzard. As it was directly behind us we could travel, continually looking over our shoulders to the hindmost sledge, for in poor visibility the hindmost sledge must, of course, set the pace. We covered 46 miles in two days. But the weather changed and the sky was overcast with wet and sticky snow. This continued for a week and we were worried about getting an observation. We had to navigate to an area some two miles square, which was hopeless by dead reckoning after a week's travel making detours every few hours for crevasses.

When we got our sight we found ourselves some fifteen miles more to the west than we had reckoned, but only 45 miles from our objective. After one more day's travel we sighted land in the evening. Next morning there was perfect visibility, and we could see the sea some ten miles away, and far below us. We felt a strong sense of fellowship with Xenophon's Ten Thousand shouting " Thalassa, Thalassa." We packed up in record time, and the dogs galloped towards the land. For the first and last time we enjoyed the luxury of sitting on the sledges and being pulled along. Eight hours later we were met by an Eskimo. He had seen us while he was hunting in the fjord, picking our way down the glacier.

On the glacier we found traces of the B.A.A.R.E. Some old dog boots, the remains of some flags that had been used to mark a way through the crevasses and, to our joy, two cases of dog pemmican. These were still sealed in tins and the pemmican was in good condition. We could give seven pounds apiece to the dogs, and saw them for once satisfied.

We had arrived after 103 days' sledging with 2½ days' dog food and one day's man food in hand. The journey was a triumph of leadership and organization for Martin Lindsay. The Royal Geographical Society had withheld their support but he had more than justified the journey. It was the result of three years' work on his part. Everything, equipment, clothing, programme, was as perfect as was humanly possible. This, combined with Andrew Croft's organization on the west coast, his enthusiasm, and his marvellous dog-driving capacity, made the journey possible.

We reached Watkins' old base hut and found an enormous box of food that we fell upon ravenously. It is difficult to say which was more marvellous, having a distended stomach, our first cup of "troop's" tea with unlimited condensed milk and sugar in it, or the first puff of a cigarette.

The Eskimos rowed us to Angmagssalik in an *umiak,* a skin boat. The boat is rowed by the women while the men paddle alongside in their *kayaks*—skin canoes—ready to dash off if a seal is sighted. We lay in the boat feasting our eyes on colour after the white wastes we had been used to ; the green of the grass, the ochre of the lichen and the rust of the rocks. For the whole of the three days that the journey took we only stopped eating when we slept.

Our arrival at Angmagssalik caused quite a stir as we were visitors. The existence of the Danes here is a lonely one, broken once a year by a ship from Denmark with mails and supplies. We met M. Paul Victor's French expedition which had attempted to reach the mountains that were our goal ; but they had tried from the east coast and had failed to get through the pack-ice and had to come south to Angmagssalik to winter. They were without dogs, and we were very glad to give them ours, as we knew they would have a good home. The Greenlanders are unbelievably cruel to their dogs ; not through vice, but sheer thoughtlessness. In the summer, when the dogs are of no use, they forget about them and all they get to eat is offal. One sees skeletons of dogs sniffing about the foreshore hoping to come across a fish stranded by the tide.

We spent some ten days at Angmagssalik waiting for the *Jacinth,* an Aberdeen fishing vessel, Skipper Tom Watson, who had promised to pick us up. The pack-ice was coming down very early this year and in large quantities. It began to look a serious possibility that if the vessel were late she might not get through and we should have to stay a winter at Angmagssalik. However, the *Jacinth* arrived in time, and we spent three very interesting weeks on her, getting insight into line fishing. Owing to rough weather, the skipper had to run into an Iceland harbour for shelter and we made a day trip inland on Iceland ponies. Ten days after we stepped ashore at Aberdeen and took the mail train to London. I had never been out of Europe before and I sensed for the first time looking out of the carriage windows the joy of being back in England's "green and pleasant land."

I have added appendices on the more technical aspects of the journey.

RATIONS.

Our scale of rations in relation to the B.A.A.R.E. was as follows :—

	B.T-G.E.	B.A.A.R.E.
Bovril Pemmican	7	8
Maypole Margarine	4	8
Plasmon Biscuits	2	5
Plasmon Oats	3	3
Plasmon Powder (phosphate of milk) ...	3	2
Cadbury's Cocoa and Milk Powder	2	1
Cadbury's Chocolate	3	3
Tate & Lyle's White Sugar	4	4
Harvest Pea Flour	2	2
Horlick's Malted Milk Powder	–	0½
	30 oz.	36½ oz.
Anti-scorbutic.	½-oz. lemon juice.	¼-oz. lemon juice. 1 spoonful cod-liver oil.

Our scale of 30 ounces per day was cut down at once. The ration boxes for seven days were made to last eight. This reduced the ration to 26 ounces per man per day.

We found ourselves ravenously hungry on 26 ounces per day. After a week the rations were increased by ⅓-lb. per day of dog pemmican. It is hard to digest and fills one with an evil-smelling wind, but we were very glad to have it. Its constituents are doubtful and it may even be dangerous for human consumption. Dr. Zilva, of the Lister Institute, considers we were very lucky to have kept so fit on it.

When it was decided that the B.A.A.R.E. ration would have to be reduced for weight-saving to 30 ounces, the margarine was reduced most as fairly warm conditions were expected. Our four ounces of margarine were adequate, but I would have been grateful for six ounces.

Two ounces of biscuit proved quite sufficient. This is a very low biscuit ration.* Watkins' 5½ ounces per day was a reduction of 11 ounces on previous British polar expeditions.

No party should go below 30 ounces a day except on short journeys. For the same journey undertaken again a 32-ounce ration distributed as follows would be ideal :—

Bovril Pemmican	10 ounces.
Margarine	6 ,,
Biscuits	1 ,,
Oats	3 ,,
Plasmon Powder...	2½ ,,
Chocolate	4 ,,
Sugar	3½ ,,
Pea Flour...	2 ,,
	32 ,,

With tea to drink.

Plus necessary quantities of Vitamins A and D (fat soluble vitamins), B, contained in Bemax or dried yeast, and C, which can now be obtained in pure form from Hoffman La Roche.

Perhaps the calorific content is increased too much at the expense of carbohydrates, but this keeps out the cold and, also, owing to the amount of fat, prevents any likelihood of constipation.

CLOTHING.

Our equipment as regards clothing varied with the individual. We experienced minus 20° Fahrenheit at two stages of the journey and I felt quite warm in the following outfit :—

Vest and pants of silk and wool.

Two very light Shetland polo sweaters.

A Viyella flannel shirt.

A thick sweater.

Trousers of Jaeger blanket material.

Coat of Jaeger blanket material. This had a collar which came over the ears.

A Jaeger camel hair balaclava which could be pulled down to form a visor. It would be worth while having rabbit fur put inside one's balaclava to form patches over one's ears.

Windproof trousers and windproof coat with a hood over the top.

* See A. R. Glen Appendix on food and equipment, *Royal Geographical Society Journal*, August, 1934.

Hand and foot wear is the most important item in equipment, as hands and feet are the most likely to get frostbitten. Provided that a party has good equipment, a good tent, and a sufficiency of paraffin, frostbitten hands or feet in much lower temperatures than we encountered are a sign of idleness.

We wore on our feet at the coldest time two pairs of socks, over them two pairs of slippers made of blanket material and moccasins over the lot. For inside gloves (not finger gloves) we had thick knitted camel-hair Jaeger wool. This was the only weak point of our equipment, and we suffered from cold fingers. One or two pairs of loose-fitting gloves made of blanket material would have been better.

We had outside gloves of " chrome " leather. These were very hard-wearing indeed. The outer gloves, in accordance with common practice, were tied together with lamp wick which went round the neck.

One's hands and feet sweat during the march and form hoar frost on the inside of moccasins and gloves. Foot and hand wear must be taken off as soon as possible after camping, the hoar frost scraped off with a spoon and the gloves, etc., hung in the roof of the tent to dry with a Primus underneath. Great care must be taken to ensure that all blanket slippers, socks, gloves and moccasins are absolutely dry before sleeping, otherwise there is a danger of frostbite the next day. It is best to take them inside one's sleeping bag next to one's skin to give them a final airing after they have been dried over the Primus.

None of our party got frostbitten hands or feet, though one member had trouble with his nose, having broken it twice boxing ; it had very bad circulation.

For survey work one must have finger gloves. There is a great prejudice against finger gloves in polar practice, but they are vitally necessary for theodolite work. A pair of loose-fitting washleather gloves with wool mittens over them will keep in heat for a surprising time if the circulation is going well before they are put on. Put over cold fingers they are worse than useless. For very cold work a pair of airman's silk gloves under the washleather give added insulation.

INSTRUMENTS.

Our instruments for the survey consisted of :—

1 3¼" Watts' theodolite with short wooden legs.
1 Battery of three aneroid barometers.
1 Hypsometer.
2 Thermometers.
1 Aeroplane compass.
1 Prismatic compass.
3 ½-chronometer watches.
1 Stopwatch.
1 Long-wave wireless set.
Tables in *Hints to Travellers*.
Parallel rulers, dividers, computation forms, charts.

For a spare in case we lost a sledge down a crevasse we carried a sextant and artificial horizon. This "get you home" set, together with tables and a large scale chart was always kept on a separate sledge.

The instruments were carried in a specially designed three-ply box lined throughout with sorbo rubber sheeting. The sorbo lining was a novelty in polar practice and was a great success. Not only did it protect the instruments from shock, but kept out drifting snow, and even water when we sledged through the morasses of slush and thaw water at the edge of the ice-cap. It will presumably be copied by all future expeditions.

The instruments were admirable, but I would suggest the following improvements.

The theodolite legs should have had base plates. The surveyors of the B.A.A.R.E. found them unnecessary, but we would have been grateful for them.

The aeroplane compass was screwed on to the leading sledge and helped fast travel considerably in bad weather or diffused light. It was a great improvement on the method used by the B.A.A.R.E. in Greenland of directing the front sledge from a following one—the following sledge driver having a prismatic in his hand.

Unfortunately the aeroplane compass failed us after a fortnight for reasons unknown. But the idea was admirable.

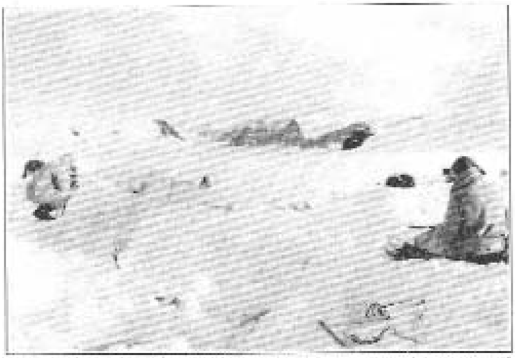
The three ½-chronometer watches were carried one by each member of the expedition. They should all have been waterproof. Each member of a sledging party should also carry a prismatic. In reducing ourselves to one for the party we carried weight-saving too far.

The aneroid barometers we took were in a specially-designed sorbo-lined battery of three. A battery weighs very little, and we should have taken the opportunity of taking at least another battery.

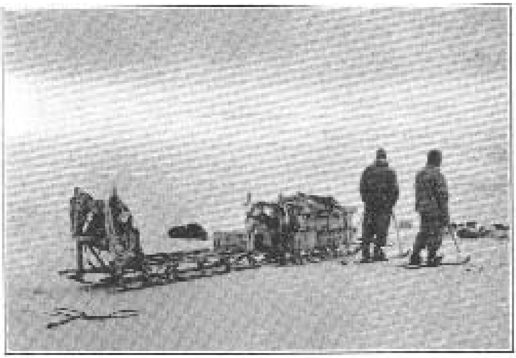
TRANSPORT.

The dogs of West Greenland have conclusively been proved to be the best for travel in snowy conditions, and Andrew Croft had chosen the best on the west coast; the dogs were magnificent. Ponies do not stand the cold so well and their food is too bulky for ease of transport. Man hauling has its advocates, but there is no question that this journey could not possibly be done man-hauling without a lot of depots. Man-hauling allows of no reserve such as is provided for the men by dog pemmican and the dogs themselves. It is also more exhausting, therefore more food is required by any man-hauling party than the same party dog-driving. It also limits the day's march to about 10 miles. Our average on travelling days of the crossing was 17 miles per day.

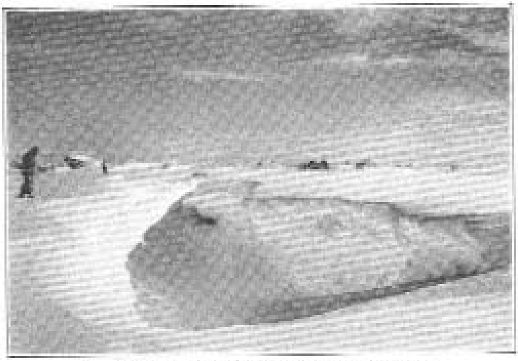
As regards the method of the dog-driving, we adopted the Greenland "fan" trace. This is more efficient than the "centre" trace which is used throughout Labrador, Canada and Alaska. In the "centre" trace, only the leading dog is pulling straight forward, the others are pulling out at about 30° either side of a "centre" trace. In the "fan" trace,



1.—Taking theodolite observations; short legs are used to save weight.



2. Landfall.



3. A crevasse in the Kangerdlugsuak basin.

British trans-Greenland expedition 1 - 3

4.—Journey's end. The Eskimos waiting in their sealskin boat to row us to Watkins' base hut.

5.—Sledge dogs.

6.—Driving fan trace on a good surface.

British trans-Greenland expedition 4 -6

several dogs are pulling effectively straight forward. Again, if in the "centre" trace a forward dog is whipped the ones behind flinch and stop pulling. In the "fan" trace all dogs are on the same length of trace. The "centre" trace is used in Canada for sledging in amongst trees, where the "fan" trace is useless. There are no trees in Greenland to confuse the issue.

The dogs fed on one pound of dog pemmican each per day. This was eked out as the loads got lighter and we needed fewer dogs by their eating each other—one dog fed approximately eight dogs. We killed the dogs with a humane killer, skinned them, cut out their livers, and cut them up into portions. The skins we buried for we found that the dogs would eat them and get constipated. The livers we also buried, as the liver of a starved animal is poisonous.

Out of forty-two dogs we lost five down crevasses early in the journey, and we ended with twelve, all in excellent condition and not unduly thin.

The sledges were special "Nansen" sledges; in effect, a framework to carry boxes on two stout skis. For the approach to the ice-cap, where all types of sledging had to be met—fjord-ice, pack-ice, snow, rocks and grass—we used Greenland sledges, which are hard-runner sledges, like English toboggans.

All stores, apart from the tent and things that could not so be contained, were so made as to fit into boxes which fitted the sledges exactly. Each box weighed approximately 50 lb. This was a convenient weight for carrying when the sledges had to be loaded and unloaded every day.

It is regretted that the map made by the Expedition cannot be reproduced in this article; it is to be published with the scientific results in the Royal Geographical Society's Journal during the autumn.

ENGINEER INTELLIGENCE FROM PHOTOGRAPHS.

By LIEUT.-COLONEL C. J. S. KING, R.E.

I.—GENERAL.

IN compiling engineer intelligence, the necessity for checking the information supplied by agents has led to the evolution of a method of producing a scale drawing in plan and elevation from a photograph. There is nothing new in the general principle, since it is the application of the normal method of making a perspective drawing from a plan and elevation, but the method is applied in the reverse direction, namely, the production of the plan and elevation from the perspective.

The method has been used with a considerable amount of success and the somewhat erratic reports of agents have been proved to be grossly incorrect in many cases. As far as is known, the method has not appeared in any textbook and it may, therefore, be of general interest.

II.—PRODUCTION OF A PERSPECTIVE DRAWING.

The normal method of producing a perspective drawing from a plan and elevation may be found in any textbook on the subject, but as this lies outside the usual experience of R.E. officers it may be very shortly summarized here.

A perspective drawing is the representation of an object, on a vertical transparent plane (called the picture plane) interposed between the object and the spectator; the plane is always vertical and is at right angles to the line of vision of the spectator, who is supposed to be using one eye only.

To produce a perspective drawing, it is necessary to know certain facts in addition to the details of the actual object, as shown in the plan and elevation. This extra information required is the height of the spectator's eye above the ground plane and the distance of the spectator from the picture plane. With this information, the perspective drawing of the object can be constructed by purely geometrical—not artistic—methods.

The essential problem is to find the intersection with the picture plane of a ray passing from the eye to any point on the object. Treating the problem from first principles, anyone can carry out the construction.

There are various conventional names and " rules " which should be known and which are used in the description of the method.

Centre of Vision.—This is the point in the picture plane exactly opposite the eye.

Vanishing Point.—The point to which lines which are in reality parallel to each other appear to converge. A vanishing point is found by drawing a line from the eye parallel to any original line until it intersects the picture plane.

Rules.

(i) Lines and planes which are parallel to the picture plane remain so in their perspective delineation.

(ii) Lines perpendicular to the picture plane vanish to the centre of vision.

(iii) Lines which are parallel to each other and not to the picture plane vanish to the same point (vanishing point).

Plate 1 gives the solution of a simple problem of a box in which the picture plane is assumed to coincide with the corner of the box nearest the eye.

Plate 2 gives the solution of a similar problem, but the box is farther away and the corner does not touch the picture plane.

In the plates, HL is the horizontal line, *i.e.*, the intersection of the picture plane with a plane parallel to the ground plane at the height of the eye.

The distance from the eye to the centre of vision (E—CV) is the distance of the spectator from the picture plane.

The distance between HL and the ground line GL is the height of the spectator's eye above the ground line.

As might be expected the resultant figures are similar, differing only in size. In order to arrive at the correct heights in the perspective drawing, use is made of the " line of heights " which is perpendicular to the picture plane at a point where one side of the box produced meets the picture plane. As is obvious, this is merely a convenient method of carrying out the actual " donkey work " of drawing.

III.—Production of a Plan and Elevation from a Perspective Drawing.

The problem here is to reverse the procedure.

Referring to Plate 2, and imagining that the perspective figure of the box is all that is available, it is clear that we can find the points V.P.1 and V.P.2 by producing lines that are in reality parallel. By describing a semi-circle on the line joining V.P.1 and V.P.2 we know that the eye is somewhere on this semi-circle. This assumes that the pairs of lines we have chosen to find the vanishing point are in

Plate 1

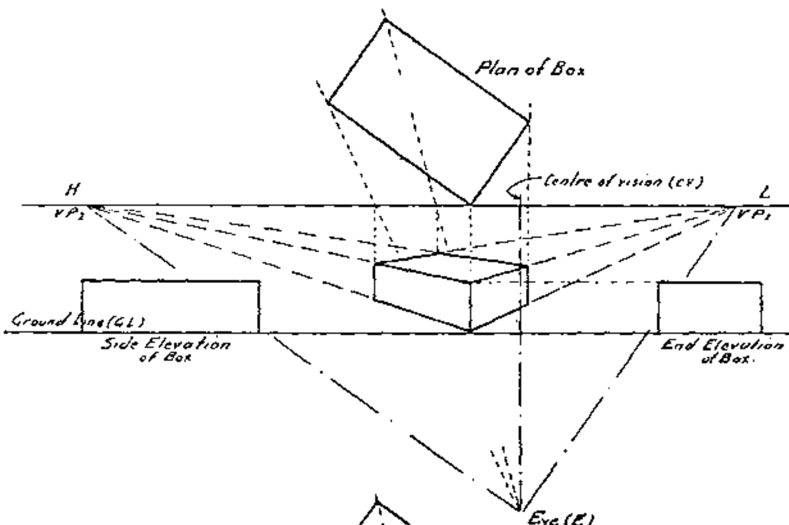
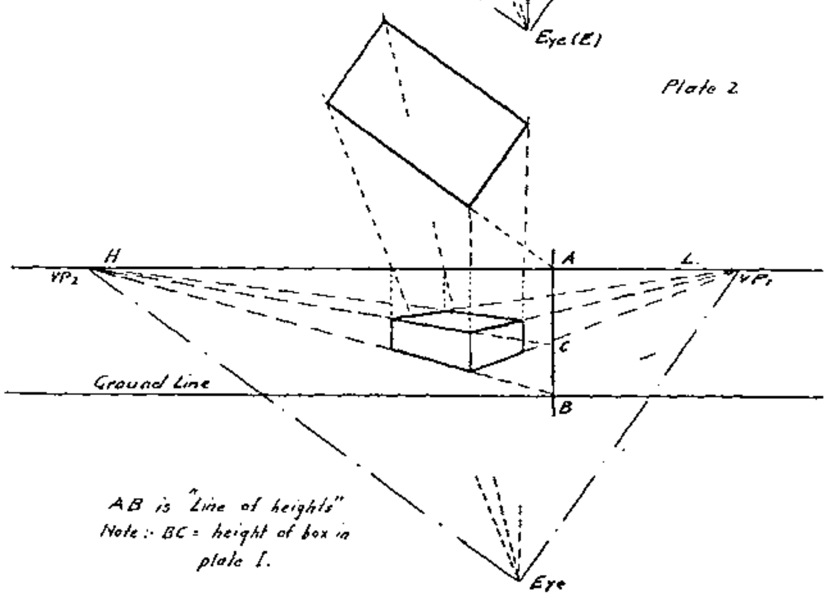


Plate 2



reality at right angles to each other—an assumption that can be justified in most bridges.

The actual fixation of the "eye" caused a certain amount of difficulty until the obvious truth was realized that the centre of vision must be the centre of the photograph—the complete print and not the centre of the main object in the photo. This presupposes an untrimmed print, which is essential. Having fixed the "eye," we have the framework for construction; actual details of the procedure sufficient to allow any ordinary draughtsman to work the method are given below.

IV.—Actual Method of Construction.

1. Three conditions must be fulfilled :—

(*a*) The photo must be taken at such an angle that the vanishing points can be found—*i.e.*, an oblique photo taken either above or below the level of the bridge.

(*b*) The photo must be untrimmed—*i.e.*, the print up to actual edges of the exposed plate must be shown.

(*c*) Some ruling measurement must be given—*e.g.*, length of a car on the bridge, height of a man, etc. Two or three are preferable as they enable a check to be made.

2. The accuracy with which results may be expected depends entirely on the completeness with which the above conditions are fulfilled. In favourable cases, an error of less than 5 per cent. can be obtained.

A photograph of a box is taken to explain the method. More complicated pictures merely involve repetition of the procedure. A few hints on the details of practical procedure are added at the end; these hints are the results of actual experience in working; an actual example worked out is added on Plate 4.

3. Referring to Plate 3—

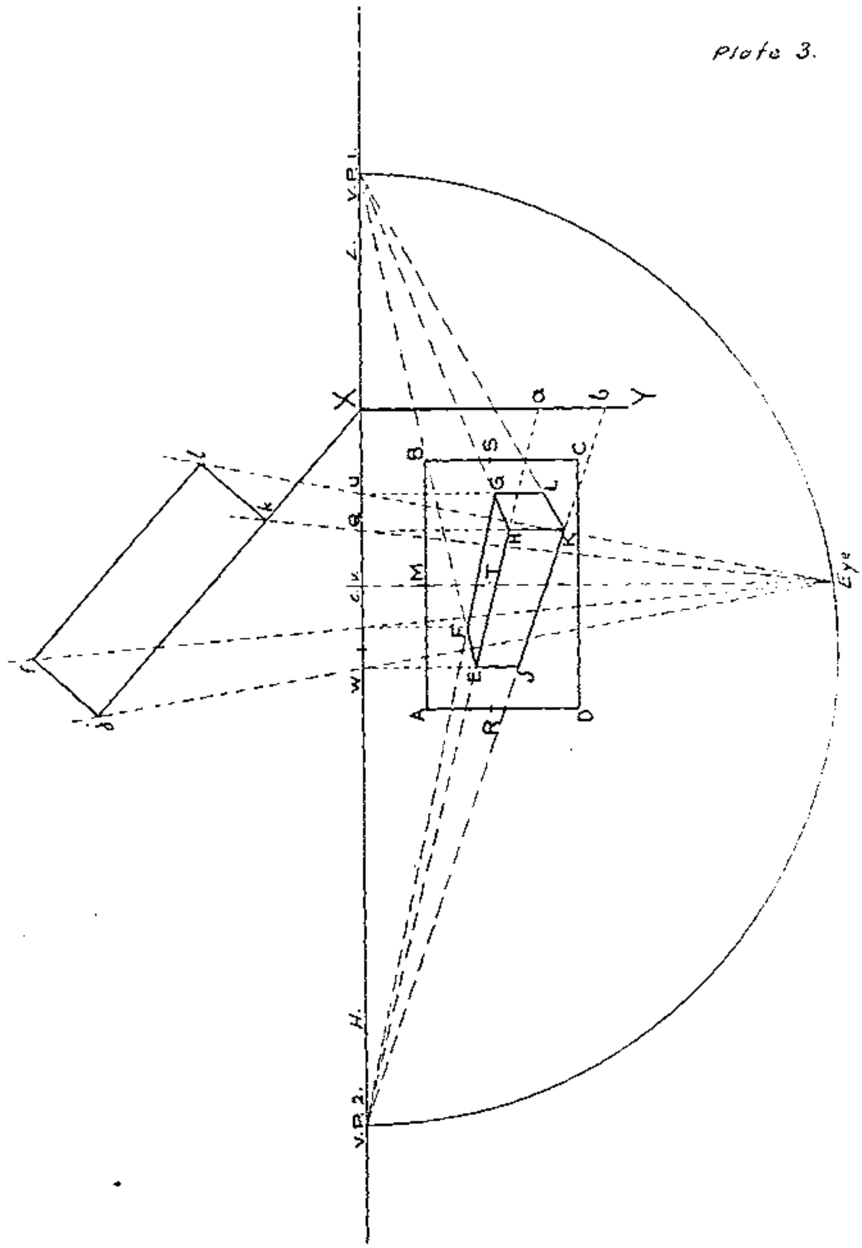
(*a*) ABCD represents the photograph of a box; the lines AB, BC, CD, DA being the actual edges of the exposed part of the film. This is pinned to a large sheet of paper.

(*b*) Suitable pairs of lines which are actually parallel in the object, though not on the photo, are then selected and produced to find the two vanishing points. In this case the best selections are—

(i) EF and KL produced to V.P.1.
(ii) KJ and GF produced to V.P.2.

It is obviously preferable to choose lines which are as far away from each other as possible to increase the accuracy of the intersection —*e.g.*, it is preferable to use EF and KL to find V.P.1 rather than HG and KL.

Plate 3.



(*c*) The points V.P.1 and V.P.2 are then joined and a semi-circle is described on this line.

(*d*) The line AB is then bisected at M and MO is drawn perpendicular to the line V.P.1—V.P.2 to meet the semi-circle at O.*

In cases where the camera has been badly tilted, it is more accurate to bisect a line drawn through the centre of the photo—*i.e.*, bisect RS at T and then draw the perpendicular. This tilting can often be seen from the appearance of an horizon or an obviously vertical line in the photo.

(*e*) We now have the framework on which the plan and elevation can be constructed.

Select the point nearest the camera—in this case K. Draw KQ perpendicular to the line V.P.1—V.P.2 and cutting it at Q. Join OQ and produce it. Repeat this process with the points J and L and F.

We then have a pencil of rays radiating from O.

(*f*) Select any point on OQ produced, at a reasonable distance from the line V.P.1—V.P.2. This is the plan of the point K and is lettered k.

(*g*) From k draw kl parallel to line O—V.P.1 to meet the ray OU in l; similarly kj parallel to line O—V.P.2 to meet the ray OW in j. Complete the oblong and this gives the plan of the box.

A useful check is provided by the accuracy with which the three lines supposed to meet at f actually do so.

(*h*) *Heights.* Produce jk to meet the line V.P.1—V.P.2 at X. Draw XY perpendicular to the line V.P.1—V.P.2.

This is the line of heights; parallel lines from a V.P. produced beyond the object to meet this line give intercepts which will be at the same scale as distances shown in the plan. For example—

Produce EH and JK to meet XY in a and b respectively. Then ab is the actual height of the box on the same scale as jk is the length or kl the breadth. It must be noted that the correct intercept is obtained by producing the line from the V.P. *beyond* the object; the intercept on the line of heights between the lines H—V.P.1 and K—V.P.1 does not provide any useful information as it lies between the V.P. and the object.

(*i*) *Fixation of actual scale.* We must know the actual size of one measurement of the box, either height, breadth or length.

In practice, it is usually the size of a man or a car in the picture. The object is produced in plan or on the line of heights and hence the scale is deduced.

4. *Practical Hints.*

(*a*) In order to avoid damage to the photo, it is advisable to use a piece of tracing paper (not linen) about ½" larger all round than the

* Marked "Eye" on Plate 3.

photo and to paste it down on the drawing paper by the edges. Great care must be taken to see that the photo cannot move. Pins are not advisable for this (*vide* sub-para. (*c*) below).

If there is no objection to marking the photograph, more accuracy can be obtained by pasting the print on to the paper without the use of the tracing paper; paper obscures the accurate location of the points to some extent.

(*b*) When finding the V.P. use as many checks as possible. The intersections are always very flat and inaccuracy in fixing these points leads to great inaccuracy in the results.

(*c*) When the line V.P.1—V.P.2 has been drawn, it saves a lot of trouble if the paper is reset on the drawing-board so that this line agrees with the T-square. This is the chief reason for avoiding the use of pins in fixing the photo in the first instance.

5. Referring to Plate 4. The photograph is taken from below the roadway and details of the actual clear width are, therefore, not available.

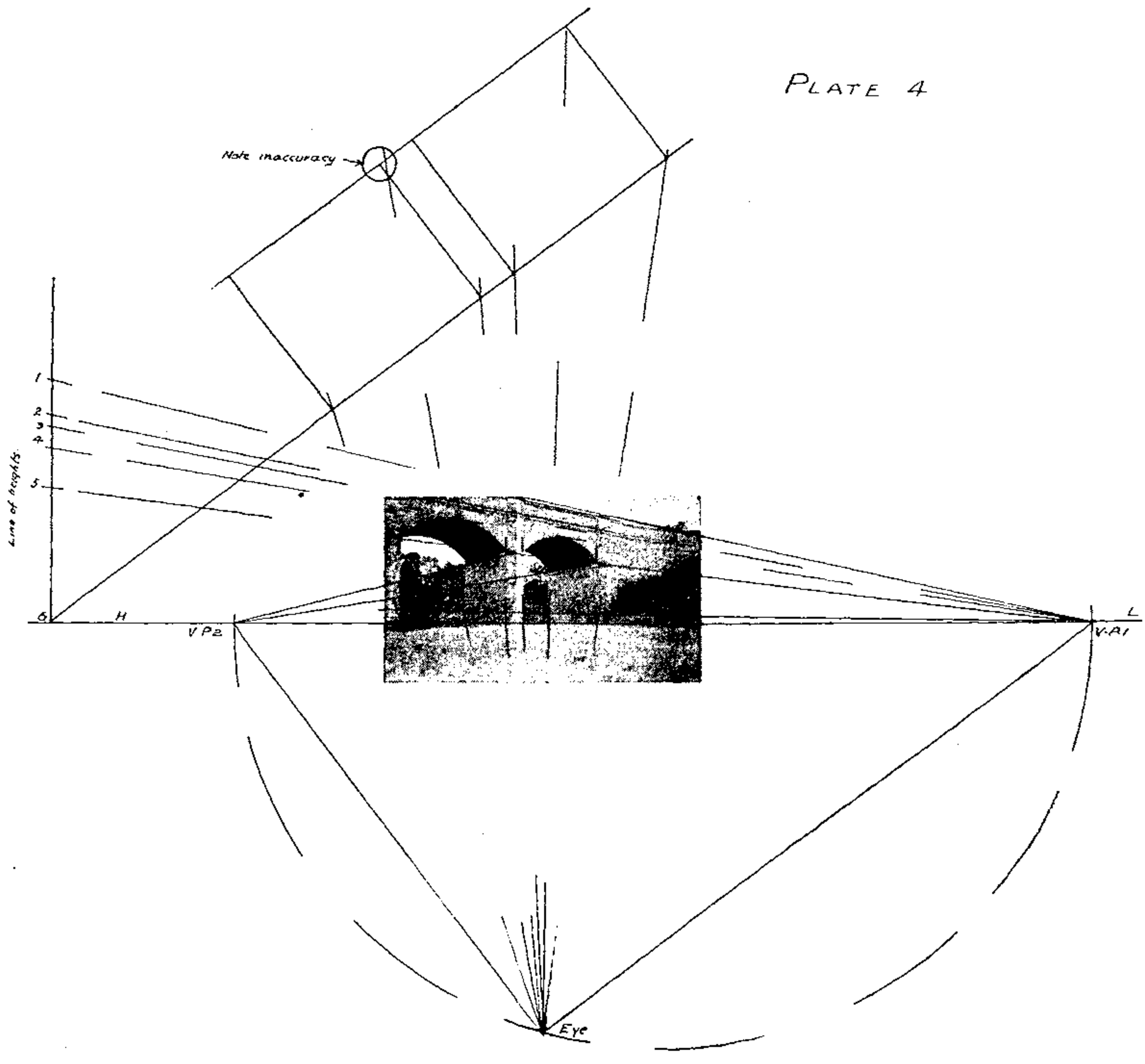
In this particular case the height of the parapet on the outside was given as 2′ 6″, *i.e.*, on the line of heights 1·2 is 2′ 6″.

Using this as the guiding measurement, the following information is obtained :—

Arch : Span 15′—from plan.
Rise $3\frac{1}{4}$′—distance 4–5 on line of heights.
Arch ring : 1′ 3″—distance 3–4 on line of heights.
Width of bridge : $15\frac{1}{4}$′—from plan.
Thickness of pier : $3\frac{1}{4}$′ from plan.
Height of crown of arch above G.L. : 15′.

Note the inaccuracy of intersection which gives an example of the amount of errors to be expected.

PLATE 4



THE R.E. PROBLEM OF THE TANK BRIGADE.

By MAJOR F. E. FOWLE, M.C., R.E.

THE formation, in 1934, of the Independent Tank Brigade, and the contemplated formation of the mechanized division, gives reason for serious consideration as to what R.E. unit, if any, will have to be organized to form part of these highly specialized troops. The following notes have been written with the idea of encouraging thought on this very important subject. They are not officially inspired, nor do they purport to represent the views of high authority, or indeed of any authority at all. The fact is that there is bound to be a tendency, on the one hand, based on purely peace experience, to decry the need of anything but the barest minimum of sappers; and, on the other hand, based on imagination coupled with war experience, to demand an R.E. unit of a strength out of all proportion. It is not so much the numbers of personnel, as the road space which their vehicles will take up, which must be the governing factor.

In 1934, the Tank Brigade manœuvred over most of the south of England most successfully with no sappers at all; but this was in peace, with every man's hand helping them and in no way a safe guide to what might happen in war. None the less, this has inevitably led to a tendency to underrate the difficulties which the Brigade would find itself faced with in a hostile country, and consequently to lose sight of the important part which the sapper may be called upon to play in assisting the Brigade to fulfil its role.

The object of this article is to paint a picture from the other side, and endeavour to some extent to redress the balance. It may be thought that we have gone too far in the other direction, but if the intention is to strike a fair balance, there is no great harm in that.

Clearly, so far as the brigades of mechanized cavalry, or whatever they will be, are concerned, the problem is no different in its essentials from that of any other formation. Provided the sappers have at least the same mobility, on and off the roads, as the rest of the Brigade, their strength and equipment could be worked out with reasonable accuracy from general experience; but when we come to the Tank Brigade itself the problem becomes very different.

The modern tank is a high-speed weapon, with a wide radius of action; the potentialities of a brigade of tanks launched against some vital link in the enemy's chain of supply, a railway junction, an ammunition depot, an important bridge, or some similar point, are enormous. That the Brigade will often be used to "intervene" in the main battle is undoubted, but it is in the former role, the long-distance independent action, that the necessity for R.E. assistance will chiefly arise, and it is with this aspect of the problem that we propose to deal.

Now, as we all know, for each existing formation in the Army there is a corresponding R.E. unit; the Field Squadron to a Cavalry Division; the Divisional R.E. to an Infantry Division: the Army Troops Companies to a Corps, and so on. Now we are adding a new formation, the Tank Brigade, and the problem is where the R.E. assistance which will be required is to come from.

The first suggestion is, obviously, from the divisional R.E.; but can we seriously believe that a divisional commander, in war, is going to give up one of his field companies just at the time that his division is going to take part in a major operation?

The next possibility is an Army Troops Company from Corps. Now the Army Troops Companies are as hard worked as anybody else in time of war as it is, and, furthermore, they do not exist in peace, so that they cannot train in peace with the Brigade. They are not mechanized, and from the nature of their normal employment they must have essentially a back-area outlook; if you suddenly pulled out a Corps A.T. Company and requested it to accompany the Tank Brigade on a raid, you could hardly expect it to show a really fat spark.

Furthermore, there is another and very important aspect of the question, and that is training. We don't mean that any officer or sapper trained in a Field Company would not be capable of doing any work that a Tank Battalion might want, but that he would not know what they did want.

At a recent R.E. exercise, attended by some forty-five officers, regular and territorial, there was not one who could give a definite decision as to whether a certain obstacle was, or was not, an obstacle to tanks. We do not quote this instance as redounding to the credit of the party, although there were several graduates of the College present, but it is a fact; unless a man has trained with tanks he does not know anything about tanks. When the "I" Tank Battalions come in, this lack of knowledge may be remedied, but even then not every Field Company will see them, and none of the officers and men who, in war, would form the R.E. units behind the Field Companies.

Again, the value of liaison between the R.E. unit and the unit or formation that it is going to work with is, as we all know, inestimable. Without ever having served in tanks, we should imagine that, at the end of a good long march, they are reasonably peevish; the accompanying sappers, not being so used to it, will be even more peevish; the result, unless they know each other pretty well, is going to be, to say the least, considerable friction.

We think, therefore, that there is a definite case for a special unit for the Tank Brigade, or rather for a unit specially detailed to work with the Tank Brigade.

Now, what sort of a unit are we going to have? Before we can consider this, we must think for a moment what sort of work it is going to have to do. This falls naturally under two headings: work when the Brigade is in action and work when it is out of action.

Considering the second of these first, we think it is safe to say that a Tank Brigade will want all the things that an Infantry Brigade wants behind the line, plus probably a few extras peculiar to itself. A Tank Brigade has roughly the same number of officers and half as many men as an Infantry Brigade, so that a unit half the size of a Field Company is as much as it is likely to need, or, at any rate, is likely to get, and the work is not going to differ so very much from that of a normal Field Company.

Now let us consider what R.E. assistance it may need when in action. I do not mean when it is going into a general action, as obviously it won't want anything then, and if it did it would not get it. But the function of the Tank Brigade now is to be fast and loose, and the faster and looser it is the more likely it is to need help, both on the approach march and in its assembly area, and, if its job is to create alarm, despondency and damage behind the enemy's lines, assistance, and very highly-trained assistance, in doing the actual damage.

It may seem that we picture the tank personnel as being a very helpless collection, but we must remember that there are no spare men in a tank and they have all their work cut out to fight their machine. In fact, once they are inside you cannot get them out unless they choose to open the door themselves from inside: they simply have not got the men.

Consider first the approach march. The enemy is going to hear of it, and he is going to block the road, either by demolition, road-cratering, tree-felling or anti-tank guns and mines.

It is no good saying it is useless to block the road against tanks, as they can walk round. If the block is well sited they won't be able to walk round, and anyway, tanks will always get along much faster along the roads or tracks than across country, especially if the country is at all enclosed.

Take the bridging problem first. Anyone can build a bridge, but it takes very specialized training to build a heavy bridge quickly. How much material is to be provided and how is it going to be carried? Bridging material for a 16-ton tank is tolerably weighty.

Road craters can be made passable by bridging them or by filling them in; the former needs heavy equipment, the latter, a lot of men.

Tree blocks can probably be dragged away, but if it is going to be done quickly, power tools are necessary, and they must be on the spot when they are wanted; or perhaps it may be easier to make a deviation round the block, perhaps by blowing down an embankment or felling trees, again involving a call for power tools instantly available.

The removal of blocks formed by tank guns is fortunately not an R.E. service.

Last, and by no means the least important, is the work to be done when the Brigade or Battalion has reached its objective.

Then there is the question of the B echelon. The Tank Brigade B echelon is no different from anybody else's, except there is more of it: it may need gaps made for it to get off the roads, turning places improved, and work of that sort, but nothing very special.

Now let us consider the strength and organization of the R.E. unit which is to carry out this work.

The Field Company, which is primarily an infantry unit, has four sections, self-contained for all purposes except rations, corresponding to the four battalions of the Brigade. Are four sections necessary in the Tank Brigade, or can it get on with two, or even one? If we are going to have four, we might as well have a fifth one for the B echelon, which is obviously absurd; so the B echelon must do without its own section, or rather, it must take its turn with the battalions.

It is obvious that none of the tasks we have suggested demand any very large number of sappers, but rather a small number of highly-trained ones, as everything will depend on speed. Probably, therefore, a unit of about half the strength of a Field Company will be sufficient, that is, 80 working men.

The next question is, whether this number should be in two sections of forty, or four sections of twenty; if the former, they cannot be further subdivided in the event of the battalions of the Brigade moving independently. It is conceivable that a battalion might be sent off on its own on an independent mission, but it is unlikely; more probably, the Brigade will split up for the purpose of a raid or similar operation, in which case each battalion would have the same need for a contingent of sappers. If there are only twenty men with each battalion they are too few for any bridging work, and none too large for a demolition, and to provide officers at the rate of one per twenty men would be uneconomical.

On the other hand, to give the Brigade four sections of forty men is obviously out of the question, to say nothing of the number of vehicles they would add to the numbers there are already on the road. Therefore it seems likely that a compromise is the only way out of the difficulty; that is, to have two sections of forty each (we are speaking throughout of working numbers, as there must always be a number of drones, like storemen, cooks, and so on), but to provide each section with two tool-cart vehicles instead of one, so that in an emergency the section can be subdivided into two sub-sections for a limited period.

So now we have the picture of a sapper unit consisting of a head-quarters with a major in command, a subaltern to assist him in reconnaissance work and so on, and two sections, each of a subaltern and about forty-five men, capable of being subdivided into two sub-sections each with its own tool-cart.

The next, and the most argumentative, problem is the question of the type of vehicles. Are the sappers going to be carried in armoured vehicles or unarmoured vehicles, and shall they be tracked or wheeled? If they are to be armoured, then the number that can be carried in one vehicle is very limited; we are not sure that any such vehicle exists at all, but obviously you can get more personnel into a 30-cwt. lorry than you can into any form of tank; this weighs the scale very heavily in favour of the unarmoured vehicle, and the argument is still further strengthened by the fact that whereas a tank crew can do all their jobs without unlocking the door, the sapper cannot do anything at all without getting out. But there is one grave objection, and that is in the fulfilment of the primary object, or what we take to be the primary object, of the Tank Brigade, and that is the destruction of some important point behind the enemy's lines. Such points will obviously be defended, and the tanks will carry out their job by charging unconcernedly through the fire of the defence, treading on the defenders, and then holding the ground for sufficient time for the sappers to disembark and do their stuff. But where are the poor sappers going to be during all the battle if they are in unarmoured 30-cwt. lorries? They will have to be a thousand yards —nearer two thousand yards—away until the defending machine-guns have been trodden on. Then they will have to come on on their own as soon as the tank commander can get word through to them. This will take time, and it by no means follows that they will not be shot up on the way, by some unsquashed machine-gun, or some partially-squashed soldier, as they go along, and in their lorries they are defenceless; so some tanks will have to go back to support them, and all this will waste more time which is going to be very precious. Whereas if the sappers had been in armoured vehicles they could have come on with the Battalion and got to work as soon as the defence had been crushed, with their tanks handy to jump into if trouble started again.

It must be agreed that the position of men in unarmoured vehicles careering about with a Tank Battalion in an enemy country will be very precarious, if the position is one where they cannot be left behind to go on afterwards. The opposition might be only machine-gun fire which the tanks can ignore, but it would effectually stop the unarmoured sappers. This question of armoured *v.* unarmoured vehicles is one to which there is no very obvious solution, and in all probability the answer is again a compromise: that is, to give each section two armoured carriers to carry ten men apiece with a space for explosives and a few tools, and to put the remainder in 30-cwt. lorries. That arrangement, when the four battalions are operating independently, will allow of ten sappers with each battalion for demolition work. We do not think that this is enough, and we are driven back to our first idea of armouring the whole lot, and so having twenty men with each battalion.

Next we come to the tool-cart. Is that to be armoured or not? The tool-cart will contain the plant necessary to work the power tools and hauling gear as well as tools and explosives. None of these will benefit from the receipt of a belt of machine-gun bullets, which the tanks they are accompanying will ignore; the driver of the lorry won't benefit very much either; so again we are being forced back to the provision of an armoured tool-cart, not necessary in the ordinary course at all, but vitally necessary in the emergency when the sappers will be most needed. It may be argued that since the B echelon of the Tank Brigade goes about in unarmoured lorries, there is no reason why the sapper tool-carts should not do the same; but there is this vital difference, that the B echelon in the crisis of affairs is laagered away behind somewhere under escort, whereas the tool-cart has to be up in the centre of the disturbance.

There is another minor point, and that is whether the R.E. carrier tank should carry any offensive weapons. At first sight, and this was our own opinion, they should not. The moment you start putting weapons into a vehicle you take up valuable space, and for another thing, you don't want sappers to turn themselves into imitation tanks and enter into the battle, which they certainly will do if they have the chance. They are there for one purpose and one purpose only, and that is to help the tanks to do their bit. But, curiously enough, when we referred this point to a distinguished officer of the Tank Corps, he was solidly of the opinion that each vehicle should have at least one machine-gun. He pointed out that you can never tell, in the type of action which we are thinking about, when the sapper tanks might not become separated from the fighting tanks, and if in that case they came up against opposition they would be powerless in their vehicles to do anything about it. We therefore bow to superior knowledge and vote for including one machine-gun in each vehicle.

Then there is the question of the command of this unit. Obviously the company headquarters, or part of it, must go along with the Brigade, and the company commander must be mobile and armoured, so that he can charge about with the light tanks and do a reconnaissance; therefore he does not want to travel in the carrier with the rest of the headquarters, but must have the equivalent of a Baby Austin for himself.

In the same way the section officers must each have their own vehicle. A multiplicity of types is a thing to be strenuously avoided, and therefore it seems likely that a standard light tank without its machine-gun would meet the case of the officer.

The armoured troop-carrier must be a special type, but there is no good reason why it should not be a special body on a standard tank chassis and the tool-cart can be the same.

Thus, reviewing all the arguments, the vehicle strength of the unit will work out as follows :—

Company Headquarters :	Two light carriers for commanding officer and reconnaissance officer.
	One armoured carrier for ten men.
Two Sections (each) :	One light carrier.
	Four armoured carriers of ten men each.
	Two armoured tool-carts.

Or a grand total of four light vehicles and thirteen heavy vehicles.

This bears a rather better proportion, from the point of view of road space, to the road space of a Tank Brigade, than that of a Field Company does to an Infantry Brigade. So we have not done so badly.

The question of the B echelon we do not propose to touch on. It will not differ from the B echelon of any other unit of similar size, and it will move at all times with the B echelons of the Brigade, or of the Battalion with which the Company is working.

Now we have to consider the equipment. The most obvious and the most difficult is the bridging material. We have got to carry a 16-ton load across a gap of unknown width and the materials to do that job are exceedingly heavy. How much are we going to carry?

Fortunately the answer to this is a great deal easier than appears at first sight, for the following reasons.

Firstly, you cannot build a heavy bridge at all without getting out on the ground to do it, and therefore, if men can work on the ground the lorry can get to the same point, and therefore the bridge equipment can be carried in ordinary lorries.

Secondly, all water obstacles are marked on the map, and no one would dream of starting on a raid without very careful consideration of the probable obstacles. Therefore you would know the number of obstacles and the number of crossings needed, and the requisite amount of bridging material could be ordered up from the army advanced park or some similar organization.

Thirdly, the possession of the tool-cart; a standard tank chassis, as already envisaged, gives you a useful capacity for the installation of power winches and derricks and so on, which will enable you to handle heavy weights with the minimum of men. There is no easily portable bridge (we use the words "easily portable" in a strictly relative sense) in existence at present to take a 16-ton load, but there is no reason why a bridge on the lines of the light box-girder should not be evolved to bridge a gap of up to, say, 90 ft., to be launched by the power tackle in the tool-cart. But it is very obvious that it will need thoroughly specialized training, if the job is to be done quickly.

There is, of course, another point to be considered in connection with bridging, and that is the creation by the enemy of obstacles on small streams and so on, involving a gap of 15 to 30 feet. These might be made almost anywhere and a bridge to deal with them will have to travel about with the Brigade. It is not unlikely that some form of bridge that can be carried and launched from inside a tank may be produced. It was done in the war to cross wide trenches, and an adaptation of that may be the solution. The catch in it is that it involves an additional vehicle, or possibly two, travelling with each R.E. section, and it is open to question whether this should not form part of the B echelon, and be brought up only when required; but there is an undoubted advantage in having ready to hand at all times a form of bridge which can be launched in the face of the enemy.

Now, the whole of our argument so far has been based on the assumption that this Tank Unit cannot function properly in war unless it has enjoyed a very close liaison with the Brigade in peace;

that is, it has been a definite part of the Brigade throughout the Brigade training and has also carried out a very specialized course of training of its own.

It is time now to turn from thoughts of war to real soldiering, and consider how this unit ought to be trained in peace. On this head, we immediately come up against the usual difficulties of establishment and money.

The Tanks Corps are luckier than most people, for their peace establishment is not so far short of their war establishment; and it is worth piously hoping that the R.E. unit might be treated in the same way. But at the best we cannot hope for more than thirty working numbers in each section, and at the worst, that may easily drop to twenty. Provided, however, they are adequately supplied with the vehicles which they will use in war, even on the lowest numbers it should be possible to keep their training on reasonably sound lines.

The bridging problem, of course, is easy; all that is necessary is a bridge and some water to put it across. But for the other aspect of their training, both for the R.E. Unit and the Tank Brigade itself, money in considerable quantities is absolutely essential. At the present time we have not enough information as to what tanks in large numbers can, or cannot, do. Can a tank battalion cross a mile of the walled country of the Cotswolds, or a mile of the Sheerness marshes, or a river valley with two or three main channels and wet water meadows in between? How long would it take them to get through a two-chain belt of fir trees? Most of these obstacles would require R.E. assistance; but without practice there is no man living who can say how much assistance will really be required.

At a recent exercise in the Southern Command, which included the employment of a Tank Brigade, the Brigade had to cross the valley of the Upper Test, and the best opinion that anybody could give was: "Of course a crossing would delay them a bit, but they would get over it in time." We submit that for a properly co-ordinated attack that estimated time would hardly be good enough.

For a Tank Brigade to practise seriously dealing with obstacles like this, there must be money available to pay really adequate compensation for the damage which they are going to do.

The road crater—a really big road crater—was the method which the Germans adopted in 1917, but we have never had any information as to the extent to which an obstacle of this type will delay a tank. We all know that a tank can cross wonderfully big holes at Lydd or Bovington, but we have not seen a tank battalion trying to cross a really large crater, and we shan't know how it can be done unless we are given the money to make a really big one, and the equipment and the personnel to evolve the quickest method of making it passable.

Then the actual question of blowing up an ammunition dump. It is worth while considering for a moment what really is entailed in blowing up a big ammunition dump, which is one of the most probable objectives for a tank raid. The rather generally accepted idea of an ammunition dump is that it consists of a large number of large heaps of shells, and that all you have to do is to loose off a guncotton charge on top of one of the heaps, for the whole dump to go up; but that is by no means the case. What the real method of doing it is, very few people know, and those who do do not seem to have passed their knowledge on.

Not so long ago we listened to a heated argument on this very point between two chief engineers and three A.D.O.S's, and none of them agreed as to what the correct method was.

Here are a few of the difficulties.

The base ammunition depot for a force of six divisions contains 38,000 tons of ammunition and occupies 876 acres. Now 876 acres provides a very pleasant day's partridge shooting for five guns. Our R.E. unit at the best is only going to produce 80 men on the job, or one man to ten acres.

Then again, the ammunition dump is laid out with the express object of preventing the explosion of one heap setting off another of the adjacent heaps or, in the words of the book, "The lay-out is designed to minimize the risk of sympathetic detonation": if there has been time there will be earth traverses between each little heap.

Therefore, if the destruction is going to be effective, it will be necessary to explode a large number of heaps. Furthermore, these heaps must be detonated simultaneously, or the demolition party will have heavy casualties, and the earlier explosions will dislodge the demolition charges from adjacent heaps.

The only answer to that is electrical communications, and if electric circuits are to be arranged quickly you need a large number of men, and a large number of very well-trained men.

Again, the ammunition may be boxed, and if it is, the detonating wave won't travel through the boxes, and the only answer is to set fire to them. That means petrol—and a lot of it—and petrol in bulk is a nuisance to carry about.

These few considerations surely lend force to our earlier assertion that ten sappers to a battalion is not enough. There seems no doubt that we have got to face up to the problem of finding a solution of these problems and, given money, there should be no great difficulty.

Without any exact knowledge of the figures, from the number of ordnance inspectors of ammunition which exist, there must be a very considerable amount of ammunition condemned each year. If this ammunition was collected in some secluded spot, say, on Salisbury Plain, and laid out scientifically, in the way in which it would be in a war-time depot, the R.E. unit could work out the problem of its destruction and carry it out in practice.

Again, the difficulties of destroying such an objective as a large railway junction are very obscure, and here there seems no good reason why the R.T.C. at Longmoor should not lay out one or more fully-equipped junctions and let the unit go out and destroy them in practice.

Other points on which thorough investigation and adequate practice are necessary will doubtless occur to everybody; and the more of these instances that can be thought of, the more the need for a really large allotment of training grant funds becomes obvious.

It may be said that we have stressed too much the very problematical role of the Tank Brigade in carrying out a raid entirely on its own. We feel that, unusual though that role may be, it is a distinct possibility, and that without its R.E. unit the Brigade could not carry out its task.

We submit that the establishment we have suggested is no more than is necessary for this purpose, and we decline to subscribe to the current opinion that a few specially selected Tank Corps personnel in each battalion will fill the bill. All cats are grey in the dark, and so are tanks in the fog of war, and it will be impossible to ensure that the tanks which contain the special personnel are at the right place at the right time.

Moreover, the tanks already have as much to learn as any sane man can be expected to absorb, and we think that the sapper problem in itself is a whole-time job.

Finally, we would urge that the peace-time training of the Unit and of the Brigade is of very real importance and it can only adequately be carried out if money is provided with a more or less unsparing hand.

WOOLWICH TATTOO, 1934.

By Major H. A. Baker, M.C., R.E.

The following account of a bridging competition, using small box-girder equipment, carried out by the Training Battalion at Woolwich Tattoo, 1934, may be of interest to others who may be called upon to do a demonstration.

We were asked to " put up " a bridging display lasting not more than 15 minutes from start to finish, if possible, of a competitive nature.

It was decided that the turn should take the form of a competition between two recruit parties in the building of a 48-foot span small box-girder bridge.

168 (Lieut. I. W. B. Edge, R.E.) and 170 (Lieut. J. de V. Hunt, R.E.) parties were chosen for the work. 170 had only done one week's fieldworks. 168 had done about five weeks'.

Two bridges were made available, one at Chatham and one at Aldershot. These were of slightly different pattern. The Aldershot one was the first ever made and was somewhat battered and out of shape. Also the two girders of the Aldershot bridge were different, one being joined with link pins, the other with ordinary pins similar to the large box girder bridge. However, it was considered that the advantages and disadvantages of each bridge would about cancel out, any advantage remaining being in favour of the Chatham bridge, and it was decided eventually not to have any handicap as it would have spoilt the display as a spectacular competition.

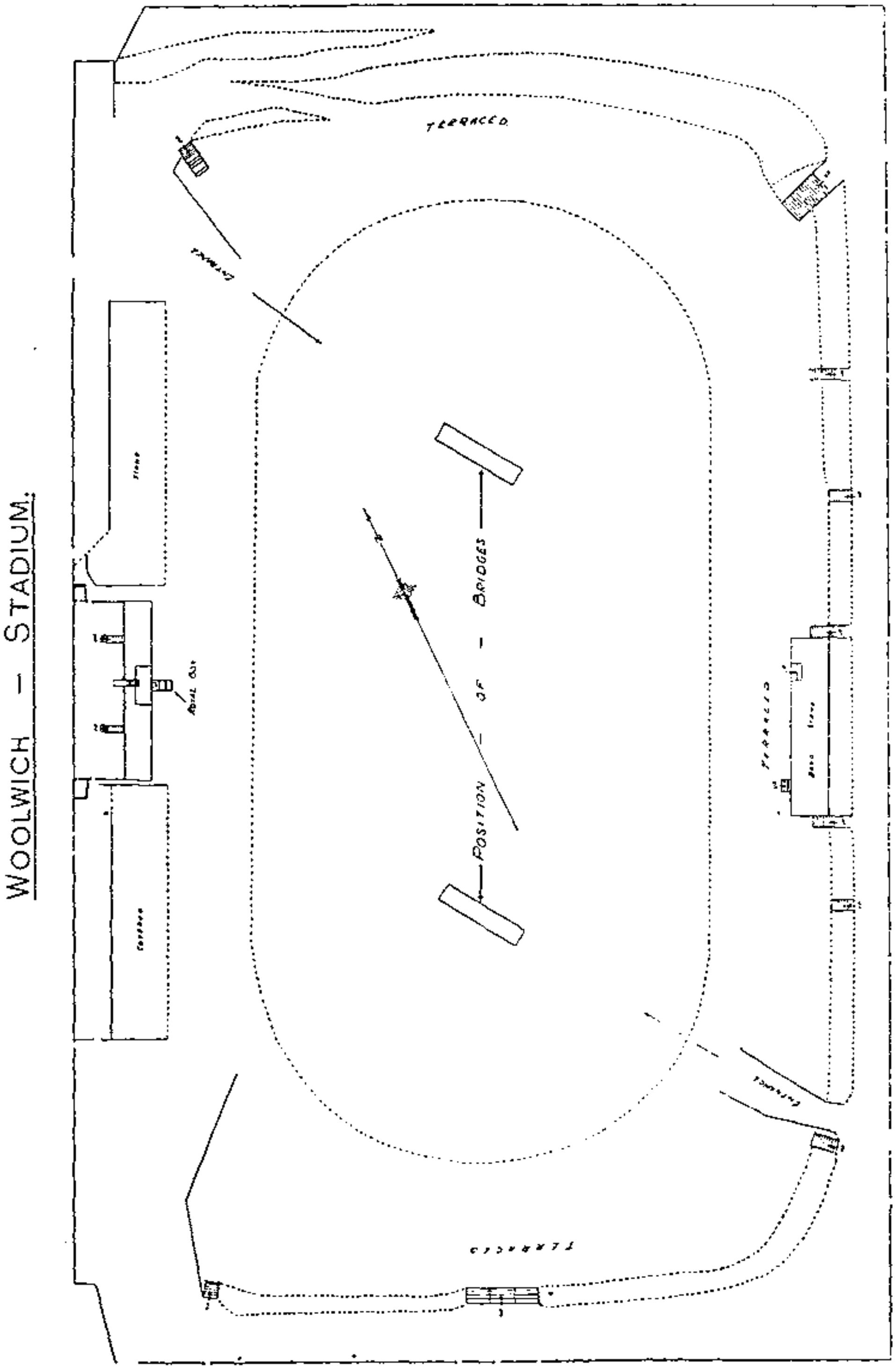
Training.

The Tattoo was to start on July 7th. Practice at Chatham began on 25th June and was continued at Woolwich in the Stadium the next week.

The first week was spent in making up drill and in constant practice of each part of it, gradually increasing the speed and perfecting details.

Usually only two complete practices were done daily. As only one set of lorries was available for loading and unloading practice, this was confined to three days each at Chatham.

The first complete run through was done on Wednesday, June 27th, before the Director of the Tattoo and took 14 minutes 10 seconds, just inside our limit.



PLAN I.

Other details which had to be arranged during the first week and which would be better settled before practice starts were :—

Dummy bankseats (see Plan II).
Dummy river (see Plan II).
Positioning rollers (see Plan II).
Marking out the ground (see Plan II).

On July 2nd the parties went to Woolwich and on that afternoon the stadium was marked out and a rehearsal carried out that evening (Plans I and II).

Rehearsals were carried out each evening that week.

The times taken in rehearsals by 170 Party were :—

		mins.	*secs.*
Tuesday	..	12	20
Wednesday	..	No time recorded.	
Thursday	..	10	20
Friday	..	9	25

168 Party, who had the Aldershot bridge and got a late start on training, were somewhat behind these times at this stage, but well within the limit.

These times include laying out the properties, unloading the bridge and building it.

The times taken during the actual performances were :—

			168.		170.	
			mins.	*secs.*	*mins.*	*secs.*
Saturday	..	..	9	20	8	10
Monday	..	..	9	25	7	55
Tuesday	..	..	8	30	7	35
Wednesday	..	..	7	25	7	35
Thursday	..	..	7	00	6	55
Friday	..	..	10	30*	7	30
Saturday	..	..	7	43	8	15

The night of Thursday was a good race in record time and practically a dead heat.

A fine silver cup was presented to the party with the best average time (170) and the whole were given an outing to Southend at the Tattoo's expense afterwards.

The show provided excellent training for all concerned who were very enthusiastic and keen to put up the best time.

* A very wet night.

CONSTRUCTION DETAILS.*

Loading.

Two medium six-wheelers and one pontoon trailer were used for each bridge loaded before the show, as shown (see Plan III).

"A" Detachment's lorry	..	1 box section. 2 hornbeam sections. 2 launching noses. 4 carrying bars. 2 cradles.
"B" Detachment's lorry	..	1 box section. 2 hornbeam sections. 1 launching nose (old type). 4 carrying bars. 1 cradle (old type).
Trailer (with "B" lorry)	..	Decking. Ribands. Ramps. Rollers. Pins. Racking bolts.

Unloading.

As soon as the properties were laid out by the detachments (not included in the race times) a squib was fired which was the signal for the lorries to drive in and lights to go up.

"B" detachment's lorry comes in first, and the trailer is unhooked. The lorries stop just before the front wheels reach the first rollers; the launching noses and cradles are taken off, the bar men get their bars, and the first hornbeam section is pulled out and tilted so that the end is resting on the ground, the lorry then drives on, and the other end of the hornbeam is allowed to drop. The lorry checks on a signal and the other two parts of the girder are dropped in the same way; the lorries then drive off.

"A" detachment were usually the first to be unloaded, and were just able to place the box section on the erecting rollers by the time that "B" detachment were ready with their hornbeam section. The bar men put their bars into the box section immediately it came off the lorry.

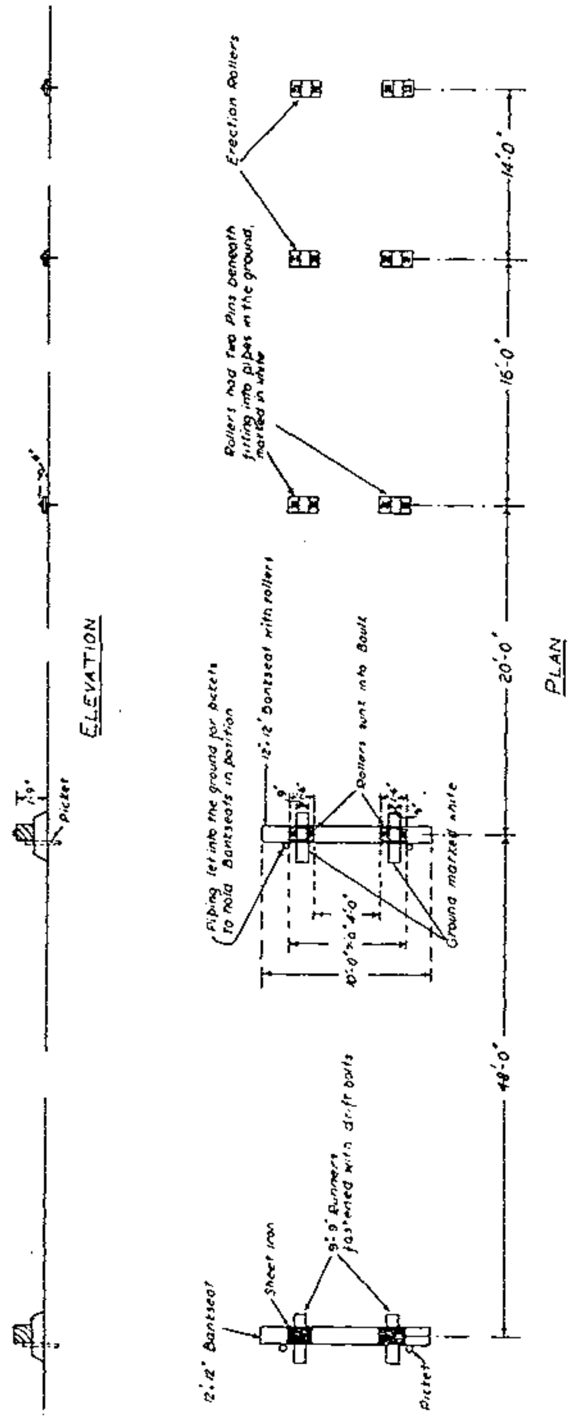
DRILL.

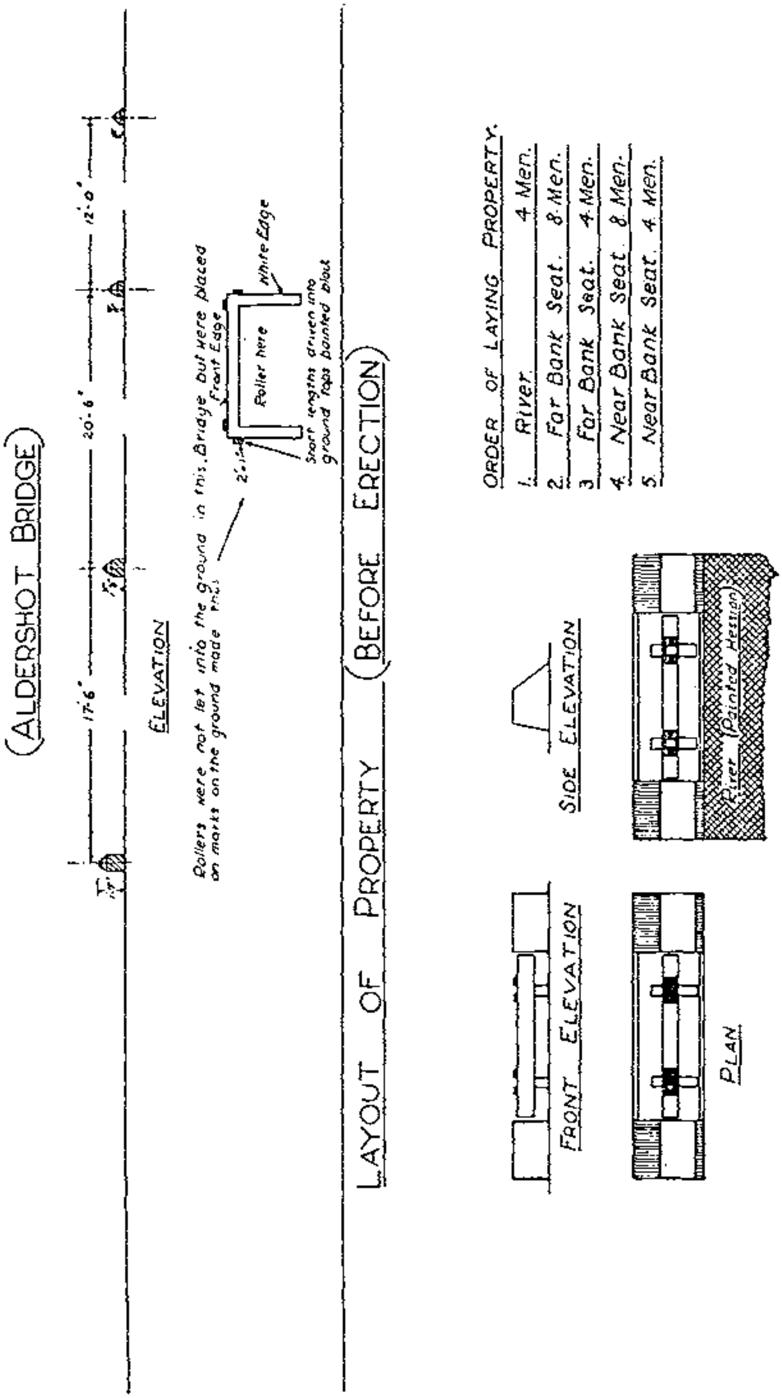
A working party of 4 N.C.O's and 46 O.R's was used split up as follows :—

"A" Detachment, fore of bridge	..	1 N.C.O. 16 carriers. 2 pin-men.

* All refer to Chatham bridge. Aldershot bridge much the same.

LAYOUT FOR SMALL BOX GIRDER BRIDGES AT WOOLWICH TATTOO (CHATHAM BRIDGE)




(ALDERSHOT BRIDGE)
17'6"
20'6"
12'0"
ELEVATION
Rollers were not let into the ground in this Bridge but were placed on marks on the ground made thus
Front Edge
Roller here
White Edge
Short lengths driven into ground tops painted black
LAYOUT OF PROPERTY (BEFORE ERECTION)
ORDER OF LAYING PROPERTY.
1. River. 4 Men.
2. Far Bank Seat. 8 Men.
3. Far Bank Seat. 4 Men.
4. Near Bank Seat. 8 Men.
5. Near Bank Seat. 4 Men.
FRONT ELEVATION
SIDE ELEVATION
PLAN
River (Painted Hessian)

PLAN II.

"B" Detachment,	aft of bridge	..	1 N.C.O. 16 carriers. 2 pin-men.
"C" ,,	fore cradlemen	..	1 N.C.O. 5 O.R's.
"D" ,,	after cradlemen	..	1 N.C.O. 5 O.R's.

On the lorries arriving "C" and "D" detachments double forward and unhook the trailer, and wheel it to the right side.

"C" detachment unload the rollers, and place them in position. "D" detachment start unloading the ramps and ribands from the trailer.

"A" and "B" detachments unload the lorries, "A" detachment on the left, "B" detachment on the right.

"Form Bridge."

"A" detachment lift the box section on to the erecting rollers. Nos. 1, 3, 5 and 7 of the front rank are bar men, they double forward and place bars in the nearest side, No. 1 to the front, two files to a bar. The rear rank double to the far side and hold the bars of their respective front rank men.

Nos. 9 of both detachments stand by with pins, front rank man on the right side of the girder.

"A" and "B" detachments then lift the hornbeams, and join them to the box section.

"Pins."

The front rank pin man puts one pin into the top of the box section, the rear rank man puts one pin into the bottom of the box section, both stand by for the hornbeam, when they reverse the process, and fix the pins in position.

The detachment commanders, as they finish, shout "Up." The bridge commander then shouts "Out."

On this command both detachments take out their bars and double to the launching noses.

While the hornbeams are being fixed, "C" and "D" detachments bring up pins, cradles and ramps.

On the command "Out," "C" and "D" detachments put on the cradles. No. 2 fixes the inside pin, and the detachment commander the outside pin.

"A" and "B" detachments then place launching noses in cradles. Detachment commanders direct positioning and place in U-bolt. Both detachments then prepare to launch the girder.

When the forward launching nose is in, " C " detachment places the forward ramp on top of the girder.

" Out."

The girder is pushed out, " A " and " B " detachments bearing down on the outside end. " C " detachment guides the girder on to the rollers, Nos. 1 at the bankseat roller, Nos. 3 at the first roller, front rank on right. " D " detachment changes the rollers for the second girder.

" Check."

The girder is checked and lowered, with the forward launching nose resting on the far bank.

" A " detachment take out the after launching nose of the first girder and turn it round, ready for the next girder.

" B " detachment double to the second box section and lift it on to the building rollers.

The second girder is then built and launched as the first.

Immediately the front hornbeam section is fixed, the bar men of " A " detachment cross the first girder, taking their bars with them.

When the front launching nose is fixed, " A " detachment start going across the first girder.

" B " detachment launch the second girder immediately it is ready and remove the after launching nose when the girder is across.

" B " detachment commander sees that the after end of the girders are correctly set laterally.

" C " and " D " detachments then fix the ramps on the after end of the girders.

" A " detachment lifts each girder in turn, and positions them on the bankseat, then removes both launching noses and fixes the ramps.

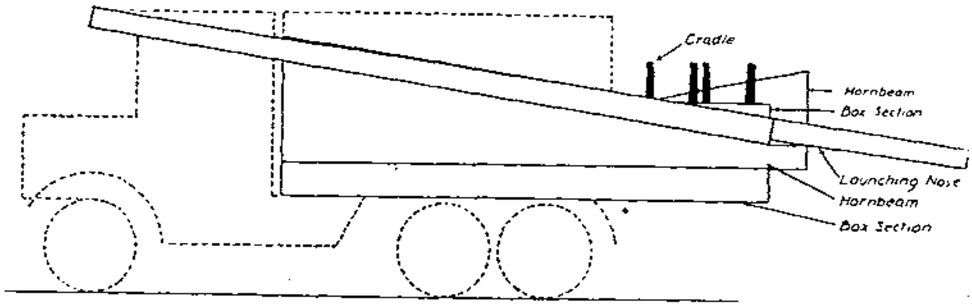
When the bridge commander sees that both the girders are in position, he gives the command " Decking."

" B " detachment decks down. Nos. 9 of " A " detachment are deck takers, and stand on the girders facing aft. Nos. 9 of " B " detachment give the decking from the trailer to the deck carriers.

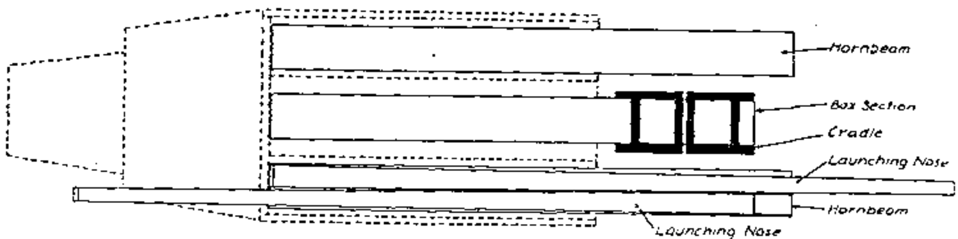
" B " detachment commander sees that the decking is taken in the correct order.

" C " and " D " detachments bring up and fix the ribands, and remove the rollers.

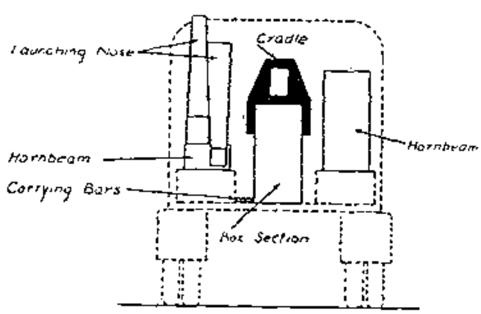
LOADING DETAILS OF "A" DETACHMENT'S LORRY (CHATHAM BRIDGE)



SIDE ELEVATION



PLAN



END ELEVATION

"B" Detachment's Lorry differs only by not having the inside Launching Nose and Cradle, also a Trailer carrying the Decking, Ribands, Ramps and Racking Bolts

On Aldershot Bridge Wooden Launching Noses had to be carried slung on outside of Lorries with Wire Slings hooked onto body.

PLAN III.

Laying Out of Properties (Plan II).

The properties (*i.e.*, two bank-seats, three canvas banks, and the river) were laid out at the side of the arena, and were placed in position in the dark; correct positioning was essential so all the lay-out of the properties was marked on the ground in whitewash, and in addition two pickets were put in behind each of the bank-seats; these pickets were put into piping let into the ground, and prevented any movement of bank-seats while launching girders.

The height of the bank-seats was 1 ft. 9 in.; with lower ones the girder did not clear the ground, consequently the ends of the bridge ramps did not reach the ground, and 9-in. x 9-in. baulks had to be put there; this made extra ramps necessary. The ramps and baulks were laid out at the side of the bank-seats.

The position of the rollers was fixed by letting into the ground pieces of wood into which were fixed two 6-in. lengths of piping, there being two round iron bars on the bottom of the rollers, which fitted into the piping. The wood was painted white.

Practical Points in Building, etc.

All the pins were cleaned each day, and the dowels, dowel-holes, and holes for the pins were also cleaned.

On the Aldershot bridge, which has male and female lugs on one girder, it was necessary each day to ensure that lugs were straight and would fit easily. Much trouble was caused in training in getting the boxes to fit until the cause was discovered in bent lugs. They were straightened with crowbars.

The dowels and round the dowel-holes was painted white, so that they could be easily seen.

The rollers that were let into the bank-seat were exactly positioned so that the girders could be correctly placed by lifting the girders to touch the outside of the rollers.

The other bank-seat was grooved an inch deep and covered with sheet iron, so that the girders could slide and drop into their correct position.

The small decking had an angle iron fitted which only just fitted laterally into the girders as long as they were exactly spaced, this was taken off and a smaller piece substituted.

In decking down it was found to be quicker to have an extra man kneeling on the decking that had already been laid and pulling each piece of decking in to the rest; this allowed the deck-takers to get their next piece of decking quicker.

The lorry drivers found it difficult to see the correct position to halt when they came into the arena, so the bridge commander stood between the first two rollers, In order to let the boards, on which the rollers are placed, in the ground, the holes were dug with jack-knives to fit the boards exactly. In this way the boards stayed firm the whole week of the Tattoo, in spite of musical drives, etc., taking place before our show each night.

DRESS.

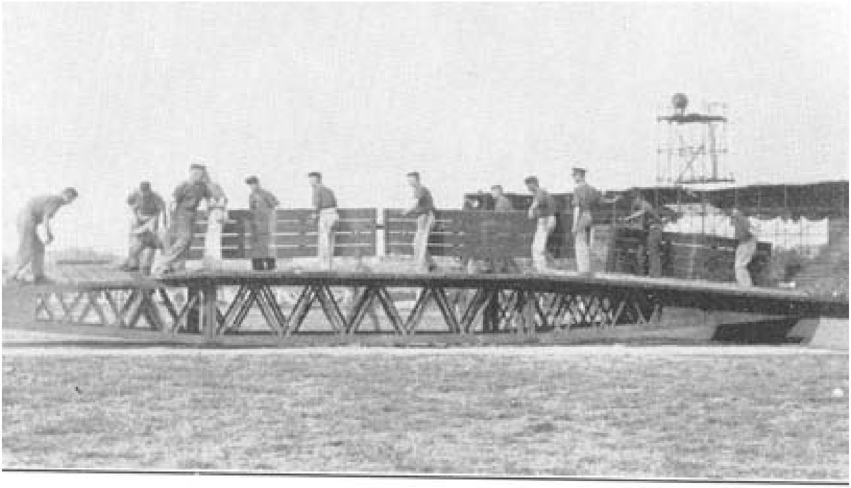
Working parties wore shirtsleeves and S.D. caps. The officer-in-charge wore khaki.

FINALE.

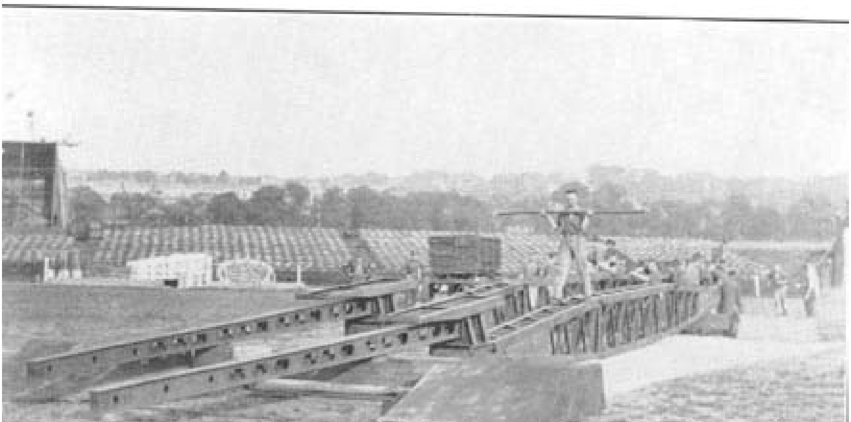
A field-gun and tractor were driven over the bridges as soon as complete to show there was no deception.

After this the two officers walked up to the box and saluted, whilst the parties lined the bridges as in photo, being sized tallest in the centre.

As we were the last turn on, we remained on the bridges while the remainder of the Tattoo performers marched in, and we marched out last.

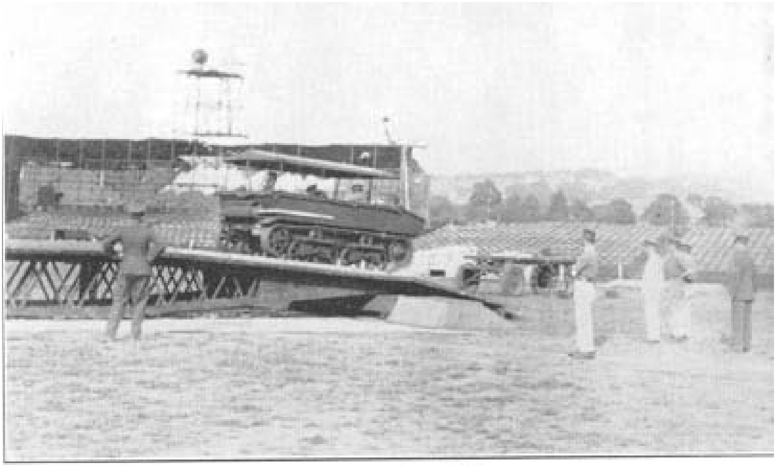


Decking down.

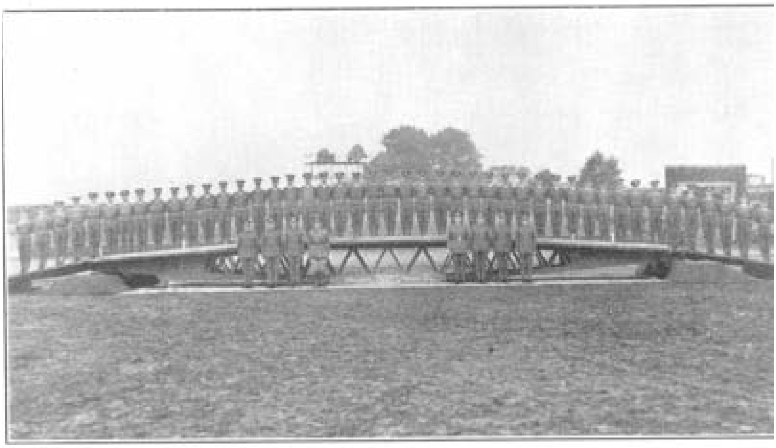


The first man over.

Woolwich Tattoo, 1934 1 - 2



Tractor crossing Bridge.



Finale.

Photos by T. Woodhall, Woolwich.

Woolwich Tattoo, 1934 3.4

ENGINEER OPERATIONS, SOUTH PERSIA. 1914–19.

By Colonel F. C. Molesworth.

Of all the sideshows of the Great War, the struggle in South Persia is perhaps the least known. Its importance was overshadowed by that of the neighbouring greater campaign in Mesopotamia. Few books or magazine articles about it have appeared, and the official history has not hitherto been made available to the public. Yet the campaign was by no means devoid of interest, and the engineering side especially deserves notice; it is not often that the engineers with a force are called upon to convert hundreds of miles of infamous caravan track into motorable roads. There were few regular R.E. officers with the forces, but our traditions were worthily maintained by the temporary Sappers there, largely drawn from the P.W.D. in India.*

Persia, theoretically at least, retained its neutrality throughout, the sympathies of the central government at Tehran varying with the changing fortunes of the struggle in Europe and the Near East. But the ministry was powerless to enforce its will in the outlying provinces. Our commanders had the supremely difficult task of operating in a professedly neutral country in such a way as to violate that neutrality as little as possible.

As regards the theatre of war, the Persian Gulf is devoid of harbours. Along its northern coast is a belt of flat country, unhealthy and extremely hot in the hot weather. Farther inland is a series of parallel ranges, running from south-east to north-west, across which the tracks from the coast rise in steps until the central plateau is reached, a region which, though mainly flat, is intersected by numerous mountain ranges. The principal valleys in this tract lie at an elevation of some 5,000 feet above sea-level, as do the principal cities of Shiraz and Kerman; the climate of this part of the country is, generally speaking, healthy, although there are great extremes of temperature. Water is often scarce and sometimes brackish. Few of the streams reach the sea, most being absorbed in cultivation or else finding their way into salt depressions. Such communications as existed were seldom better than mule or camel tracks.

* The writer was deputed from A.H.Q., India, as liaison officer in connection with engineer services; he visited Bandar 'Abbas in November, 1918, Shiraz in the following month, and Bushire in January, 1919.

In the early years of this century, South Persia was in a state of anarchy; brigandage was rife, and the Persian army was quite incapable of putting it down. In 1909, it had been necessary to send an Indian cavalry regiment to Shiraz to protect British subjects. About 1911, a gendarmerie under Swedish officers was formed, which, by the time of the outbreak of the Great War, had begun to do something towards restoring order, and it had been possible to withdraw the Indian regiment. Most of the gendarmes were, however, scattered in small detachments along the chief trade routes, and looked upon their location there as a heaven-sent opportunity for extracting blackmail from the caravans they were supposed to protect. Moreover, these small posts, which seldom contained more than eight men, were sometimes captured—men, rifles, ammunition and all, by tribesmen.

It will be convenient to describe the military operations in South Persia during the Great War in brief before detailing the engineer services which they necessitated.

The centre of British influence in South Persia before the War was Bushire, where the Resident in the Persian Gulf was stationed to protect our interests, with half a battalion of Indian infantry as escort. There was also a German consul called Wassmuss and, if any man in history has ever deserved well for his activities on behalf of his country, it was he; for, almost single-handed, he plotted and intrigued among the tribesmen until we needed the equivalent of almost two divisions to put down the forces he raised against us. He turned Mussulman, informing the Persians that his Emperor —Haji Wilhelm, as he called him—was a Mussulman, too. An apparatus consisting of two bamboo poles and a telephone receiver led the more gullible to believe that he was in wireless communication with the Kaiser himself and, incredible as it may sound, he succeeded in borrowing large sums by this means from certain Persians, money which has never been paid back.

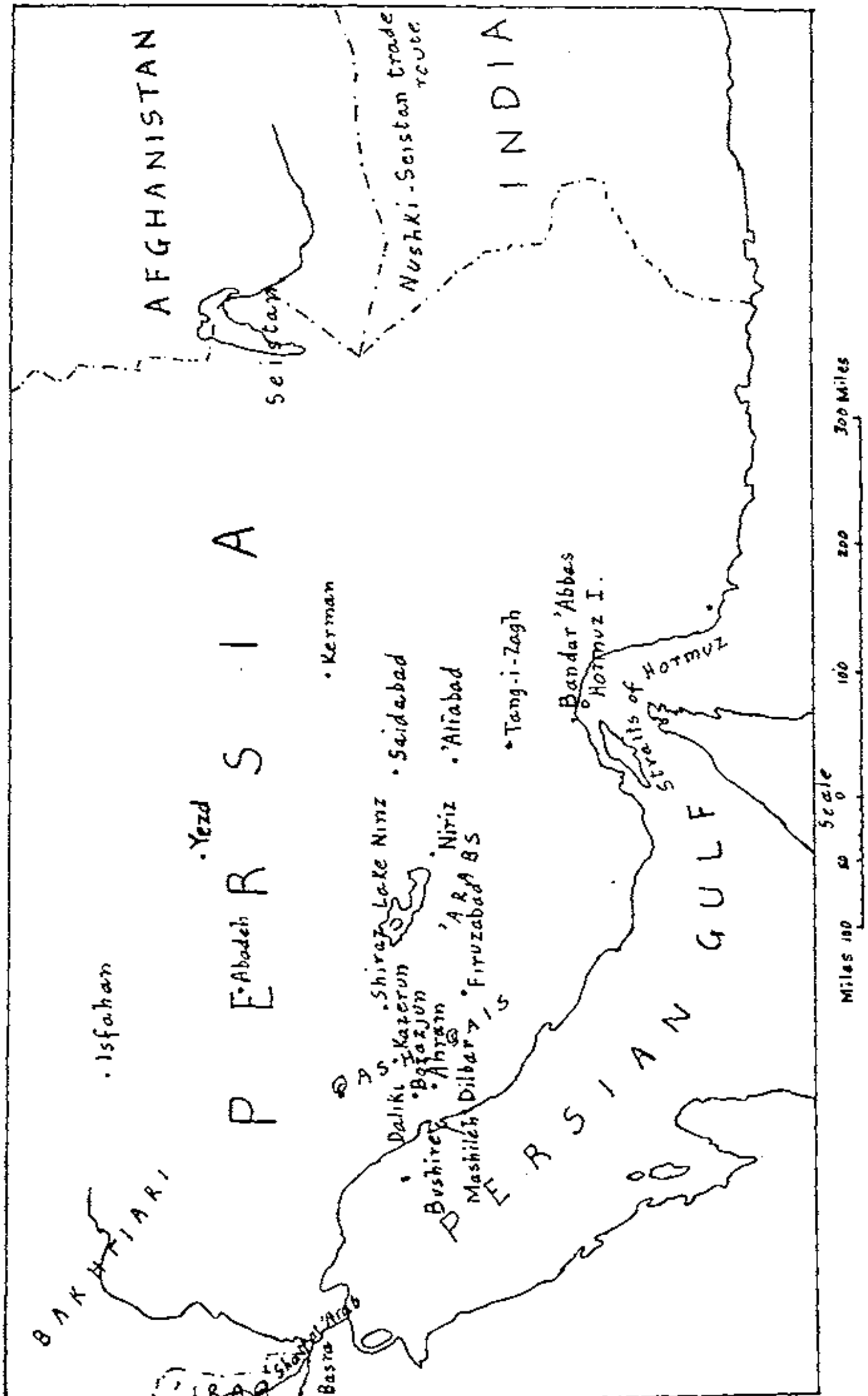
His first move—the organizing, early in 1915, of an attack on the British and Russian communities in Bushire—was however a failure, and he left for Shiraz; and the Navy, by an attack on Dilbar, paid back the insurgents in their own coin. The Residency was reinforced by a battalion of Indian infantry, but anti-British propaganda continued in Bushire itself; several attacks were made on our position about the Residency, and in August, 1915, it became necessary to occupy the town itself.*

The Persian navy, consisting of one converted merchant steamer, was taken over, and spent some time in the Shatt-al-'Arab with the white ensign at its masthead.

Bushire lies at the northern end of a peninsula shaped like a

* The local supply of Persian stamps was taken over and surcharged, and a rather rare issue of "Bushire in British occupation" resulted.

ENGINEER OPERATIONS, SOUTH PERSIA.



hammer-head, separated from the mainland by a muddy isthmus named the Mashileh. Using this as left-flank protection, a line of posts, designed principally by the late Major R. C. Lord, M.C., R.E., was established across the peninsula to defend our position. Several sporadic attacks were made by the tribesmen. At length the repulse of a more serious one ended the fighting for the time being; things became quieter, and in October the city was handed back to the Persian authorities.

Meanwhile, German propaganda swept over central and southern Persia. German consuls raised armed levies on the pretext of restoring order. The activities of these bodies were, however, always directed against the lives and property of British and Indian subjects. British residents were forced to flee to the coast. The British colony in Isfahan, where our Consul-General was wounded and his orderly killed, made its way across the difficult Bakhtiari country to Basra.*

The British Vice-Consul in Shiraz was murdered, and the British subjects there were captured by a pro-German *shaikh* and kept in durance at Ahram, some thirty miles east of Bushire. British influence disappeared from South Persia. Most of the Swedish officers of the gendarmerie joined the German parties with their men, and rendered them valuable services. Central Persia in effect became a corridor by which German agents reached Afghanistan and the N.W. Frontier of India. Had this state of affairs gone on unchecked, Persia might easily have become, as it was on many occasions in the past, a highway for the invasion of India.

Such a state of things could not be tolerated. The consent of the government at Tehran was obtained to the formation of a Persian force under British officers to restore order. Brig.-General Sir Percy Sykes, an officer with very great political experience in Persia, and no little military service in South Africa, was appointed to raise and command the force, which shortly afterwards became officially known as the South Persia Rifles. With a small escort of Indian cavalry, and a few B.O's and B.N.C.O's to act as instructors, he landed at Bandar 'Abbas in March, 1916, receiving a warm welcome from the inhabitants, and proceeded to raise the force.

This was by no means an easy task, as eighty per cent. of prospective recruits had to be rejected on medical grounds. But discipline was instilled into the remainder and, within two months of landing at Bandar 'Abbas, Sykes started in command of 700 Indian troops for Kerman, where he was warmly welcomed by its inhabitants, who bitterly resented the behaviour of the Germans. Leaving a few officers to raise and form a brigade of the S.P.R. he

* A few months later, Sir Percy Sykes intercepted a letter from a German official, Seiler by name, in which he boasted of having arranged the assassination of the Russian Vice-Consul and the attempted murder of the British Consul-General.

continued on to Yezd. The fleeing German missions were, through his influence, captured by the Arab tribesmen and subsequently handed over to him, with all their papers. The transport and supply difficulties of the column were great, for there was a partial famine due to robbers and locusts, so progress was slow, but the British force was already having a good effect, and German influence was almost eradicated. Passing through Yezd, the column reached Isfahan in November, joining up with the Russians there, and marched thence to Shiraz, which became its headquarters. It may here be noted that in three years this column covered 5,000 miles.

The force had all this time been constantly occupied in putting down brigandage. There were many small fights with bandits, in which the Indian troops invariably, and the Persian Rifles sometimes, showed dash and courage. As a result, by 1917, the part of Persia occupied by the force attained a degree of tranquility which it had not known for a generation. Sykes had the pleasant experience of receiving the congratulations of a greybeard who was cultivating the land of a village which had been abandoned for twenty years on account of robbers: "This is thy work."

But there were still powerful anti-British elements in the situation, chief among which was the tribe of the Qashqais, whose principal habitat lay between Shiraz and the coast; it was estimated that they possessed 25,000 rifles. When the intensity of German propaganda reached its climax in Persia, in March, 1918, the Qashqais and some other tribes rose in arms and attacked some of our posts. The loyalty of the South Persia Rifles was tried to the utmost; some detachments deserted and some mutinied and killed their B.O's and B.N.C.O's, while many others had to be discharged.*

At one small post, Abadeh, the S.P.R. deserted and the insurgents besieged the small garrison of Indian troops. The enemy tried a novel manner of destroying the walls of the post by diverting against them the water of an irrigation channel. A temporary R.E. officer, Captain G. D. M. Gwynne Griffith, accompanied by a B.N.C.O., sallied out, and, at the cost of his life, destroyed the diversion.

It was decided to assist the hard-pressed force in South Persia by an expedition from India, to advance from Bushire, but such help could not be forthcoming, owing to the intense heat of the coastal plains, until the following cold weather. The Shiraz force had therefore to fend for itself, and right well did it do so. Expeditions into the Niriz area assured the safety of the L.-of-C. with Bandar 'Abbas. Possible trouble in Shiraz city was forestalled by the occupation of the principal points in the city, and a series of actions in early July

* A B.O. with the S.P.R. told the writer that he used to go to bed during the worst of this period wondering whether his men would wake him before they shot him or kill him while he slept.

drove the Qashqais with heavy loss from the neighbourhood. As soon as Shiraz was clear, a relief force was sent north to Abadeh, which it reached after a march of 170 miles in seven days in intense heat. The Bushire road was cleared for about thirty miles, and an expedition to Firuzabad to the south gave the Qashqais a final blow in October; active operations ended, so far as the Shiraz force was concerned, with complete success.

They were scarcely over when the troops at Firuzabad were attacked by influenza, which in South Persia was probably more virulent than anywhere else in the world. The force lost about twenty per cent. of its effective strength, and all the sound men had to be employed in looking after the sick and dying. It was noticed incidentally that it was the halest and heartiest who seemed to get the disease worst. Animals had perforce to be let loose to fend for themselves. From Firuzabad the detachment made its way back by slow degrees to Shiraz, but there, too, influenza had been rife, as indeed all along the line. At Niriz, 90 Indian O.R's died out of an effective strength of 150. At Kerman, and at Bandar 'Abbas, which had just recovered from a cholera epidemic, the disease was somewhat less serious. The Persian inhabitants suffered as severely as the British and Indians, whole villages were deserted, and dead Persians, their corpses being eaten by dogs, were to be seen along the roadside. Mercifully the duration of the pestilence was short, and it ceased almost as suddenly as it began.

Bushire also, where a force was now collecting, was affected by influenza, though not to the same extent as the rest of South Persia. About two brigades, with ancillary troops, were arriving from India. The force, under Major-General J. A. Douglas, was extremely well found as regards medical and all administrative services. An advance inland was begun on September 29th, and slowly and methodically the force made its way towards Shiraz, not without occasional fighting. Kazerun was occupied on January 28th, 1919, and on the following day touch was gained with the force from Shiraz. Operations came to a close in May, and the Indian troops re-embarked for India, many to be engaged almost at once in the Third Afghan War.

The future of the South Persia Rifles was long in doubt, but it was eventually decided to disband them, much to the regret of its B.O's, who, in three years, had made it into a respectable fighting force. Its last act was to escort its B.O's to the coast. Most of its Persian officers and men were re-enlisted into the new Persian army, where they have constituted its best-trained units.

To turn now to the engineering side of the operations. It was a difficult country from an engineering point of view, for, as has already been mentioned, there were no harbours on the coast, and no metalled roads inland. Pack animals—camels, mules and donkeys—were the only form of transport available, and tracks connecting even important towns were often fit for caravan animals only. There were practically no bridges. Engineering stores of most kinds were absolutely unobtainable; timber was scarce and consequently very expensive.

The L.-of-C. of a force based on India, operating in South Persia, would naturally seem to be overland. But the only practicable route connecting India and Persia—the Nushki–Seistan trade route—was taxed to its utmost capacity to supply the East Persia Cordon. A few light cars did, as a matter of fact, get through to Sykes by this route, but the desert conditions—there was a stretch of 100 miles absolutely without water points—made it impossible for men and animals. Bandar 'Abbas was therefore selected as the base, and an L.-of-C. had thence to be established over very bad terrain to Kerman and Shiraz.

Officers making the journey along the line were, of course, provided with chargers, but one at least preferred to do the journey on foot. Sir Percy Sykes asked for a financial adviser from India, and in due course an officer of the Accounts Department arrived at Bandar 'Abbas. He had unfortunately never been on a horse before and, during the first stage, found the unaccustomed motion very trying, and so returned his mount from the first halt with the memo: "I regret I cannot ride your horse, as his stirrups are of uneven length." The stout fellow did the rest of the 450 miles to Shiraz on foot!

To return to engineering; soon after his arrival, Sykes asked fo an engineer officer for road reconnaissance. Major (now Colonel E. T. Rich, of the Survey of India, was consequently sent, and after thorough reconnaissance, reported on the route by Gakum and Saidabad as the best between Bandar 'Abbas and Kerman, and the Government of India in due course sanctioned the construction of a light motor road on this alignment. The country between Saidabad and Shiraz was easier, so far as the making of a road went.

There was at no time an officer in the position of C.R.E. on this line, but there happened to be with the Burma Mounted Rifles in the country an officer of the P.W.D.—Lieut.-Colonel F. C. Lowis, C.I.E.—with great experience in roadmaking in the mountainous tracts of northern Burma. To him was entrusted, for most of the time, the charge of the greater part of the Bandar 'Abbas–Shiraz road, and he was assisted by several works officers at different points along the route. In addition to local labour, which was, generally speaking, bad and expensive, works companies and labour corps carried out the task. These organizations were recruited in India, and sent out after a modicum of training. Generally speaking, they took some time to settle down, but thereafter were capable of very good work.

Officers were a problem: India was at its wits' end to find suitable men. Promoted subordinates of the P.W.D. formed a proportion, and planters and others with a modicum of engineering skill, combined with the power of driving workmen, the rest.

A beginning was made in the cold weather of 1917–18. The hot weather of 1918, followed by the cholera and influenza epidemics, meant a slowing down of work, but things were got going again in the ensuing cold weather.

At Bandar 'Abbas there was at the time an open roadstead, where ocean-going vessels had to lie out three-quarters of a mile to unload. The first essential, therefore, was a pier; this was constructed, with wood imported from India, and completed just before operations on this line ended. Ashore, troops and depots were housed in mat huts and other temporary shelters, which were in process of being replaced by brick and stone structures. The local engineers incurred a certain amount of odium by erecting their own mess first, a very fine building which would not have disgraced a cantonment in India. It was provided with an immense cement bath, which must have cost hundreds of rupees, but, owing to the scarcity of water, could not do more than wet the soles of a bather's feet. In justice to the builders, however, it must be added that it seemed then that the war might drag on for decades, while a permanent British occupation of South Persia seemed not unlikely.

Other works in Bandar 'Abbas included a water-supply, some metalled roads, a brick kiln—for practically all bricks had to be burnt by the engineers themselves—and a landing-ground.

The main employment of the engineers was, of course, the road to Shiraz. The specification was for a 16-foot road, maximum gradient 1 in 20, except for approaches to *nullahs*, where 1 in 10 could be used. As a great part of the soil of Persia consists of very hard earth, metalling could be dispensed with almost entirely, the only portions needing exceptional treatment being the first six miles, which traversed a stretch of soft sand, various causeways which had to be roughly paved, and certain patches which went soft after rain. But immense amounts of cutting—often in hard rock—embankments and revetting were necessary.

The first six miles out of Bandar 'Abbas were macadamized, stone for the purpose being brought by steamer from a barren island, called Hormuz, in the straits of that name. Here the engineer in charge of the quarries could moralize on the decay of human greatness, as this was the very same spot of which Milton wrote:

> "High on a throne of royal state, which far
> Outshone the wealth of Ormus and of Ind."

A ruined Portuguese fort alone testifies to the former magnificence of the place. The few inhabitants now make a precarious livelihood by fishing and mining red ochre.

The southernmost stages of the road lay through a barren country, where innumerable *nullah*-crossings and one or two formidable passes made roadmaking a matter of considerable difficulty. Nor was the work entirely unmolested. Colonel Lowis and an assistant were attacked by brigands, and had to defend themselves with revolvers. 2nd-Lieut. F. J. B. Hastings (now Major Hastings, R.E., I.A.) had a narrow escape from raiders who captured his camel and cameleer, while he himself was out after ibex: the camel-man turned up next day clad only in a newspaper.

By the time that orders were received to cease work on this line (February, 1919), 84 miles of the road had been completed to specification. At the end of this stretch came the most formidable obstacle of the whole route, the Tang-i-Zagh, a defile some miles long with sides which were often precipitous and several hundreds of feet high, where the track at the bottom was the bed of a stream and consequently impassable in floods. Enormous boulders, dislodged at various times from the cliffs above, had blocked the way at one point, so that it had been necessary to unload pack animals on one side of the obstacle and reload on the other, a state of affairs which, according to travellers, had existed for many years before the British came. The project for the road included a by-pass at this point, but time did not allow of its construction, so the defile was cleared, and a good camel road made through. The camel road continued, again through execrable country, to 'Aliabad, about 176 miles from Bandar 'Abbas, whence, under somewhat easier conditions, a motorable road was made through to Kerman. In all 230 miles out of the 322 from the coast to Kerman were made fit for motors.

This section of the road passed through Saidabad, where the road to Shiraz took off. One of the principal sights of Saidabad was the local ice factory, consisting of a mud wall about thirty feet high, with three slightly concave bays facing a little to the east of north. Ice was manufactured in winter by carrying water to the top, and letting it trickle down the northern face of the wall till it froze. The resulting mixture of earth and ice was then scraped off and buried in pits for summer use. An inscription stated that the factory was built in A.H. 1274 (about A.D. 1860).

The engineers in Saidabad had a particularly difficult time owing to the almost complete absence of timber, but they carried on wonderfully, building a fort and several depots, substituting arches and domes in burnt and sun-dried brick for roofing timber.

From Saidabad, a motorable road was carried as far as Shiraz. Immediately to the east of Saidabad was what is known as a *kavir*, an immense expanse of salt and saline soil, produced by the evaporation of a bygone lake, for few of the rivers of Persia reach the sea. the majority of them draining into depressions inland. The surface of this *kavir* was solid salt, and one of the best imaginable for motoring, except at the edges where, in wet weather, pack-animals poach up the ground, which later solidifies into large hard lumps very trying to wheels.

The main difficulty on the Saidabad–Shiraz stretch was near Niriz, where an escarpment many hundreds of feet in height had to be dealt with. A practicable track down this obstacle was made by a Subadar-Major of the 106th Hazara Pioneers (now disbanded) with local labour and at a very small cost. It had gradients of about 1 in 5, and consisted of little else than hairpin bends ; parapet walls were seldom more than a few inches high, and a motor drive down it was an unforgettable experience ; but it " got there."

In Shiraz and its neighbourhood, engineer services were, for many months, including the very anxious period in 1918, in charge of Staff-Serjeant Hallsworth of the M.W.S., who, with the help of a few Indian subordinates of the same service, carried out the duties of a C.R.E. Accommodation, roads, water-supply and many other works were part of a very important charge. Among other items must be mentioned a workshop, which served for the repair of Ordnance equipment as well as for the manufacture and maintenance of his own.

The force at Bushire was very well supplied with engineer troops ; there were two field companies, the 63rd of the Q.V.O. and the 54th of K.G.O.S. and M., an Engineer Field Park, and a large number of works companies and labour corps ; as far as memory serves, there were five engineers to every three combatants of the other arms. Not that the engineers were not all wanted, for Bushire, like Bandar 'Abbas, was devoid of engineering resources, and the road thence to Shiraz was a byword among roads in Persia, and that is saying a good deal. Works were under Lieut.-Colonel Taylor (of the P.W.D., India) with Temporary Major H. W. Longdin as deputy.

Bushire was an open roadstead, and the landing of heavy stores extremely difficult, and consequently a good deal had to be done as regards improving wharves and making piers. The base included an enormous hospital, nearly all the accommodation for which had to be improvised ; a ward of 300 beds, which must constitute a world's record, was one of its constituent parts. E. and M. works included an ice factory and a deep-well bore. The latter was necessary as the water on the peninsula was nearly all brackish, and it was hoped that by penetrating the clay stratum which underlay the soil to obtain fresh water ; but though a depth of over 300 feet below sea-level was reached, no water was encountered.

The first 45 miles of the road from Bushire traversed an almost level plain. Here, except over the Mashileh, which turned to liquid mud after rain, roadmaking presented no great difficulty : eventually on this stretch a light railway was constructed as far as Borazjun, 30 miles from Bushire, whence a cart road was made as far as Daliki at mile 45. At this point the road entered the hills, and the real difficulty of the task began. There were six passes between Daliki and Shiraz, enormous steps leading through the jagged ranges which barred access to the interior. As the striking force moved forward, the engineers followed on their heels, and at times almost every available man in the infantry was put on to help. By May, 1919, when operations came to a close, an excellent camel track had been made to Shiraz, and it was possible to travel the whole distance, about 150 miles, in a light car in a day.

When the forces evacuated South Persia, they left behind, in addition to a very wholesome respect for the fighting powers of the Indian soldiers, monuments of their untiring industry in the shape of hundreds of miles of good roads, where barely the semblance of a track had existed before. The Persians have not been slow to take advantage of the new facilities for travel, though it is to be regretted that many of the roads we made have been allowed to go to rack and ruin. Motor-lorries now traverse in hours what mule and camel caravans used to do in days and weeks, and the Persian is rapidly becoming mechanically minded. The landowners, the muleteers and the peasants realized to some extent the benefits which our occupation of South Persia gave them.*

* Since the article was written, the vernacular name "Iran" has been officially adopted instead of "Persia."

A CONSIDERATION OF DEMOLITION METHODS—ESPECIALLY AS APPLIED TO POWER PLANT—WHICH COULD BE ADOPTED BY A MOBILE STRIKING FORCE.

By CAPTAIN W. M. BLAGDEN, R.E.

THE great speed and cruising range of the modern armoured fighting vehicle enables it to be used in an independent role to form a mobile striking force, which, by breaking through the enemy position or by executing a wide turning movement round it, would be able to make raids upon unprotected civilian centres in rear of the enemy line.

The object of such raids would be the destruction of industrial material, with the idea of hindering the production of war munitions and supplies, or of causing disorganization and discomfort to the civil population of a town or countryside. Resistance would naturally have to be overpowered by force, but political as well as humanitarian considerations would normally rule out any drastic action against the unarmed people themselves, as this might well stiffen morale by arousing resentment, and would create indignation among neutral powers. Care would therefore have to be exercised to avoid employing means of destruction that might cause widespread havoc and loss of life.

The objectives singled out for attack would either be the factories where munitions or supplies were being manufactured, or else those institutions, the destruction of which would bring about the greatest dislocation of the amenities of life. Foremost in the latter category are power stations, water-pumping plants, gasworks, and large bridges.

Various means of destruction are available, and they mostly call for the employment of engineer personnel; it seems, in fact, fairly certain that a specially trained party of "wreckers" would have to accompany the striking force as passengers, carrying their demolition stores as personal baggage. The methods open to them must next be considered in detail.

1. EXPLOSIVES.

The most obvious method of demolition is the use of high explosives, which are spectacular and decisive in action, and familiar to the R.E. officer. In this case, however, they have certain disadvantages. In the first place, for a task of any magnitude, a fairly large weight of explosive would have to be accommodated on top of, or inside, the already cramped fighting vehicles, and it is possible that the commanders of these vehicles might object, for more reasons than one, to the carrying of such a cargo. Secondly, the placing of an explosive charge may take time, and to avoid endangering the lives of the operating party, all charges would have to be fired simultaneously, at the moment of withdrawal. Failure at this juncture would mean the ruin of the whole undertaking.

Explosives would therefore, if possible, only be used as an addition to other methods of destruction. Their most convenient form for rapid work would be plastic H.E., which needs no dry primer and, being capable of being moulded to the shape of the object to be destroyed, would need less tamping than guncotton. The dynamo exploder and electric detonator would be simpler than F.I.D. and safer than time fuse, but ready-to-use bombs, H.E. or incendiary, would be sure to come in useful.

When dealing with structures, as opposed to machinery, it is fairly certain that explosives will be the only satisfactory weapon, and in addition to this, some form of rock drill would be needed for making boreholes in concrete or masonry. Failing a compressor, it should be possible to operate such tools as may be needed from a power take-off on the vehicles, through the medium of flexible shafting.

2. Thermit.

In the place of explosives one could in some cases make use of thermit, a substance which when ignited evolves a heat sufficiently intense to melt steel. This also would take up space inside the vehicles, and its use would only be justified on special occasions.

3. Oxygen Cutting.

The next possibility is the oxy-acetylene blowpipe; this is a powerful weapon, and it could be used for cutting up the shafts of machines, or tension members of girder bridges. For example, a 3-inch steel shaft could be cut in under a minute, with the expenditure of about two cubic feet of oxygen and less than half a cubic foot of acetylene. Portable outfits could easily be devised, with gas cylinders of about 50 cubic feet capacity, light enough to be carried in the hand or on the back for short distances.

4. Sledgehammer.

Smashing of anything breakable with a heavy hammer is a rapid and reliable means of dealing with delicate machinery; it is especially suitable for electrical gear, and motors up to 5 B.H.P. would probably succumb to this form of treatment.

5. Sabotage.

Deliberate mishandling of running plant, so as to make it destroy itself, is an attractive course to pursue, as it does not involve the carriage of stores and tools, but it calls for considerable technical ability on the part of the performer, and usually takes more time than is likely to be available in this sort of work.

6. Gun and M.G. Fire.

Any outdoor and easily accessible appliances, such as insulators on power lines, can most readily be dealt with by fire from the armoured fighting vehicles, while the latter are waiting for the wrecking parties to complete their work indoors.

It is clear that a large number of things can be done, but it is unlikely that it will be possible or even expedient to attempt them all. Much depends on the accommodation that will be available for the carriage of the extra men and stores, and the length of time during which the wreckers can expect to remain undisturbed. The time factor is much influenced by the secrecy or otherwise of the preparations, and the degree of surprise that can be achieved.

Apart from these considerations, the actual plan adopted will depend primarily on the nature of the objective, and it will be influenced by the information, from aerial photographs, etc., that is available for the commander of the force.

A complete technique of destruction for every different kind of industrial plant or structure would be outside the scope of this discussion. It is proposed merely to take a single example—that of the "super" power-station, such as has lately been installed in this country to feed electric power into the high-tension "grid"—and to arrive at a plan for putting it out of action.

A modern power-station is a highly complex organism, which, owing to the very great importance attached to maintaining the continuity of electrical supply, it is inherently difficult to disable completely. Power-station machinery is always made up in multiple "sets" with a liberal allowance of spare plant, and auxiliaries are duplicated so as to guard against breakdowns. Automatic devices are incorporated in most of the gear which protect it from damage by accidental mishandling, and which make sabotage a matter of much difficulty.

The chief points of attack, taken in logical order, are:

1. *The fuel-handling plant.*

This is not entirely indispensable, as alternative means of handling can always be resorted to. Coal dumps can be set on fire and oil tanks blown up, but such damage might spread to the civil population, and fuel is easily replaced.

2. *Boiler House.*

It may appear an obvious course to blow up boilers under steam, but this, though spectacular in effect, is not so easy or as profitable as one might hope. The modern power-station boiler consists mainly of water tubes; its steam drums are of relatively small capacity, heavily lagged, and situated at a considerable height above the ground. It would not be easy to make sure of blowing it up if one were in a hurry, and the effect of doing so would probably not be catastrophic enough to involve the boilers on either side. To be certain of complete success, all the boilers in the station should be attacked, and this is probably out of the question.

Steam pipes could be cut with H.E., but would be quickly replaceable. When cut they would make the station untenable until the steam had ceased to escape, and this item would have to be left till last.

A simple and profitable action would be to smash the motors driving the stoking gear or the coal-pulverizing mills.

3. *Turbines.*

These are normally well protected against mishandling. They would burst in a most satisfactory manner if run above a certain speed, but they are fitted with governor gear and emergency over-speed devices to prevent this, which are not readily accessible, even to a man who knows where to look for them.

They could best be attacked by detonating a charge of H.E. against the low-pressure casing, near the shaft gland. This is at once the weakest and the coolest spot, and it should be possible to wreck both shaft and casing. These parts should take longer to replace than anything else on the turbine. The shaft could also be cut with the blowpipe, but if this is done, it should be as close to the casing as possible.

4. *Auxiliaries.*

Boiler-feed pumps, condenser circulating water and air pumps, together with their driving motors could probably be put out of action with hammers, but they could be replaced without much difficulty.

5. *Alternators.*

High-speed alternators, of the kind that one finds coupled direct to steam turbines, are easy to put out of action but hard to destroy beyond repair. They can be disabled very quickly by smashing the exciters and brushgear with hammers, but these parts are replaceable. They would not be damaged electrically by putting them on short circuit, unless this state of affairs could be maintained for some time. The rotor shaft could be cut with H.E. or with a blowpipe, but to do really serious damage to the stator one would require time and a fair amount of explosive. It is worth remembering that one might have to deal with half a dozen alternators at once.

6. *Control Board.*

This would probably be in a room by itself, with windows overlooking the main engine-room, and the switch handles on it would probably act on the high-tension switchgear through some form of remote control. The instruments would all be connected through instrument transformers, and could be mishandled with safety.

The switches would all be protected by automatic breakers, operated by a local low-tension circuit energized by a battery, but this circuit could be disconnected by a person with electrical knowledge, and if the battery were accessible it could be smashed up. This would make the protective devices inoperative, and it might be possible to create a diversion by closing all the open switches, putting any stationary sets, all unprepared, on the bus-bars. This would not necessarily damage the machines, but it would probably bring out the circuit breakers of most of the neighbouring power stations that were feeding into the same " grid " and make the trouble more widespread.

The instruments and relays could then be smashed up with hammers; this would make it impossible to work the station until they had been replaced.

7. *Switch House.*

The actual switches would probably be housed in a separate building, and a large incendiary bomb or a bag of thermit might be used to break open the switch tanks, release the oil, and set fire to it.

8. *Transformers.*

The duty of the transformers is to step up the voltage generated in the alternators to the extra high-tension that is required for economical transmission over long distances. There is a growing tendency to site them out of doors, in which case they can most readily be disposed of by gunfire.

Confronted with such a bewildering mass of possibilities and given a strictly limited time, the wrecker would, with every ill-will in the world, be unable to select the most profitable objects for the exercise of his art, unless he were possessed of both electrical and mechanical knowledge, and had a clear idea in his mind beforehand of what he was going to do. No matter how thorough the destruction, it must be a mere question of time before the station can be put into commission again—even if the site were ploughed up and sown with scrap-iron. The wrecker, in singling out points for attack, must know, not only what parts are vital to the functioning of the plant, but also what parts will take the longest time to replace. He must aim at getting the utmost value out of the time and stores at his disposal.

It should be clear at this stage how important it is that the commander of the force should have as much information as possible about the power station he is going to attack, as the methods to be adopted will depend on this. For example, an aerial photograph may reveal the layout of the approach roads and the fact that the transformers are accessible to his vehicles, or the intelligence branch may be in a position to tell him how many alternator sets there are in the station.

The plan should aim at two things. First to put the entire station out of action by the quickest possible means, secondly to do some vital damage that will take some weeks to put right again. It may be that there will only be time for the first object to be carried out.

Let us suppose that the vehicles of the force can only accommodate, in addition to their own crews, a party of seven individuals carrying 30—40 lb. of stores each, and that this party can only be allowed a quarter of an hour in which to carry out the disabling of a power station. How can this material be employed to the best advantage ?

For producing an immediate "blackout," the most vital and readily accessible point of attack is the control-room, and the most effective weapon the sledgehammer. At the same time damage of a more lasting nature must be wrought elsewhere, and for this explosives and the oxygen blowpipe are more suitable.

The composition of the wrecking party might well be as follows:

One officer or N.C.O. with E. and M. knowledge.
Two men with sledgehammers.
Two men with explosives.
Two men with oxygen blowpipe outfits.

These men must be able to do their work without being molested by the power-station staff, and the commander of the force must detail some men out of his crews to act as escort, and others to round up and take care of any civilians that they may find about the place.

On arrival at the power-station, the party leader will conduct his troupe into the building, sending the explosive and blowpipe men into the main engine-room and taking the sledgehammer men into the control-room with him. There he will disconnect the low-tension circuit, if he can find it, and close all switches. If the switches are themselves operated by the low-tension circuit he must try and break the protective circuit only. While this is going on the sledgehammer men will smash all the instruments and relays.

The explosive party will lay charges on as many turbines as possible, and the blowpipe men will cut all the alternator shafts of the stationary sets. Meanwhile the sledgehammer men, having polished off the control board, will smash up first the exciters and brushgear, and then any auxiliary motors that they can find.

When the explosive charges are all laid in place, and the allotted time is up, the leader will withdraw his party and fire off the detonators himself. This will be the signal that the good work has been completed, and the force commander, who will have been filling in the time by abolishing the outdoor transformers at point-blank range, will re-embark the wreckers and their guards, and get his force out of harm's way as quickly as possible.

The programme set forth above is one which, it is felt, should give good results for a relatively small expenditure of time and stores. If more time could be available, more points could be attacked, and a more thorough job could be made of the business. Whatever department is selected for the attentions of the wreckers, it is essential that every appliance in it should be done away with, so as to make a clean break in the organization.

The plan, when it is decided upon, must be well rehearsed beforehand, and all members of the wrecking party must be made acquainted with the kind of machinery that they are likely to encounter. If possible, they should be taken on a tour round a power-station similar to the one that they are going to destroy.

In conclusion, it is perhaps comforting to be able to say that, in spite of its highly technical nature, the operation will largely depend for its success on such purely military factors as reliable information, secrecy, surprise, co-operation and protection, while mobility is naturally the keynote of the whole undertaking.

SMALL GENERATING AND WATER-SUPPLY PLANT—EFFICIENCY LAYOUT AND CONTROL.

By CAPTAIN E. McDONALD, R.E.

THIS article is based upon a recently completed installation in Delhi, involving a renewal and change of form of existing services.

I.—THE SCOPE OF THE ARTICLE.

In the March, 1934, number of *The R.E. Journal,* "Bijli" described the general layout and costing of the electrical side of a very similar station.

In this article is described how capital and operating costs were reduced in Delhi. To this end, locally designed labour-saving and safety devices were incorporated, permitting of unification of control and reduction of staff. Not only standardization of plant, leading to reduction of spares, but also symmetry of layout, to facilitate rapid manipulation without mistakes, has been aimed at. Performance has been brought under continuous scrutiny from shift to shift.

II.—REQUIREMENTS.

The power and lighting demand is about 150,000 units per annum at a maximum demand of 60 kilowatts, and the mean water demand is 80,000 gallons daily.

III.—THE FINAL INSTALLATION.

A complete installation of electrical generation, and water-supply from local wells, in place of the former bulk supplies of both commodities, was approved.

It was necessary, however, to show a very considerable saving over the former operating costs before financial consent was forthcoming. It is hoped to save in seven years the total sum expended. This has entailed rigid economy in design and the final layout took the form indicated below.

All plant is by well-known British makers and none need be mentioned by name.

Electrical Installation Figures.

Generating plant.—Cold-starting, oil engines, direct-coupled to 240-volt direct-current generators. Three sets, 140 kilowatts in all.

Fuel-handling plant.—One hand-operated rotary pump at rail-siding; another, identical, at generating station. Capacity, 200 gallons per hour against 40 feet head with one man on handle. Twenty-ton tank at rail-siding and two 20-ton tanks at generating station.

Circulating-water system.—One 30-in. natural zeolite base exchange softener passing make up to either of two 900-gallon sumps, whence water is lifted against 26 feet head by two 2-in. motor-driven pumps to a single head-tank serving engine and compressor jackets. Gravity return from open tundishes on each jacket to one mechanical cooler, or, when this is not required, to sumps direct, for re-circulation. For the single mechanical cooler, one spare motor only was considered sufficient.

Starting air.—One kerosene oil engine and one motor-driven set, capacity of each 10 cubic feet of free air per minute. Two bottles, each capable of four consecutive starts without recharging.

Lubricating oil recovery.—One electrically-operated disc-type filter, capacity 10 gallons of oil per hour (also intended to handle transformer oil from a neighbouring installation).

Workshop.—This is an Area mechanical repair shop serving other installations outside. The usual equipment includes lathe, sensitive drill, shaper and power hacksaw, driven by a 3 b.h.p. motor. In accordance with the policy in the Area, electrical repairs for this and other installations are centralized elsewhere.

Performance (1933–34):

Connected load	177 kilowatts.
Units supplied to consumers' meters ..	156,504 b.t.u.
All-in cost per unit supplied at meters ..	3·12 annas.

Water-Supply Installation Figures.

Pumping plant.—Six $1\frac{1}{2}$-in. three-stage turbine pumps, rated at 30 gallons per minute at 120 feet total head, direct-coupled to 3 b.h.p. drip-proof motors wound for variable-speed control.

Treatment and storage plant.—Two rapid mechanical pressure filters, capacity at 100 gallons per square foot per hour of filter area, 60 and 30 gallons per minute respectively, connected to rising mains from wells, and passing filtered water to one automatic chlorination plant, whence it falls by gravity into one of two 50,000-gallon pressed-steel tanks on a 25-foot staging.

Distribution system.—One ring main for a treated water-supply for domestic purposes from one storage reservoir, and one ring main running parallel, carrying an untreated supply for sewage flushing, vehicle washing, etc. Reservoirs and mains can be interconnected if it is desired to supply treated water to both systems, but normally interconnecting valves are locked. Both mains are metered in bulk and at consumers' premises.

Station performance (1933–34) :

Average daily output, treated	25,000 gallons.
" " " untreated ..	60,000 gallons.
All-in cost per 1,000 gallons supplied ..	11·26* annas.

IV.—GENERATING PLANT AND AUXILIARIES.

Space permits of only the very briefest mention of outstanding points of the layout.

1.—*Fuel-handling Plant.*

Adequate capacity for the quick decanting of the largest individual consignment, in a rectangular tank permitting of ready measurement of its contents, has been provided at railhead to avoid demurrage and disputes as to short delivery. From the tank, flow is by gravity to the station—15 tons in 2,000 feet of 2-in. pipe in 6 hours, with a fall of 10 feet.

2.—*Circulating-water System.*

Every effort has been made to reduce to a minimum the rather disproportionate losses in this system, directly due to the flow of circulating water not being easily reduced below the designed circulation for full station loading—with auxiliary losses ; and indirectly due to the thermal loss and cylinder wear induced by the consequent overcooling. The sump, which is in two compartments, one of which can be used when required for other purposes as described later. The circulating pumps can, when required, pump direct to the engine jackets, thereby enabling the head tank to be laid off for cleaning while saving the cost of a second tank.

3.—*Induction Air and Exhaust System.*

Careful design of exhaust pits, particularly in respect of drainage and ease of access, without sacrifice of gas tightness has been studied.

On induction air trunks the viscous oil type of air filter has been found, judging by the grit removed, most efficient and easily cleaned, but extremely noisy, so much so that it makes exhaust noise a secondary consideration, at any rate in the immediate neighbourhood of the set. Fortunately it does not carry to any distance.

4.—*Lubricating-oil Handling.*

Used oil is pumped by permanent fixtures from engine sumps to a high-level used-oil tank provided with run-off cocks at different levels, according to the sludge to be rejected, directly into the filter head tank. The filtrate is run off into four-gallon drums fitted with

* As the plant was not ready until the end of the first quarter of the year this all-in cost includes a quarter of the total water bought at a *cash* price of 9 annas per 1,000 gallons.

cap flanges to take a screwed-in pouring spout. By this means it is hoped to save oil and labour, not only directly, but by keeping the engine-room floor and the exterior of the sets clean.

5.—*Air Auxiliaries.* (Photo 1.)

These are grouped, not scattered amongst the sets. Compressors and bottles are arranged on a common bus main.

6.—*Switchboard.* (Photo 2.)

The recording voltmeter is mounted on the board when not in use on the line. Note the pump feeder tell-tale panel mounted at the top in the centre of the board. One circulating water sump is permanently equipped with resistance plates and permanent leads to the board. The wire rope controlling the plate movement can be hooked into a differential tackle slung immediately in front of the board and the attendant has personal and fine control of the resistance load being placed on any breaker. This arrangement facilitates overload tests of circuit breakers, so often neglected because of the trouble involved in rigging gear temporarily.

7.—*General Layout of Station.* (Photos. 1 and 2.)

Different groups of pipes and containers carrying water, fuel oil, etc., are painted distinctive colours.

All piping and main cables are trenched wherever possible, and all internal station wiring is buried in mud plaster in the walls.

Adequate workshop-pattern lighting, including special lighting to a scale of four-foot candles on each main machine, facilitates part of the routine maintenance being carried out by the night shift. An emergency lighting system energized from a six-volt battery, which also energizes certain relays, is provided.

The workshop is laid out in prolongation of the line of the machine-room, thereby enabling the crane to serve both.

V.—WATER-SUPPLY PLANT.

1.—*Source.*

The shallow surface wells in the area may safely be worked at an inflow velocity of two to three feet per hour, at a working level below the highest rest level recorded, of between 10 and 25 feet, according to the season. Recuperation tests in 1931 over a period of several weeks in each well indicated a working level of about 645 feet above mean sea-level, 45 feet below average ground level at site. A probable yield of 60,000 and 25,000 gallons per pumping day of 20 hours was estimated for wells Nos. 14 and 28 respectively (see diagrams), the wells eventually chosen as the source of supply. Service performance has varied to a considerable extent, the yield being luckily obtained at a higher working level. This unfortunately is not always the case and the writer would always prefer to carry

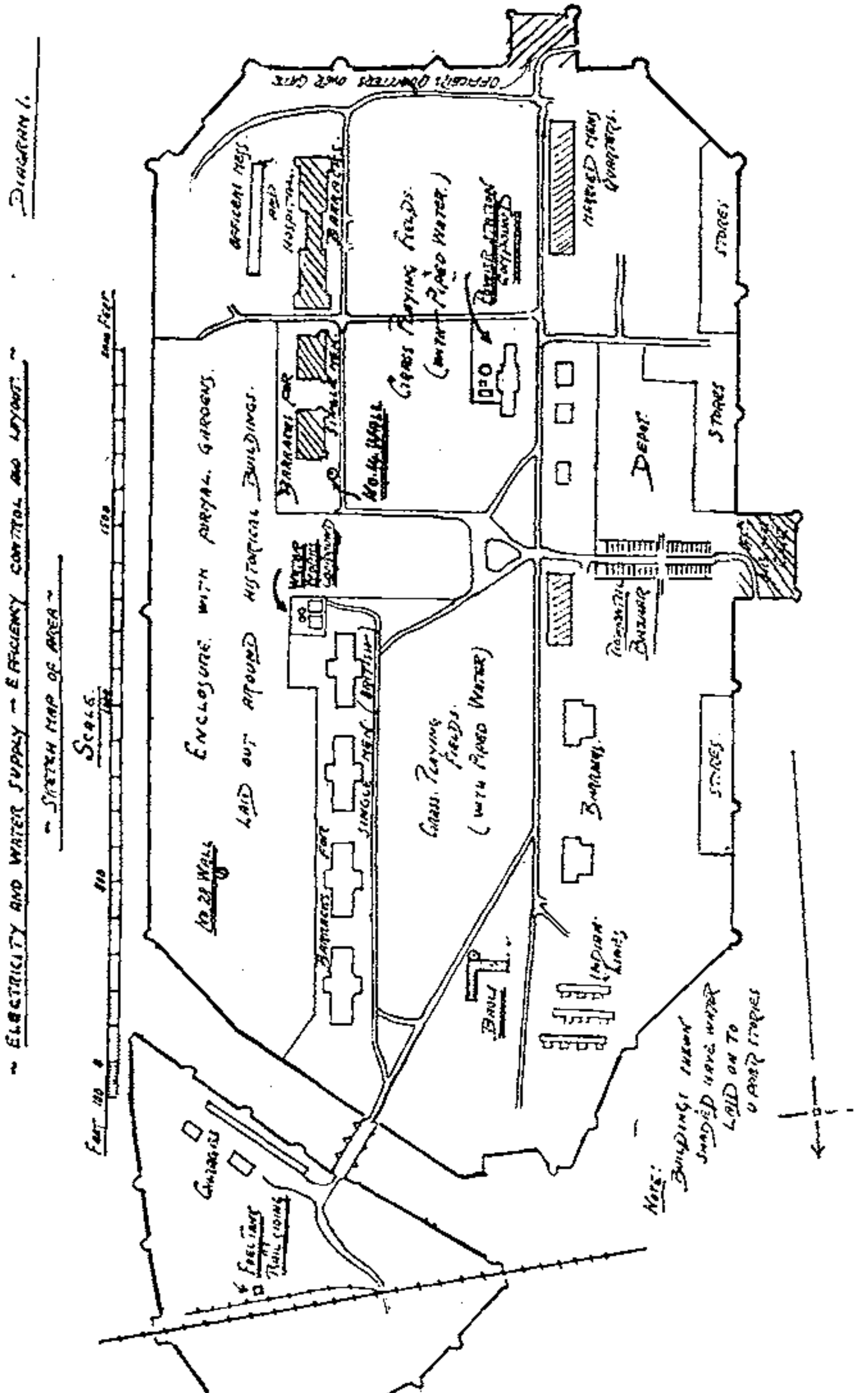


Diagram I.
– Electricity and Water Supply – Efficiency Control and Layout –
– Sketch Map of Area –
Scale.
Enclosure with partial gardens laid out around historical buildings.
Grass Playing Fields (with piped water)
Officers' Quarters over Gate
Officers' Mess and Hospital
Barracks
Married Men's Quarters
Stores
Depot
Barracks for Single Men (British)
Indian Lines
Garages
Note: Buildings shown shaded have water laid on to upper stories

out a full year's test pumping at the required draw-off before sinking capital in a scheme solely dependent on such a source. In this instance circumstances were different. It was a case of developing existing sources to the full so that the least that could be depended on might be accurately known against the event of the town supply, available normally to augment the well source, being cut off.

2.—*Main Pumping Plant.*

The small high-speed centrifugal turbine pumps rated to meet the safe yield of the wells at a high load factor have a reliable suction of little over 12 feet. Some tables give a much higher figure, but it is doubtful if any reputable firm would guarantee their product to maintain continuously its maximum efficiency at much over 12 feet. The seasonal range, therefore, demanded either a submerged pump or alternative pump platforms.

The former type are expensive in small sizes, and require rigid and accurate alignment of the shaft. They did not lend themselves, therefore, to a system of rapid interchangeability of complete units, which would permit of a single unit being held as a mobile reserve in replacement of one defective, thereby cutting capital costs. Moreover the installation of electrically-driven pumps in a humid well, unless they are constantly in use, invites insulation troubles, the windings in cooling beginning to suck in moisture from the moment the motor stops. It follows that spares should be held outside the well whenever possible.

In the installation finally decided upon there is 50 per cent. of spare plant, since the *baoli* (Hindi for a large ablution well, usually with a stepped adit) is really a reserve well, a pump set only being installed there when resting No. 14 well. The sets in normal use are two in No. 14 well, one in No. 28 well and one for boosting, all being identical and interchangeable with the *baoli* and the one additional spare set.

3.—*Pump Arrangement.* (See Diagram 2 at end of article.)

Wells Nos. 14 and 28 have each duplicate platforms, one just above the highest seasonal rest level, and a second 15 feet below it and at right angles to it. On each platform are two pump positions, although, in the case of No. 28 well, the second position is merely to ensure continuity of pumping when changing sets.

The piping to each position is permanent. The rising mains start from the lower platform, with branches to each leg from the upper platform positions. A separate suction pipe leads to *each* pump position, however, as any unnecessary branch bend or valve in a suction line is definitely bad design. When a set is to be replaced the spare unit is wheeled over the open trap in the flat well cover, on a specially designed trolley (Photos. 3 and 4), and lowered to upper platform level or, if necessary, through this by sliding back four

SMALL GENERATING AND WATER-SUPPLY PLANT—
EFFICIENCY LAYOUT AND CONTROL.

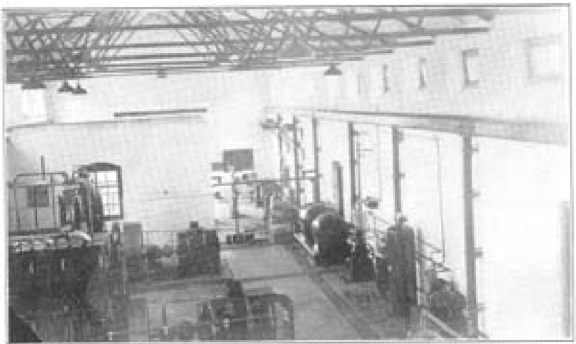


Photo 1.—Power station and workshop. Note grouped air auxiliaries on right.

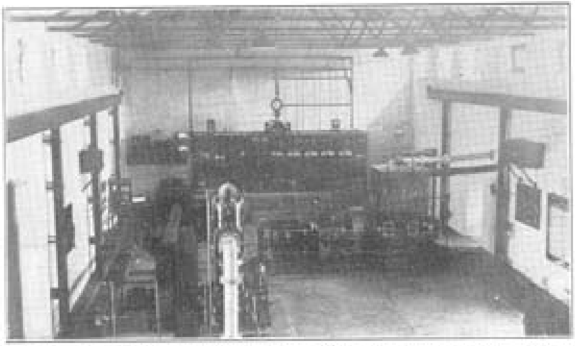


Photo 2.—Switchboard end of station. Note maintenance chart for whole year mounted on wall on right.

Photo 3.—Pump-handling trolley. Note approach ramp, and dished manhole trap to exclude surface water.

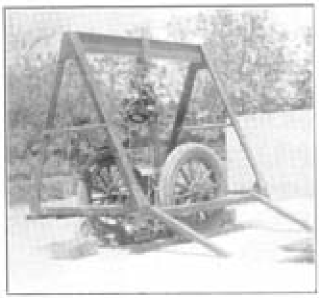


Photo 4.—Pump-handling trolley. Pump being lowered.

Small generating & water-supply plant 1 - 4

Photo 5.—Reservoirs with chlorinating plant on platform between and control house under.

Photo 6.—Reservoirs. Note continuous roof, platform between tanks, gantry for hoisting chlorine cylinders.

Small generating & water-supply plant 5-6

platform deck planks, to the lower platform. From either platform level it is skidded on two greased battens to its position, and the holding-down bolts slipped through the flanges of the bearer joists without any part of the weight of the set having to be taken by hand at all. The suction and delivery pipes are mounted so that the flanges are allowed a slight axial movement with the holes in register with those of the pump flanges, but when bolted up no strain comes on the pump casting.

The portable gantry incidentally obviates the necessity for any wellhead tackle, a matter of great importance in the case of No. 28 well which is situated in the Moghal Palace Gardens, one of the show places of Delhi.

An alternative design, embodying a slung pump platform and length of flexible delivery pipe, was considered, but discarded as lacking the necessary simplicity of operation and rigidity, except at a greater cost than the design adopted. It would have been almost impossible to have ensured that the pump shaft was always truly horizontal. Failure to maintain this would have resulted in undue end thrust. In assembling the pump bearers on the platform joists, a type of knee was devised to permit of accurate levelling of these bearers necessitated by any slight settlement of the platform.

When it is required to clean the wells, a bucket or well grab can be lowered from wellhead through both platforms right to well bottom, the framework supporting the suction pipes and the pipes themselves being arranged to give clearance for this.

4.—*Treatment and Storage Plant.*

Only 25 per cent. of the demand is for domestic purposes requiring treatment, and this is met at present solely from No. 28 well, which, for no apparent reason, is the only one in the area of sufficiently low saline content to be drinkable except in an emergency. The water contains about 20 parts per 100,000 of sodium chloride and about 100 parts of total solids.

No. 14 well, which with the *baoli* as reserve, supplies the balance of the demand, has a total saline content of over 45 parts of sodium chloride per 100,000, and pumps direct to one of two 50,000-gallon storage reservoirs feeding a ring main for non-domestic services. This well also supplies an existing irrigation distribution system direct from wellhead. No storage being necessary, the extra cost involved in lifting this quantity of water to the reservoirs is avoided. It is hoped by continuous pumping to reduce the saline content of No. 14 well to a potable figure, and the pipe arrangement illustrated in Diagram No. 2 permits either of the two main wells to serve either filter, and either reservoir to serve either distribution system.

Apart from the operation of the control gear, points of interest in this plant are the siting of the filters in the open, and the grouping of the bulk of the control valves, boosting pump and bulk supply meters in a room built up between the stagings of the adjacent reservoirs (Photos 5 and 6) with the chlorinating apparatus carried on a light staging built up from the continuous floor beams of the reservoir staging, the whole being under one roof. By this vertical arrangement considerable economy was effected in first cost and plan area, without affecting the symmetry of valve arrangement, thereby making for ease of control. This is further facilitated by marking unfiltered water pipes by red, and filtered water pipes by green bands at intervals, an arrow marking the direction of flow. All valves are numbered and indicated on a pipe diagram similar to Diagram 2, but on a larger scale, with clear instructions for each operation. As a further precaution certain valves, only required to be used at long intervals, such as the cross-connection between the distribution mains, are secured by a steel strap bolted to the valve gland and with a square hole fitting over the valve spindle.

Asbestos pipes were used to some extent in the layout here, and might have been employed further with advantage and economy. They are particularly useful in cramped layouts, being easily cut with a hacksaw in a few seconds. Where pipes have to be supported on brackets, on reservoir staging for example, their light weight makes them particularly suitable, but the joint employed must never be subjected to axial stress. They were used, for instance, to carry the discharge from the weir tank (Diagram 2) to the upper corner of the reservoir farthest from the outlet, where it discharges over the edge of a 3-ft. diameter cascade plate, thereby ensuring a certain amount of aeration. Although a 6-in. diameter pipe was necessary owing to the small head available, it was light enough to be safely hung from the roof trusses.

The use of special cast-iron specials instead of standard specials and W.G.I. fittings invariably results in economy in awkward layouts, although it involves a little extra work in the drawing-office.

5.—*Pumping Control.*

The pump motors and controllers are designed for a speed range of from 1,600 to 2,300 r.p.m. to meet, with nearly equal pump efficiency, the several different heads demanded by the direct irrigation service, and pumping to reservoirs, either direct, or through filters—involving a difference of head up to 15 feet—from water levels which are liable to seasonal fluctuations over a 30-foot range. A chart (reproduced in Diagram 4), prepared from the performance of the sets on acceptance tests, is hung against each starter, and from this the superintendent marks, from time to time, the regulator handle position to be used by the attendants for any particular duty.

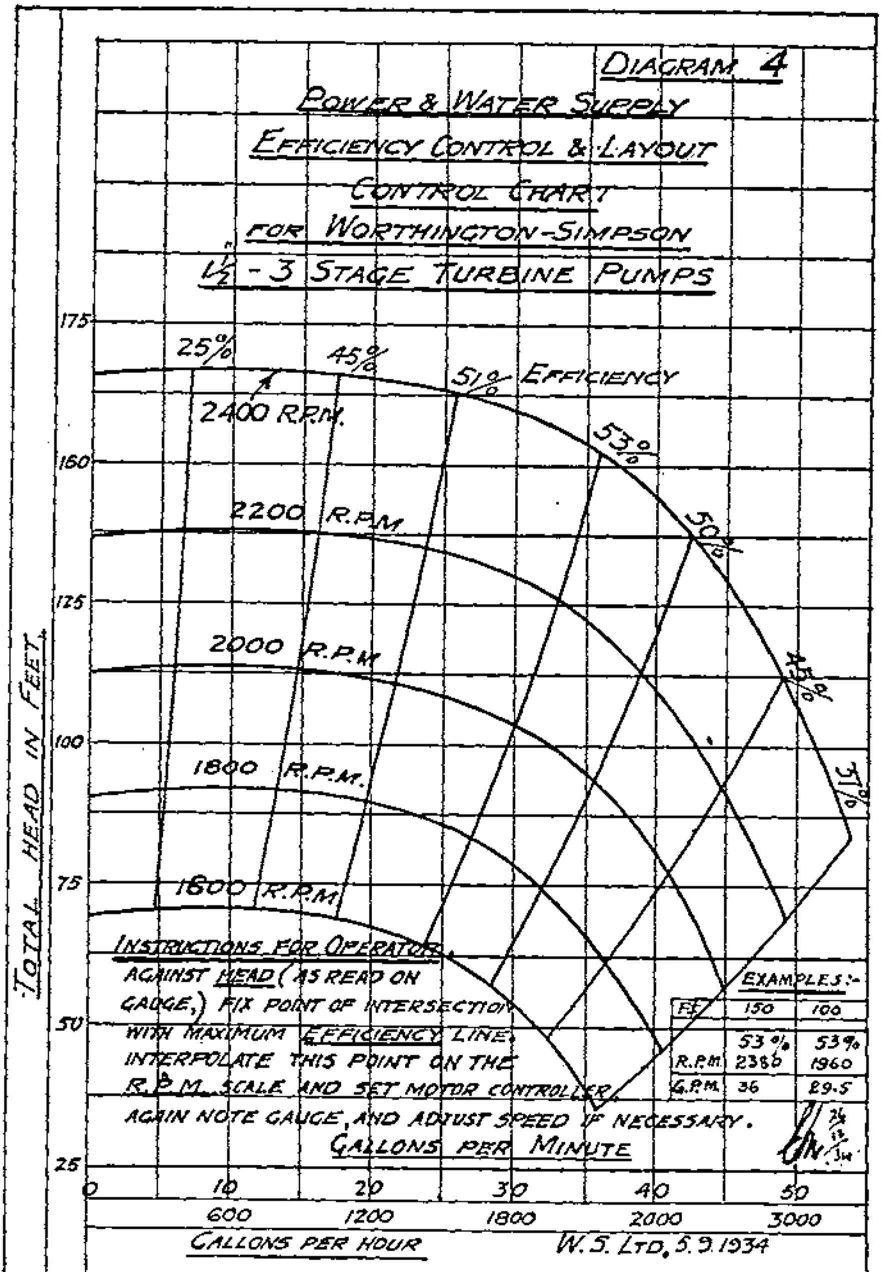


DIAGRAM 4
POWER & WATER SUPPLY
EFFICIENCY CONTROL & LAYOUT
CONTROL CHART
FOR WORTHINGTON-SIMPSON
1½" - 3 STAGE TURBINE PUMPS
25%
45%
51% EFFICIENCY
53%
50%
45%
37%
2400 R.P.M.
2200 R.P.M.
2000 R.P.M.
1800 R.P.M.
1600 R.P.M.
TOTAL HEAD IN FEET.
175
150
125
100
75
50
25
INSTRUCTIONS FOR OPERATOR.
AGAINST HEAD (AS READ ON GAUGE,) FIX POINT OF INTERSECTION WITH MAXIMUM EFFICIENCY LINE. INTERPOLATE THIS POINT ON THE R.P.M. SCALE AND SET MOTOR CONTROLLER. AGAIN NOTE GAUGE, AND ADJUST SPEED IF NECESSARY.
EXAMPLES:-
FT. 150 100
53% 53%
R.P.M. 2380 1960
G.P.M. 36 29.5
GALLONS PER MINUTE
0
10
20
30
40
50
600
1200
1800
2000
3000
GALLONS PER HOUR
W.S. LTD. 5.9.1934

The generating station switchboard attendant is also pump attendant and makes a two-hourly round of wells and waterworks, and the shift cleaner also makes periodic visits for oiling and cleaning. Actually any abnormality, excepting only failure of the chlorinating apparatus, can be detected from the station switchboard. (See Diagram 3 at end of article.) The pump indicator panel, designed and constructed locally largely from scrap material, is a record of the situation at any moment. The numbered discs indicate the location of individual pump sets at any time, whether mounted on a platform above or below rest water level, and whether the spare set is under overhaul or ready for use. The plant is divided into two groups, each controlled by separate link fuses, and with an open scale ammeter sufficiently sensitive to indicate the slightest irregularity, such as a dirty brush in any set.

At the top of the board there is mounted a green pilot lamp for each set installed. High-water level, or low-water level in well or reservoir, or the tripping-out of a pump due to a fault—but not the deliberate shutting down of a set at the conclusion of a run—extinguishes the particular lamp. The indication being positive, the failure of the lamp itself does not mask a fault. If the supply to the whole pump feeder fails, a red pilot lamp, separately energized from the station emergency battery, lights. When this complete shutdown is, as described below, due to faulty manipulation of the filter-control valves, the fault is indicated by the position of the shutter in the glass-fronted relay box marked FILTERS. Since the seal of this box must be broken to reset the relay before restarting the system, the attendant cannot, even if he would, conceal the fact from the station superintendent who can, if necessary, temporarily increase the chlorine dosage, to deal with any unfiltered water passed to the reservoir meanwhile.

The electrical control is indicated in Diagram 3. On the starter units, of one of which the relevant wiring is shown in full, contactors (1) and (2) are in series with the particular green lamp at the generating station switchboard, (1) opening on high water, and (2) on the starting handle (a) returning to the OFF position under the action of its return spring, due to overload, or failure or diminution, of the supply voltage. The operation of contactor (1) does not, for obvious reasons, stop the pump pending investigation. In the event of low water, however, where a further small drop would lead to the pump losing its suction, with consequent damage to the water-lubricated white metal rings, contactor (3) closes and shunts the no volt coil, releasing (a) and initiating a sequence which stops the pump and gives visible warning by opening (2). If, however, the pump is stopped normally, as it should be, by opening the main switch (b), contactor (4) is closed simultaneously and shunts (2), so that the opening of (2), consequent upon the operation of (3),

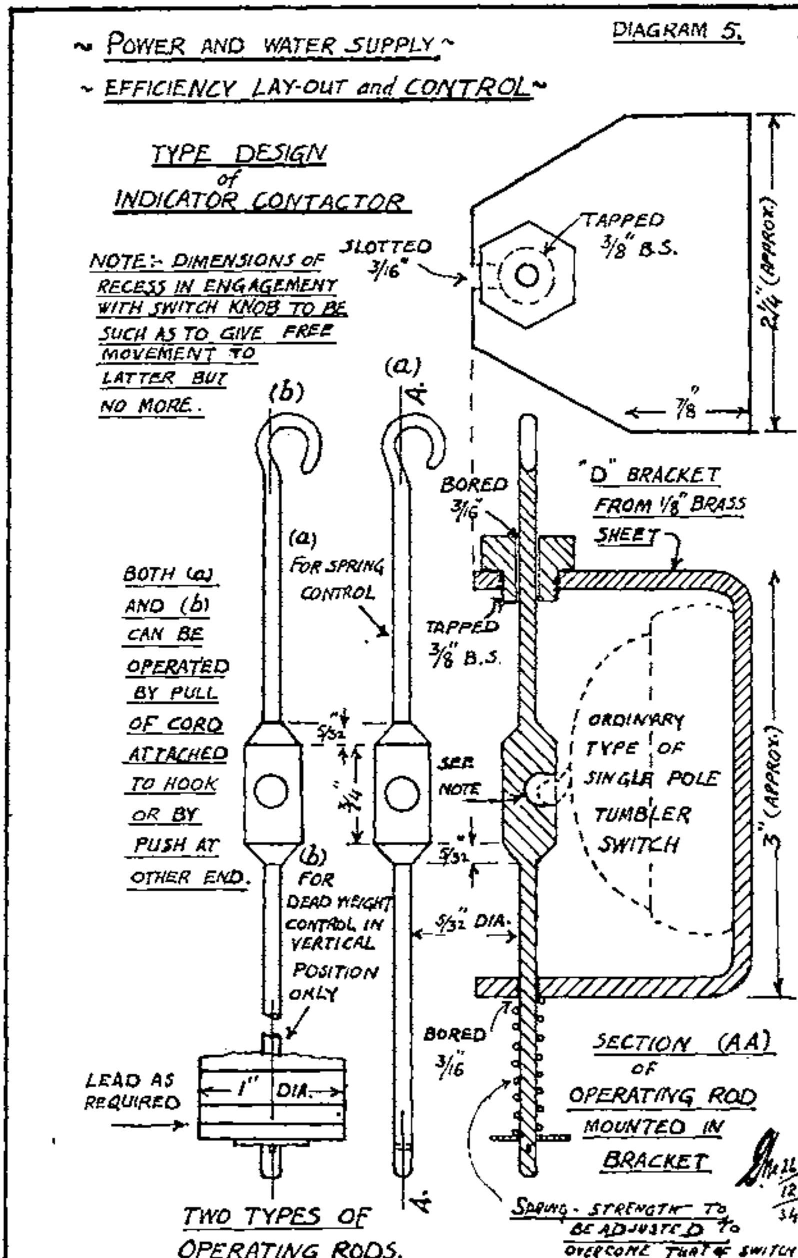


DIAGRAM 5.
~ POWER AND WATER SUPPLY ~
~ EFFICIENCY LAY-OUT and CONTROL ~
TYPE DESIGN of INDICATOR CONTACTOR
NOTE:- DIMENSIONS OF RECESS IN ENGAGEMENT WITH SWITCH KNOB TO BE SUCH AS TO GIVE FREE MOVEMENT TO LATTER BUT NO MORE.
SLOTTED 3/16"
TAPPED 3/8" B.S.
2 1/4" (APPROX.)
7/8"
(a)
(b)
A.
BORED 3/16"
"D" BRACKET FROM 1/8" BRASS SHEET
(a) FOR SPRING CONTROL
BOTH (a) AND (b) CAN BE OPERATED BY PULL OF CORD ATTACHED TO HOOK OR BY PUSH AT OTHER END.
TAPPED 3/8" B.S.
ORDINARY TYPE OF SINGLE POLE TUMBLER SWITCH
3" (APPROX.)
5/32"
3/4"
SEE NOTE
(b) FOR DEAD WEIGHT CONTROL IN VERTICAL POSITION ONLY
5/32" DIA.
BORED 3/16"
SECTION (AA) OF OPERATING ROD MOUNTED IN BRACKET
LEAD AS REQUIRED
1" DIA.
TWO TYPES OF OPERATING RODS.
SPRING - STRENGTH TO BE ADJUSTED TO OVERCOME THAT OF SWITCH

does not open the pilot lamp circuit, which will, however, open later if, during the period of shut-down, the water rises to a dangerous level in the well.

The locally-designed type of contactor is shown on Diagram 5. Deadweight control of the operating rod is preferable whenever it can be arranged, as springs waste in service, their tension being affected. The use of a standard tumbler switch simplifies replacement of a defective unit, and gives instantaneous make or break irrespective of the speed of the operating-rod movement. The first types, made up in door switch form, used to arc and fuse and occasionally stick, owing to the slow approach of the contactor poles mounted on the ends of the operating rod.

The set of four contactors is bolted to each standard controller, according to a drilling template, so that these units also are strictly interchangeable for use with any set. A strong waterproofed fishing line was found after trial to give the lightest and most sensitive connection between contactors and floats. It will be observed that the low-water float is anchored down, to prevent its line becoming entangled with the structure at high-water levels.

In the waterworks compound the booster-pump controller contacts are in series with similar high- and low-water float contactors in the reservoirs, so that a single pilot lamp indicates any irregularity in that neighbourhood.

Automatic starting and stopping of pumps, or even remote manual control, was not considered to offer any advantage commensurate with the expense involved. The attendant who is provided with a bicycle, has plenty of time to visit the wells, and frequent visual inspection of the sets is thereby ensured. It was partly for this reason that the starters were installed at upper platform level and not, as is often found in such installations, at wellhead.

It is considered that starters should always be sited as close as possible to the sets which they control, and within reach, if possible, of the delivery valves, and in view of the gauges. Each set is provided, not only with a delivery gauge, but also with a suction gauge. The latter may appear an unnecessary luxury with such small sets, in open wells with visible water level. Properly interpreted, however, its readings form a valuable index of pump performance and irregularities.

6.—*Boosting Pump and Control.* (Diagram 2.)

Only 10 per cent. of the total demand of domestic water is required at other than ground-level standposts and taps, but this 10 per cent. has to be raised 70 feet. To boost this small amount was obviously more economical than to raise the main storage reservoir. By suitable disposition of sectionalizing valves on the ring mains, these services have been grouped so that the service house tanks of each group can be filled simultaneously, at the economic pumping rate of the booster, by raising the pressure in the section of the main concerned, during the small hours of the morning, when the normal demand is practically *nil*.

Each head tank, except the highest, in each group is controlled by a ball valve, the highest having an overflow and discharging in a position audible from ground level. The attendant visits this point when he sees the booster delivery gauge begin to rise, and the overflow indicates the moment when the last tank of the group has filled.

The town main which originally supplied the Area has been retained. Since the residual head of this supply has been in the past insufficient to fill a low-level reservoir, the booster connection is so arranged that it can, if need be, boost this supply also to the new high-level reservoirs.

7.—*Pumping Performance.*

The type of small pump installed, while reliable enough, is designed for economic mass production rather than high-class finish. The parts, therefore, are not machined to fine limits, and it is quite possible to assemble two sets which, to all outward appearance and practicable gauging, are identical, but which have as much as 10 per cent. difference in performance. Such a case was actually experienced during acceptance tests. The defective unit was dismantled and no fault being found was reassembled, when it gave its guaranteed output on re-testing.

Every set, therefore, after its periodic stripping in the workshop, is slung up to a prepared test bed on the staging of the generating station head tank, and given 30 minutes' run on a 15-foot static suction head from one of the circulating water sumps, delivering through a meter and a throttled delivery to the head tank, and its performance at the service operating heads compared with the basic performance as read from the chart. As the sump is calibrated, the meter can be checked at the same time. The piping for this test is permanent, and the whole test, including slinging up the set on a differential tackle, only takes an hour. On these artificial tests the suction should be a natural one. A throttled suction has been found to be as unreliable on test as it is undesirable in service. Incidentally the layout of small centrifugal pumping plant is often spoilt by the assumption that the diameter of the pump delivery and suction flanges determine the diameter of the connected piping.

As installed at site, as in test, each set has its own electric and water meter, the performance, in ft.lb./b.t.u., being set out in a column of the log sheet after each run. A set losing its efficiency is pulled out at once, and, in any case, at regular intervals. The chief point requiring attention in the motors is the removal of carbon dust accumulations from behind the commutators. In damp situations this cakes instead of being blown out, and eventually bridges across from commutator bars to armature spider, unless periodically removed.

In the pumps, white metal rings and neck bushes wear, as a rule, radially, opposite the delivery trunk and affect the rotor clearance.

All this attention appears unduly meticulous, but is justified just so far as the cost of labour and material expended on repairs is less than the pumping loss involved by leaving the fault to develop further. To quote figures, a slight eccentric wear on one of the white metal rings will not materially affect the running of the set, but will entail a loss of efficiency involving a pumping loss in two days equal to the cost of replacing the ring.

To sum up, performance is maintained by complete individual metering and comparison with basic performance figures at frequent intervals, immediate replacement of faulty units, ready facilities for handling, repair facilities under comfortable working conditions on the bench instead of in a dark and humid well, and test facilities at repair shop, thereby ensuring that a set *is* properly adjusted before return to service.

8.—*Filter Control.*

The danger inherent in any pressure filter plant is the rupturing of the coagulent film which forms the bacteria filter, due to a surge in the pumping main, usually at the moment of starting up. A quotation obtained for mechanical gear to ensure very gradual opening of the filter inlet valves was very high—about £100. An electric control was designed and fitted locally which gives an adequate measure of protection except in the case of deliberate disregard of instructions by the attendants, at a cost of under £5.

When a pump is being started up by the attendant at wellhead, valves (iii) and (iv) on the filter (see Diagram 3) are shut and (ii) is open, the water passing initially to the non-domestic reservoir. Valve (i) is sealed open, except when the filter is laid off for cleaning. The gauge shown was originally supplied by the filter manufacturers to be connected to filter inlet, outlet or drain, by opening cocks (c), (d) or (e) at will, thereby determining the head loss across the filter. This gauge has been adapted to perform, in addition to its intended function, that of relay contactor for the protection of the filter against sudden surges.

Normally cock (d) is left open and the gauge reads, when the pump is not running, the static head in the vertical pipe (A) between the filter and non-domestic reservoir inlet which, unless there is a leak on the rising main or filter, is about 37 feet. Opposite gauge scale readings "25" and "60" (in feet), are two spring-steel contacts, insulated from the gauge case and connected together electrically. These contacts are sufficiently resilient to cushion the blow of the gauge needle, forming the other pole of the contactor which is in a circuit energized from the station 6-volt system and containing a simple relay at the switchboard as indicated in Diagram 3. Neglect by the attendant of instructions to see that valve (II) is open before he starts the connected pumps results in putting the shut-off head of the pump on the gauge, immediately on starting the set. As this is over 60 feet the gauge needle closes on the upper contact, closing the secondary circuit of the relay on the station switchboard. This shunts the no-volt coil of the pump-feeder circuit-breaker, shutting down the whole pumping system. Since the attendant has to visit then, first the switchboard to reset the relay and close the circuit-breaker, and thereafter go to each well in turn to restart the pumps, he rarely repeats the mistake! The filter is, of course, strong enough to take the full head of the pumps. The surge is liable to disturb the coagulent film, hence the protection described above.

The pump being properly started, the attendant, in order to put the filter into use, goes to the waterworks compound and closes valve (II) while simultaneously opening valve (IV), keeping the gauge needle floating well away from the upper and lower contacts, by judicious manipulation of the valves. The movement takes between one and two minutes. Were the attendant to open (IV) quickly, the effect would be to lower the head at the outlet below 25 feet, the gauge needle then closing the relay circuit with the consequences already described. The sudden rush of water which might break the film is thereby guarded against.

Having passed the filtered water to waste for a few minutes, the attendant closes (IV) and opens (III), thereby gradually transferring the flow to the treated water reservoir, *via* the chlorinating plant weir tank. Hasty or jerky movements result in a shut-down.

The maker's instructions prescribe a maximum permissible flow through the filter, when forming the film while passing to waste, of about one-half normal flow. The setting of the lower contact on the gauge ensures that if this is exceeded the resulting head is less than 25 feet, and the pump circuit is tripped.

Any small leak in the filter, or on the rising main, or reflux valve situated in each well, or due to the attendant carelessly leaving open the valve of the small priming bye-pass round this reflux valve, will manifest itself very soon after the cessation of pumping by draining pipe (A) below 25 feet when the pumping feeder will trip, thereby calling attention to the fault.

The gauge and its stopcocks (c), (d) and (e) are covered by a locked glass-fronted box. When testing the head loss to determine if the filter is due for washing, which operation is always carried out under his personal supervision, the superintendent unlocks box and puts the trip circuit out of commission by opening a switch therein.

9.—*Chlorination Control.*

The chlorination plant and an automatic device for maintaining a predetermined dose in parts of chlorine per million of water, irrespective of the quantity flowing, and determined by the height of the stream over a notch in a weir tank, is the makers' standard design.

It has been found advisable to keep this device under constant supervision, however, the attendant visiting it on his two-hourly round and checking the dose as indicated by a sight feed on the apparatus, the result being logged. The control has been found very sensitive to temperature changes.

10.—*Water Testing.*

Periodical water testing is, of course, the responsibility of the medical authorities. An appreciation of the general outlines of the applicable laboratory technique is very helpful to the water engineer, however, for an intelligent interpretation of the results of tests, and of the precautions to be observed if truly representative samples are to be drawn from any part of the system in his charge. In addition to official publications, perusal of a standard handbook such as that of Thresh and Beale is strongly recommended.

The bacteriological test results of water samples taken from different parts of this system, and sent to a laboratory only 50 miles away, were sometimes so contradictory that the medical authorities gave their approval to the provision of testing equipment in the local hospital. This equipment cost surprisingly little, as the most expensive items as listed in makers' catalogues, the steriliser and incubator, were made up in the local electrical repair shop. It was found that a steady temperature of within one or two degrees of 37°C. for incubation, and of 180°C. for sterilization, could be maintained by the suitable grouping, under switches, of ordinary incandescent lamps. With this local testing the medical and engineer officers can ensure that samples are in the laboratory within an hour of being drawn, and without passing through the hands of several intermediaries. Lateness of trains, the unreliability of orderlies, the melting of ice, misunderstandings leading to the media not being ready against the arrival of the sample, any of which causes may result in the water, when tested, being in a very different condition from that in which it was drawn, need not be permitted to vitiate the results.

Sterile sample bottles are prepared at the hospital, but a small spirit lamp is kept ready at the waterworks for the sterilization of the test taps which are fitted at various points in the treatment plant. These cannot be too thoroughly flamed, the perfunctory passing of a flame across them once or twice being useless if the tap has been recently handled.

The siting of these test taps requires careful attention. For instance, it might be thought that a $\frac{1}{2}$-in. tap on a 12-in. length of horizontal $\frac{1}{2}$-in. pipe, screwed into a 4-in. vertical main, 20 feet vertically below the reservoir outlet, would give fairly representative samples of the water flowing in the main, almost at once on opening the tap. Actually the chlorine content of the water tested at this point is often found to go on increasing for several minutes, even though the amount being drawn off is only a fraction of what is passing in the main at the time.

The performance of the filters in the reduction of bacteria is expressed and logged as a percentage efficiency, according to a formula provided by the makers:

$$\frac{\log_{10} R - \log_{10} F}{\log_{10} R} \times k \times 100$$

where :—

R = total colonies (of bacteria) in 1 cu. cm. of raw water.

F = ,, ,, ,, ,, ,, ,, ,, filtered water.

k = a constant = 2, permits the result being expressed between 1 and 100 (*i.e.*, as a percentage of efficiency).

As a guide to the interpretation of results :—

Below 50%—Bad.
,, 50–75%—Fair, capable of improvement.
Above 75%—Good.

Actually 99·5 per cent. has been obtained at times from the Delhi filters by judicious adjustment of the alum doseage, which is varied from time to time according to the figures obtained by testing the raw water, with an alum dose testing set, maintained by the superintendent at the waterworks. The improvement, or otherwise, is confirmed by submitting samples of raw and filtered water to the hospital for bacteriological counts, the results being substituted in the formula given above.

The production of an absolutely sterile water by both filtration and chlorination independently is aimed at. The higher the efficiency of filtration, however, the less the danger of post chlorination taste troubles, arising from the combination of chlorine with certain, possibly quite harmless, organisms.

The resultant free residual chlorine content is tested daily by the superintendent at the reservoir outlet, after the finally treated water has had from 24 to 36 hours' storage and a figure of between 0·1 and 0·2 parts per million as determined by a colorometric testing set is aimed at. The absence of any complaints of chlorine taste is undoubtedly due, however, to the efficiency of the pre-filtration.

High salinity and hardness cause the most trouble. The present figure, although by no means so high as is met with in some water supplies, is nevertheless quite sufficient to be noticeable and is tested periodically by the superintendent to ensure that it is not rising in the domestic system, and therefore requiring dilution with town's water, and to maintain a continuous record, particularly of salinity, in the non-domestic system, as it is hoped that the well feeding this will improve with continued pumping.

The apparatus used for salinity testing is a simple glass U-tube, proportioned so that the resistance of the column of water under test, when in contact with two anodes fitting in the ends of the tube, can be directly read on the open part of the scale of an ordinary Evershed and Vignoles meggar. Town main water which has a very low saline content is used as a control.

Hardness-testing equipment, bought against the installation, is maintained at the hospital, and periodical tests are logged. The results obtained in the generating-plant circulating-water system, normally tested by a testing set supplied with the softener, are also checked occasionally with this equipment.

11.—*Distribution System.*

The only point of interest lies in the use of asbestos cement pipes chosen for part of the replacement of the worn-out existing mains. The writer was much impressed by their cheapness in first cost, lightness, resulting in reduced freight and handling charges, freedom from breakage in transit, ease of cutting, and the speed with which they could be put down by men who had had no previous experience of the type. They were tested to 100 feet hydraulic head before filling the trenches, and except where a 90° bend blew off because the axial stress was not taken by a packing against the trench wall, showed no signs of leakage. A section of road below which a length was laid at a depth of only 24 inches was consolidated with a 13-ton steam-roller and the pipe subjected successfully to a further 100-foot test head.

The durability of the rubber joint-ring and the absence of erosion and corrosion, as claimed, remains to be tested with age. There seems to be no reason why the rings which, after all, are protected from mechanical damage, screened from all light, and (*provided that their use is restricted to mains which normally run full*) water cooled, should deteriorate, as does rubber in the tropics under less favourable conditions.

The high salinity of the non-domestic system will effect a rigorous

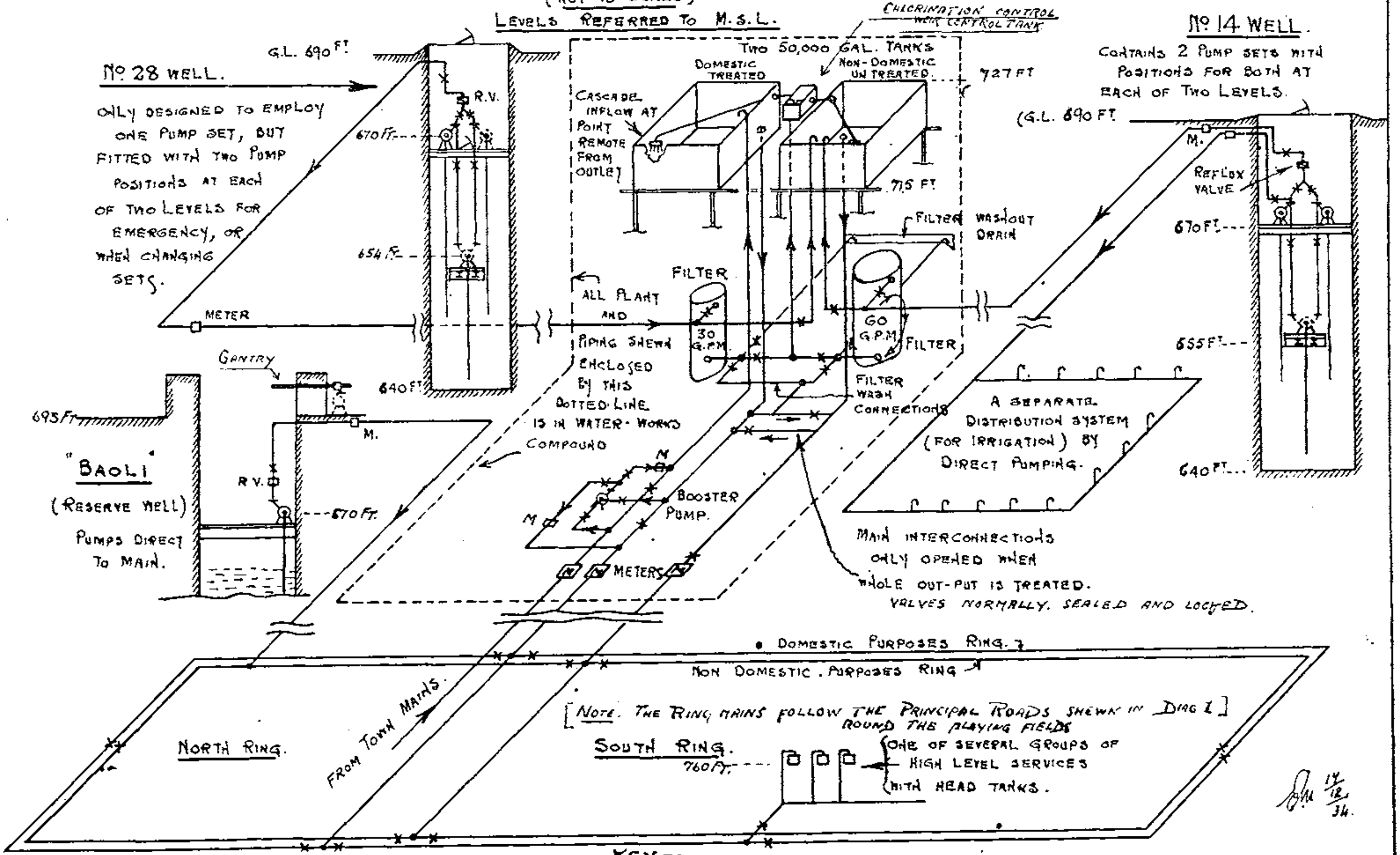
DIAGRAM 2.

— ELECTRICITY AND WATER SUPPLY – EFFICIENCY CONTROL AND LAYOUT —

DIAGRAMMATIC REPRESENTATION OF WATER SUPPLY PLANT CONNECTIONS.

(NOT TO SCALE)

LEVELS REFERRED TO M.S.L.



— KEY —

VERTICAL LINES ON DIAGRAM REPRESENT VERTICAL RUNS OF PIPING. HORIZONTAL RUNS DENOTE NORTH AND SOUTH RUNS, AND THESE AT 45° SLOPE, EAST TO WEST RUNS. SEE DIAGRAM 1 FOR SCALED LAYOUT. OTHER CONVENTIONAL REPRESENTATIONS :—

⊥ = PIPE JUNCTION; X = SLUICE VALVE; ⊗ = CENTRIFUGAL PUMP (SUCTION FLANGE AT CENTRE, DELIVERY AT PERIPHERY); + = PIPE LINES CROSSING BUT NOT CONNECTED:

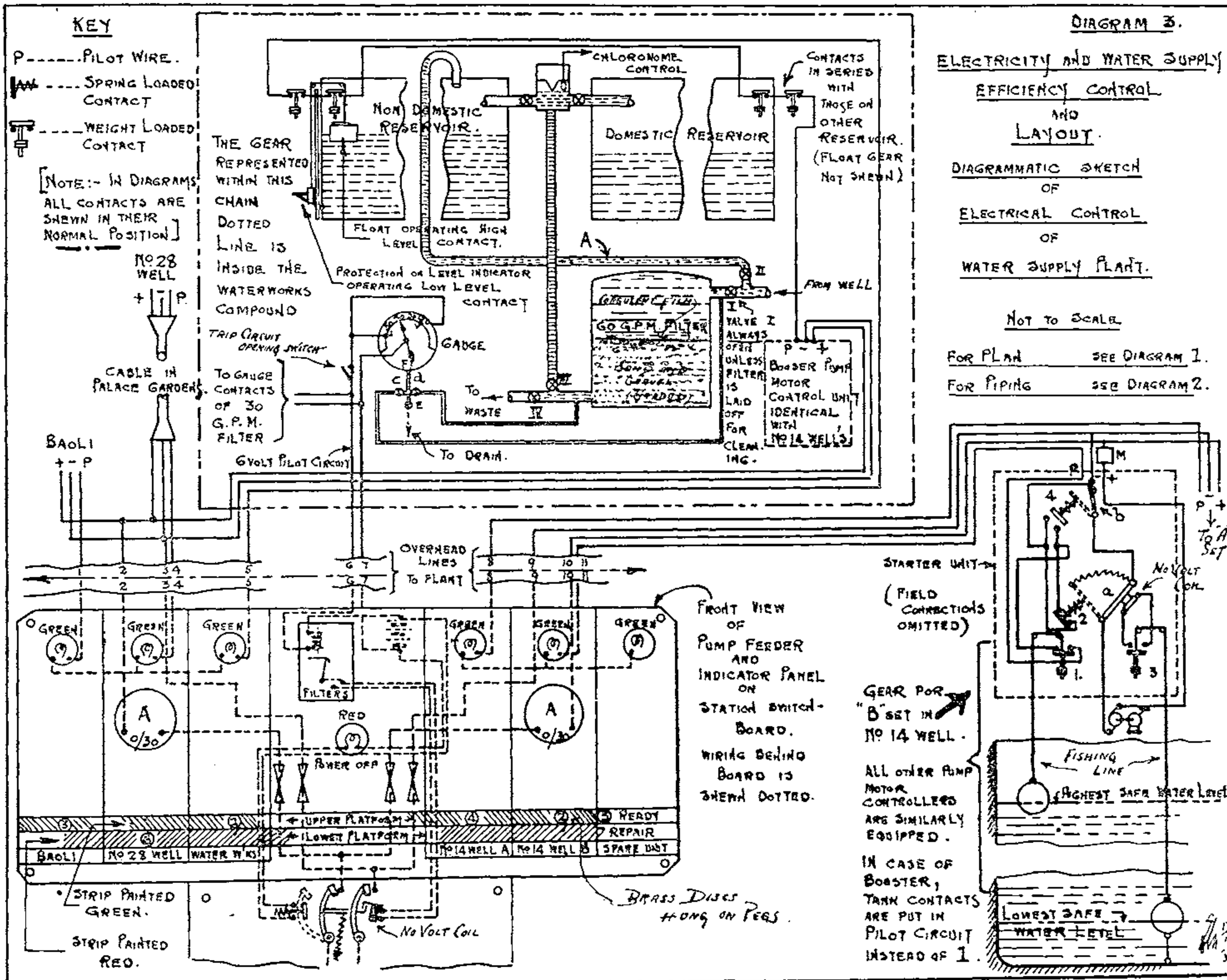


DIAGRAM 3.
ELECTRICITY AND WATER SUPPLY
EFFICIENCY CONTROL
AND
LAYOUT.
DIAGRAMMATIC SKETCH
OF
ELECTRICAL CONTROL
OF
WATER SUPPLY PLANT.
NOT TO SCALE.
FOR PLAN SEE DIAGRAM 1.
FOR PIPING SEE DIAGRAM 2.
KEY
P - - - - PILOT WIRE.
- - - - SPRING LOADED CONTACT
- - - - WEIGHT LOADED CONTACT
[NOTE:- IN DIAGRAMS ALL CONTACTS ARE SHEWN IN THEIR NORMAL POSITION]
THE GEAR REPRESENTED WITHIN THIS CHAIN DOTTED LINE IS INSIDE THE WATERWORKS COMPOUND
NON DOMESTIC RESERVOIR.
DOMESTIC RESERVOIR
CHLORONOME CONTROL
CONTACTS IN SERIES WITH THOSE ON OTHER RESERVOIR. (FLOAT GEAR NOT SHEWN)
FLOAT OPERATING HIGH LEVEL CONTACT.
PROTECTION OR LEVEL INDICATOR OPERATING LOW LEVEL CONTACT
FROM WELL
60 G.P.M. FILTER
VALVE I ALWAYS OPEN UNLESS FILTER IS LAID OFF FOR CLEANING.
BOOSTER PUMP MOTOR CONTROL UNIT IDENTICAL WITH NO 14 WELL
GAUGE
TRIP CIRCUIT OPENING SWITCH
TO GAUGE CONTACTS OF 30 G.P.M. FILTER
TO WASTE
TO DRAIN.
6 VOLT PILOT CIRCUIT
NO 28 WELL
CABLE IN PALACE GARDENS
BAOLI
OVERHEAD LINES TO PLANT
STARTER UNIT
(FIELD CONNECTIONS OMITTED)
NO VOLT COIL
TO 'A' SET
FRONT VIEW OF PUMP FEEDER AND INDICATOR PANEL ON STATION SWITCH-BOARD.
WIRING BEHIND BOARD IS SHEWN DOTTED.
GEAR FOR "B" SET IN NO 14 WELL.
ALL OTHER PUMP MOTOR CONTROLLERS ARE SIMILARLY EQUIPPED.
IN CASE OF BOOSTER, TANK CONTACTS ARE PUT IN PILOT CIRCUIT INSTEAD OF 1.
FISHING LINE
HIGHEST SAFE WATER LEVEL
LOWEST SAFE WATER LEVEL
GREEN
RED
FILTERS
POWER OFF
UPPER PLATFORM
LOWER PLATFORM
READY
REPAIR
BAOLI
NO 28 WELL
WATER WKS
NO 14 WELL A
NO 14 WELL B
SPARE UNIT
STRIP PAINTED GREEN.
STRIP PAINTED RED.
BRASS DISCS HUNG ON PEGS.

test of the asbestos pipes by comparison with cast-iron and W.G.I. pipes of similar sizes laid at the same time.

Mention of the duplicate mains has already been made. The mains and branches of both systems run as close to each other as is possible, the pipes of the one system always bearing a definite position relative to those of the other, which is noted on the record drawing. Laying bare one main lays bare the other and invites reference to the plan as to which is the correct one to tap. Otherwise there is a distinct danger of a man tapping the first main uncovered in the general position as indicated on the plan.

VI.—Staff.

The whole of the plant is run by a joint installation staff of three men per shift, an engine driver, a switchboard *cum* pump attendant, and a cleaner. For discipline one man is placed in charge of the shift. This would preferably be the attendant, but among the class of labour recruited, the drivers are often the more reliable, if less literate, men.

With the water-supply plant and the writing up of both logs, the attendant has little time to doze on his switchboard, as so often is the case.

The night-shift driver is given, whenever possible, the dismantling of plant due for attention next day, ready for the daily labour fitter to get on with the job.

This daily labour comprises a fitter, an electrician linesman, a water-supply linesman, a wireman and two coolies. From amongst these one man is trained to act as a relief driver, and one as a relief attendant, and these keep their hand in by taking a shift, and thereby breaking the shift sequence, once a month. Men continually on the same shift are liable to form bad habits, particularly on night shift, when they are out of the superintendent's regular supervision.

TECHNICAL TRAINING OF FIELD COMPANY N.C.O's.

By CAPTAIN G. R. MCMEEKAN, R.E.

1. OWING to the number and variety of duties for execution by engineer field units in mobile warfare, it cannot be expected that engineer officers will be available to reconnoitre, plan and execute all that is required of these units. The efficient R.E. N.C.O. is capable of *executing* most of these duties. Few, however, have had the necessary training and experience to justify their being entrusted with the *reconnaissance* and *planning* of any but the simpler engineering jobs. It is thought that their training has been directed primarily to making them into efficient "gangers" rather than "foremen of works" in the sense of their opposite numbers in the Works service.

The present-day field company commander at home suffers from several handicaps, not the least of which is the celerity with which his N.C.O's are whisked away by implacable "Records," just as they are beginning to pull their weight; indeed, it is peculiar how often it happens that N.C.O's posted away do fall into this category —according to the company commander.

It is difficult to see how this state of affairs can be improved. We must provide men for overseas, and we must send good men as instructors for schools or for the T.A. In these circumstances, the field unit must continue to suffer from the rapid turnover. It remains to see how better use can be made of the short time the N.C.O. spends with a field unit.

The military year is divided into two training seasons, collective and individual. These, with due allowance for furlough, fill the entire year and leave no convenient routine period during which N.C.O's might have special instruction.

It is now proposed to examine these two seasons separately to see how we can begin to improve N.C.O's training up to the standard required.

2. COLLECTIVE TRAINING SEASON.

Comments are inevitable on a number of "exemptions" fro fieldworks, and efforts are thus made to ensure that every carries out at least 50 per cent. of his annual fieldworks course

N.C.O's on administrative jobs, cooks, storemen, and clerks are all turned out for a month or two. These men are generally those with long service, and they have to be relieved by younger men who need all the training that they can get. As a result the spotlight tends to focus on the sapper and his training, with officers and N.C.O's lurking in the prompter's box.

Now the sapper gets a very good education for his job as a field company sapper before he leaves Chatham. Moreover, when he gets to a field unit, he very likely remains in it until he is promoted or goes to the reserve.

In the writer's opinion, too much emphasis is laid on the further training of the sapper in the unit. The primary object of field company training should be to train leaders for their jobs in war, and the company commander should consider firstly how to train himself, secondly his officers, and thirdly his N.C.O's. The training of the men will then follow almost automatically.

Peace conditions are liable to formalize the work of engineers even more than that of other arms. Even so, too many fieldworks jobs are apt to be done as instructional set pieces in which, because we are thinking only of training men, estimates of time, labour, and materials are very often not called for; there is no tactical "situation"; and proper orders are not issued. In such works, the necessity for clear, concise orders is often forgotten. Worst of all, the unexpected, which might develop the resource and initiative of subordinate leaders, happens only by accident.

A company accustomed to meeting with accidents, casualties and warlike misfortunes may produce disappointing data for its fieldworks report; but it will be fit for war.

3. The Individual Training Season.

Many field company N.C.O's disappear for the winter on administrative jobs, on specialist courses, and as trade instructors. An N.C.O. cannot expect normally to spend more than one winter during his tour with a unit on his own general technical training. For this reason it is recommended that divisional engineers should run each year a technical course for N.C.O's, from serjeant to lance-corporal. The individual standards of knowledge will not vary as much as one would imagine, because the more senior will be newly arrived from other walks of life in the Corps, whilst the junior will have been recently promoted after several years as a sapper in the unit. In any case it is not possible to provide instructors for a senior and a junior class in the same winter, particularly if it is proposed to run a "Drill and Duties" course just before the Spring Drills.

4. WHAT A FIELD COMPANY N.C.O. MUST KNOW.

The following suggested syllabus is based on experience gained from two short courses run by 1st Divisional R.E. this winter. The time allotted totals 30 working days, which is considered the minimum in which this syllabus can be covered.

Working Drawings (*2 days*).

Most N.C.O's can read a drawing, but very few have been taught how to make one themselves. A high standard of skill is not essential, but N.C.O's must be able to illustrate reconnaissance reports, etc. Instruction should include elementary craftsmanship, use of materials and tools, method of showing dimensions, etc., choice and construction of scale, explanation of plan, elevation and section.

Map Reading and Field Sketching (*6 days*).

It has become a platitude to say that all ranks in a mechanized unit must attain a high standard of map reading. But the standard is still low, largely because N.C.O's imagine that once having acquired their 2nd-Class certificate of education they know all about it. Deprive them of railways, rivers, roads, and churches-with-spire—put them, in fact, on Salisbury Plain, and they are lost. They know the theory and the conventional signs ; what they require in a course is practice in country which has no artificial landmarks. Incidentally, a more lavish distribution of maps on manœuvres would provide some of this practice for junior N.C.O's.

A treasure hunt on bicycles is an excellent method of speeding up map reading and of teaching accuracy. The clues should be difficult, otherwise the hunt develops into a bicycle race. In a slow hunt, the instructor can do a lot of teaching when cheering on the laggards. Night work with prismatic compasses should be practised.

Levelling (*2 days*).

This should include use of dumpy level, boning rods and clinometer, together with some practical levelling work.

Works Organization (*2 days*).

After being shown where to acquire the necessary data, the class can work out examples of working-party tables, transport tables, quantities, stores, etc., finishing with a complete scheme for, say, roadmaking as an example.

Demolition (*5 days*).

This is definitely one of the jobs where responsibility would often have to be delegated largely to N.C.O's. They must be able to work out straightforward cutting and mining charges, and know where to place them. They must be able to organize working parties fo such work. They must practise this, until they are confident of tackling any medium-sized demolition. Finally, they should be capable of reconnoitring a more complicated job sufficiently well to enable an officer to calculate for it without seeing it.

Bridging and Use of Spars (6½ days).

N.C.O's usually get plenty of experience of bridging with standard equipment. It is suggested that a detailed project might be worked out for a stick-and-string bridge ; this, though some might consider it archaic, will give the student grounding in the principle governing all bridge design and so fit him to deal with expedients. Simple calculations for strength of materials, buoyancy and use of spars and tackles should also be given. The class should be exercised in working out the safe load on existing bridges, and in reconnaissance for a bridge site.

Water-Supply (4½ days).

An N.C.O. will not be called upon to design a permanent camp water-supply, but he may have to plan and construct unaided a water point for a brigade group. He does not, therefore, need to calculate the loss of head in a pipe, though he must understand that friction does cause a loss. He must be able to work out the water requirements of a small mixed force, and to design water points for it under different conditions with service equipment. And he must be able to make a detailed list of stores for the job.

Roads (2 days).

The work of field units (other than road construction companies) is likely to be limited to (a) improvement to existing tracks, (b) repairs, (c) construction of short temporary lengths of roads, probably either slab or mix-in-place. Lectures on work of this type, in which special emphasis should be laid on materials and drainage, can profitably be followed by a visit to a mix-in-place plant in operation.

Tramways (1 day).

A lecture followed by a small project will suffice.

Concrete (2 days).

It is important that all N.C.O's should understand the principles of reinforced-concrete construction. Reinforcement calculations, of course, need not be attempted.

A lecture on these principles can be followed by an explanation of the rules for mixing and pouring the concrete, and for bending and placing the reinforcement. They should be practised in calculating quantities from a drawing, and should see a good reinforced-concrete job under construction.

5. Organization of Course.

Arrangement of Periods.

The work of necessity consists chiefly of lectures and paper schemes. Provided that long stretches of continuous lecturing can be avoided, it is better to work continuously at one subject until it is finished.

Judging from the keenness shown by N.C.O's this year, afternoons or evenings given to homework or reading will not be wasted. But, they must be advised what to read, and junior N.C.O's must have facilities for getting all the books they want.

Duration.

The course could profitably fill two months.

The first of the 1st Division courses tried to cover the whole of the above syllabus in 15 working days. In this short time N.C.O's were only able to get to grips with those subjects of which they had considerable previous experience. In the second course, roads, tramways and reinforced concrete were omitted altogether, on the grounds that it will be the exception for work of this type not to be reconnoitred and planned by an officer. It is considered that 30 working days is the minimum time in which to cover satisfactorily the whole syllabus.

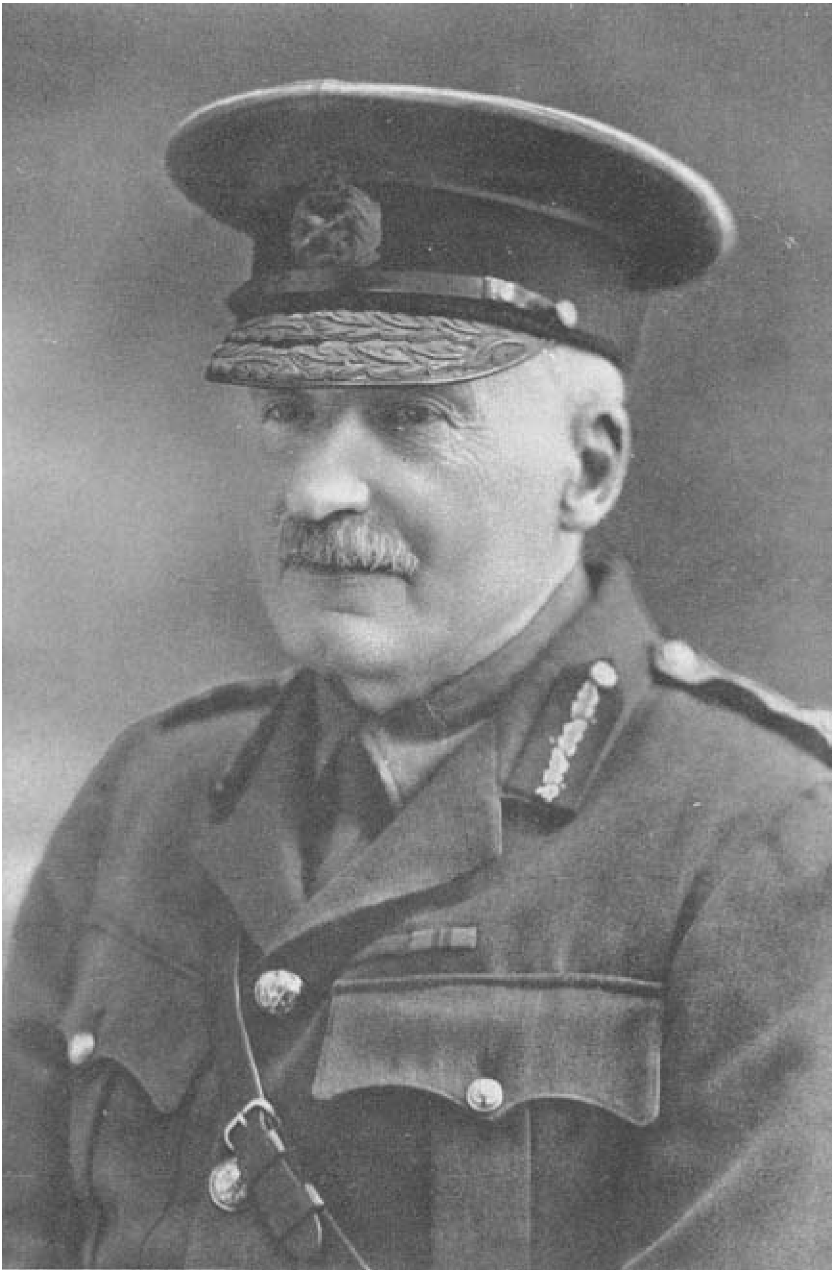
Instructors.

For a class of 15 to 20 N.C.O's, two full-time officers are the ideal, rarely to be obtained. Usually a number of instructors will have to take one or more subjects each. This "higher education" of the N.C.O. is making yet another call on the time of the field company officer, and in units where N.C.O's come and go so quickly a shortage of officers seriously affects training.

6. What should be a Conclusion, but is only a Query.

The wisdom and truth of the words at the head of this article are not to be denied. An attempt has been made to show the extent to which it is possible, under existing conditions, to follow the instructions implied by these words.

Soldiers nowadays are running a never-ending race, for ever galloping in the wake of the scientist. In this race, we, the engineer field units, are in danger of being outstripped by other arms. This unpalatable fact may be ascribed in part to the number and variety of duties—or shall we say obstacles?—with which we are faced. But can we still afford the handicap of the "General Roster" system as applied both to officers and to N.C.O's? Are we perhaps to be forced willy-nilly into specialization?



Maj Gen Sir Richard Matthew Ruck KBE CB CMG

MEMOIRS.

MAJOR-GENERAL SIR RICHARD M. RUCK, K.B.E., C.B., C.M.G.

RICHARD MATTHEWS RUCK was born 27th May, 1851, the second son of Lawrence Ruck, Esq., of Newington Manor House, Kent. Both his father and mother were of Welsh extraction and his mother's family could claim descent from Owen Glendwr, the last Welsh Prince, who was crowned King of Wales in 1404. Educated at a private school, he joined the R.E. from the R.M. Academy in August, 1871. There he had made some reputation as an athlete, playing cricket and Rugby football for the " shop " and also gaining distinction in the sports and in gymnastics.

On joining the R.E. he showed the same proficiency at the dribbling game, played for the Corps, and was a member of the team which won the Association Cup in 1875. Later, when golf developed in England in the 'eighties, he took this up keenly and soon became a scratch player.

On completing his courses at the S.M.E. in 1873, he was sent for a few months to Aldershot, but in September, 1874, he joined the Submarine Mining Service at Chatham, thus beginning a continuous service of 24 years in this branch of the R.E. He was employed for some years in command of a section of the 28th Company at Cork Harbour, Pembroke Dock, and other stations until in March, 1881, he was appointed Assistant Instructor at the School of Military Engineering in charge of the Submarine Mining School at Gillingham. He was promoted Captain in 1883. In May, 1885, he was moved to the War Office and in January, 1886, was appointed Assistant Inspector of Submarine Defences with the temporary rank of Major. In July, 1891, he succeeded to the appointment of Inspector which he held to December, 1896.

An account of his work in these appointments is given in the *History of Submarine Mining in the British Army* (published by the R.E. Institute, 1910). As Ruck himself said in a foreword to this history, " The Submarine Mining Service was not a one man's show," but Ruck's share was a big one. When an instructor he had developed many improvements in the electrical and other apparatus, and he was always specially interested in the application of mechanical appliances for military purposes. He was one of the three officers to whom was divulged the secret of the Brennan torpedo when it was purchased. At the War Office, while he was always keenly interested in the technical work of the R.E. Committee, his work lay more in the organization of the service, especially the welding into a whole of the groups of militia and volunteer units, which were gradually formed.

It must have somewhat amused old Submarine Miners to note the space given recently in the Press to the proposed fuller employment of Territorial units in the anti-aircraft defence of the country. Such employment only repeats the organization of the Submarine Mining auxiliary forces which began nearly fifty years ago! The I.S.D. was the electrical adviser of the Inspector-General of Fortifications and it was largely due to Ruck's initiative that electric light was first introduced into barracks.

At the end of 1896 Ruck left the War Office on promotion to the rank of regimental Lieut.-Colonel. His work can be best appreciated by an extract from the history. "The efficiency of the Submarine Service at this date and especially the way in which the organization has been adapted to meet the requirements of ports in all parts of the world are a lasting testimony to the value of his (Ruck's) guidance."

On promotion to Lieut.-Colonel, Ruck was appointed C.R.E. Shoeburyness, but after a period of half-pay on account of ill-health, he was ordered abroad for his first foreign service as C.R.E. West Sub-District at Malta. Here he found a much overdue programme of barrack construction in progress and took up wholeheartedly the building of the new barracks at St. Andrews, introducing improvements, both in layout and in the general design. Among other jobs he was appointed by the Governor of Malta—Lord Grenfell—President of a Committee to form a Sports Club on the Marsa for officers of both services. The club was formed and Ruck personally laid out the golf course and designed the club house, celebrating the event by winning the scratch prize at golf open to the officers of both services!

In June, 1902, just before completing his period as regimental Lieut.-Colonel, he was recalled to the War Office to take up the appointment of Deputy Inspector-General of Fortifications under General Sir Richard Harrison.

In 1904 there occurred the remarkable reorganization of the War Office and the Army based on the recommendations of the Esher Committee. The office of Inspector-General of Fortifications was abolished. The head of the Engineer work was in future to be a Director with the rank of Colonel only, under the title of Director of Fortifications and Works. The duties of Inspector of R.E. units, formerly carried out by the I.G.F., were transferred to an Inspector of R.E., with the rank of Colonel, working under the Chief of the General Staff. A new branch was formed for barrack construction which was placed under a civil member of the Council. But as this branch found itself unable to deal with foreign stations, the change gave little reduction in the work in the D.F.W.'s office. On the other hand the staff of the Assistant Adjutant-General was reduced with the result that the work connected with the equipment of R.E. field units was transferred to the D.F.W.

Ruck was offered the appointment of Director of Fortifications and Works. He did not like many details of the new organization, especially the subordinate position of the Director and the loss of rank for the senior appointments open to the R.E. He had several meetings with the Esher Committee, at which he was promised that the position of the Director would be improved. But he had all through his life acted on the principle of obedience to constituted authority, and held the view that the Government had the undoubted right to settle questions of policy and that the first duty of an officer was to obey orders and do his best with the work entrusted to him.

It is impossible within the scope of this memoir to go into all the details of the work done by Ruck during the next four years. Not only had he to entirely reorganize his own office, but the Esher Committee had been followed by a recasting of the whole organization of the Army, with a result that every detail of R.E. work had to be examined and explained to the Military Members, while every financial detail was closely scrutinized by the civil branch of the War Office under the direction of a Secretary of State, who was inclined to minimize the work of the R.E. and was decidedly antagonistic.

In the midst of this tangle of interests, Ruck proved to be the right man in the right place, and it was well for the country and the Corps that we had at the head of R.E. work an officer with his equable temperament, ripe judgment, and it may be added his remarkable capacity for work. Not only was his long previous experience of the War Office most valuable, but he knew personally and was liked by all the senior permanent officials whose co-operation was so necessary. His personal qualities made him trusted by his superiors and he was constantly consulted on questions of general interest.

His loyalty was sorely tried by the decision in 1904 that the Submarine Mining Defences were to be transferred to the Admiralty, but the form in which this decision was conveyed made it very difficult for him or any military officer to oppose the decision. When it became evident after a few months that the Admiralty intended to destroy the mine defences and use the buildings, boats and stores for other purposes, the transfer had gone too far for protest. The removal of the mine defences not only involved a reorganization of the R.E. fortress service, but a somewhat drastic review of all coast defences at home and abroad.

On the whole it may be claimed that the reorganization of the R.E. work of the Army initiated by Ruck and his confrères proved thoroughly sound and stood the strain of the Great War.

During his time at the War Office, Ruck never ceased to push the claims of the senior officers of the R.E. for improved rank and position. He managed to defeat an attempt which was made to withdraw from the Chief Engineers of Commands the Engineer pay which had been given to their predecessors. He also pressed very strongly that the head of the Engineers at the War Office should be given the rank of Major-General, not only because of the absurdity of a ruling which prevented any military engineer being employed on Engineer work after the age of 57, but also because of the bad effect of such a ruling on the efficiency of the Corps, in support of which he instanced the number of senior officers who had left the R.E. and had obtained distinction in other branches of the Government Service. His views were partly met on the introduction of the rank of Brigadier-General in July, 1905, when this rank was granted to the Inspector of R.E. and to the D.F.W. at Headquarters, and also to the Chief Engineers of the four larger commands at home. The further step of the rank of Major-General for the D.F.W. was not given till five years later, when Ruck, who had been promoted Major-General in April, 1908, retired at his own request on 1st October, 1912, in order to make a vacancy for the promotion of Brig.-General G. Scott-Moncrieff, who was then D.F.W., and would, if not promoted, have been retired under the age clause.

On completion of his appointment as D.F.W., Ruck was appointed Major-General in charge of Administration, Eastern Command, which he held until his retirement, and as such took charge of the military arrangements in London in aid of the civil power during the great railway strike in 1911.

On the outbreak of the Great War, he at once volunteered for service and was appointed Chief Engineer of the Central Force, an organization of Territorial units for the defence of London and the Eastern Coast from the Wash to Portsmouth. In addition, Ruck had the special responsibility of preparing the defences of London, for which a scheme had been prepared when he was at the War Office. In April, 1915, the command of the Central Force was combined with that of the Eastern Command, and in October, 1915, Ruck was appointed Major-General in charge of Administration to the Eastern Command until relieved by a serving officer in June, 1916, when he was appointed G.O.C. London Defences.

But Ruck's work did not end with his military service. He had always been keenly interested in aeronautics. The writer remembers an occasion in the War Office in 1905 when, on the initiative of the Secretary of State, two of the military members were discussing the abolition of our Balloon Service and a saving on the vote for that purpose. Ruck, when asked his opinion, made the remarkable forecast " that he was confident that in the early future the question of military supremacy would be decided by fighting in the air." The vote was saved.

When he left the Active List in 1912, he became Chairman of the Council of the Royal Aeronautical Society which he held till 1919, and in 1920 he became Vice-President.

In 1916, on leaving the Eastern Command, he was appointed Vice-President of the Air Inventions Committee under the Air Ministry and was also made a member of the first Civil Aerial Transport Committee. He threw into this the same energy, coupled with the same thorough command of detail, as he had shown in his military work.

In the matter of honours and rewards, Ruck was not fortunate. For his Submarine Mining work at the War Office Sir R. Grant recommended him for a Brevet Lieut.-Colonelcy, but this was refused as it was not considered desirable in those days to give brevet promotion for purely peace work. He saw no active service until the Great War. Thus it was not until 1911, after 40 years' service, that he received his first decoration—C.B. (Civil).

In 1917 he was mentioned in dispatches in the Eastern Command and was made a C.M.G., and in 1920 he was made a K.B.E. for his work for aeronautics.

In his later years his time was largely occupied as joint trustee of the Raynham Estates in Norfolk, the property of the Marquis Townshend. True to his mechanical principles, as he himself put it, he was specially interested in the application of machinery to farming operations.

He kept up his golf to a good age and in 1933 was gratified by being elected President of the Welsh Golfing Union which he had helped to found in 1894.

He married Mary, daughter of Mr. John Gully, *M.P.*, and widow of Mr. Thomas H. Pedley. Old friends will remember how ably she helped her husband in many ways and the kindly hospitality they showed to the younger officers at Chatham and London. She died in 1914.

During the last few years of his life he lived with his adopted daughter and her husband—Rev. Geoffrey Warwick. He passed away in London on 18th March, 1935, in his 84th year.

His personal character may be judged by the above notes, but a word must be added as to the esteem and affection in which he was held by those with whom he worked. This was particularly the case in the Submarine Mining Service. He had the knack of getting the best out of his subordinates and always gladly acknowledged the assistance he obtained from them. As an officer who knew him well writes, " He had a very strong character and a quiet efficiency which was very comforting to his subordinates."

W.B.B.

COLONEL SIR WILLIAM G. MORRIS, K.C.M.G., C.B.

William George Morris, the eldest son of the late Lieut.-Colonel W. J. Morris, Bombay Army, was born at Malagaum, on February 12th, 1847. He was educated at Cheltenham and the Royal Military Academy, and was commissioned in the Corps on 10th July, 1867.

His early service was spent at Chatham and Mauritius, and from February, 1874, to January, 1876, he was at the Staff College. After short periods at Aldershot and Colchester, he returned to Chatham in June, 1877, as Assistant Instructor in Survey, holding this appointment for five years. In July, 1882, he was placed in charge of the Expedition sent to Queensland to observe the Transit of Venus, returning to England in February the next year. On his return, he was lent to the Colonial Office, and proceeded to South Africa, where he was employed for ten years on Geodetic Survey work under the direction of Sir David Gill, H.M.'s Astronomer at the Cape. Sir David had the promotion of this survey constantly in mind, and enlisted for it the sympathy and support of all who could by their influence be in any way of help in assisting to forward it, such as Cecil Rhodes and, after the South African War, Lord Milner. He had an able coadjutor in Morris. To these two men, South Africa owes a great debt for the work accomplished on this Survey, and Morris pulled the labouring oar. Morris's work during these years is described in the *Report of the Geodetic Survey of South Africa executed by Lieut.-Colonel W. G. Morris*, 1883-1892, *under the direction of Sir David Gill*, 1896, and was rewarded by the C.M.G.

In those days, when survey parties in South Africa depended mainly on animal transport, the problems of administration and organization made far heavier calls on the surveyor than in these days of mechanization. Morris had a train of many horses and mules to look after, with wagons, carts and their equipment. Care of harness and the health of animals was an important detail, especially as, on the high veldt, transport animals are so subject to horse sickness. Owing to Morris' care and forethought, his survey parties lost comparatively few animals. He had also a large number of men to look after and keep in health, while the conveyance of delicate instruments required more care and supervision than with motor transport.

Morris was promoted Lieut.-Colonel in July, 1893, and on his return to England, was appointed O.C. Training Battalion, at Chatham, and in July, 1895, he became Assistant Commandant of the S.M.E., which position he held till he had completed five years as Lieut.-Colonel in July, 1898. On promotion to Colonel, he again

Colonel Sir William George Morris, K.C.M.G., C.B.

Col Sir William George Morris KCMG CB

went to South Africa as C.R.E., and he remained at Cape Town throughout the Boer War. That no better use was made of his unique knowledge of the topography of South Africa must seem amazing. It was a great disappointment to him. His work at Cape Town was, however, of great importance. An immense amount of work was done there on hospitals, equipped on a large and modern scale, on remount depots, prisoner-of-war camps, and accommodation generally. Morris and his staff also arranged in detail for the construction of the blockhouse lines over a great part of that extensive country, by means of which the long guerilla warfare was eventually brought to an end. He was twice mentioned in dispatches and awarded the C.B.

Morris went on half-pay on vacating the appointment of C.R.E. in October, 1902, and immediately returned to his old work on the Survey of South Africa. His old friend and chief, Sir David Gill, had pressed for the continuance of the Survey and obtained the appointment of Morris as Superintendent of the Grand Trigonometrical Survey of South Africa. Morris directed this work in the Transvaal and Orange River Colony till its completion five years later.

In 1904, a scheme was promoted by the War Office for the systematic topographical survey of the whole of South Africa under Morris, but this was abandoned for financial reasons. Morris' work, however, on the primary triangulation is a lasting monument to his skill and energy, and will always serve as an essential framework for any future surveys. Sir David Gill was its most effective and enthusiastic supporter as a beginning of the measurement of the great meridional arc from the Cape to the Mediterranean, which was his (Gill's) great ambition to see carried through. Thus most of Morris' work was of precise geodetic value, and he was by training and temperament well equipped for carrying it out. It is described in detail in Volume II, *Reports of the Geodetic Survey of the Transvaal and Orange River Colony*. In the preface to this, Sir David Gill commends Morris' report "to those who may have to organize similar work in other parts of the world; it embraces the results of his unique experience not only as a superintendent of Geodetic Field Work on a large scale, but as a practical worker in the field. The care and forethought bestowed by him on all details of administration and the example of his untiring personal energy have been the chief factors in the smooth working and complete success of the whole operation." For this work, Morris received the K.C.M.G. in June, 1907.

Morris had retired from the Army in February, 1904, and on finishing his great work in South Africa, he settled down at Bettws-y-Coed. His heart had been truly in his work, but when that was completed his only wish was to retire to Wales and "absorb nature," as he put it. He was twice married, firstly, in 1871, to Edith, daughter of the Rev. W. W. Tireman, rector of Bowers Gifford, Essex; and, secondly, in 1917, to Ethel Joan, daughter of Mr. R. Warren, Gosford Pines, Ottery St. Mary.

Morris was an omnivorous reader on a variety of subjects: Jeans, Eddington, Lodge—books on surgery, medicine, relativity, wild nature, criminology, were all grist to his mill. He was passionately fond of music. His long years on his beloved veldt perhaps helped to reach the great age of 88, and, though he spent the last 14 months of his life in bed in a bay window whence he could see his favourite Welsh mountain, Moel Siabod, he had good eyesight and hearing till the end. He died on 26th February, 1935.

Sir David Gill describes Morris as "a very splendid fellow—as high-souled, pure minded a man as I ever met—full of work and full of earnestness and fun too."

Colonel H. M. Jackson, one of his assistants on the Survey, writes: "He was a most keen and thorough worker, never omitting any detail of preparation and organization which might help the perfection of results. He had the gift, too, of getting the best out of his assistants, and was a good man to work with. A somewhat detached and philosophical temperament carried him through many difficulties. That same detachment of disposition enabled him to settle down after his retirement amongst the Welsh hills in contented independence."

Colonel C. G. Burnaby, who served with him during the South African War, writes: "He was a most charming man to work under, and his intimate knowledge of the topography of the places where he sent me was marvellous."

Colonel E. M. Burton* writes: "Sir William Morris loved his work on the Survey and his life on the veldt. He was never so happy as when roaming about and photographing in out-of-the-way places around Cape Town—on Table Mountain, at Caledon, or on the outdoor work of the Survey in the Cape, the Orange Free State, Natal and the Transvaal, and on the hills round Bettws-y-Coed. He passed away at the ripe age of 88, among the mountains he loved so well, in the little house he had built on the hillside at Bettws-y-Coed above the fast flowing Llugwy."

* NOTE.—This memoir is mainly based on notes supplied by Col. Burton.—(ED. *R.E.J.*)

Brigadier-General H. R. Stockley, C.I.E.

Brig Gen Hugh Stockley

BRIGADIER-GENERAL H. R. STOCKLEY, C.I.E.

On March 3rd, an attractive personality and distinguished officer of the Corps, who had seen much active service, passed away at his home, Alkerton Grange, Eastington, near Stonehouse in Gloucestershire. Brigadier-General Hugh Roderick Stockley was the son of the late Colonel H. W. Stockley of the Royal Artillery, and was born on March 23rd, 1868, so was not yet 67 at the time of his lamented death.

Educated at Wellington College, where he was in the Cricket XI, he passed direct into Woolwich in the summer of 1885. There he won the Military Topography Prize and received a commission in the Royal Engineers in July, 1887, retiring on an Indian pension with the rank of Brigadier-General in October, 1922, after more than 35 years' service in the Corps.

In his younger days Stockley was an athlete of some standing, being a particularly fine cricketer who played for the Shop during his two summers there, and captained the team in 1887. Later, he became one of the regular bowlers for the Corps, and a Free Forester, and was elected a playing member of Lord's. He played much cricket in India also for a number of years.

In the football field, too, he was a keen and energetic forward, doing much yeoman service for the R.E. Rugby XV. This, at that time, was gradually replacing the Association Football traditions of the Sappers, who could point to the proud distinction of having won the Association Cup in 1874. As an oarsman, Stockley also displayed his prowess by stroking his Batch Four at the S.M.E. in 1888.

Tall, handsome, well-built, and of commanding presence, Stockley always looked the beau ideal of a soldier; and his subsequent career fully confirmed his early promise, though many consider, with ample justification, that his sterling qualities never met with adequate reward during the 35 years he served his country with so much zeal. And yet, so strong was his sense of duty, he would probably have disclaimed any lack of appreciation on the part of those in whose hands his advancement chiefly lay.

After completing his course at the S.M.E., Stockley proceeded to India in the autumn of 1889, and was soon posted to the Bengal Sappers and Miners, with whom he spent much of his service for a number of years. During the earlier part of this period, the N.W. Frontier was in a greatly disturbed condition, and expeditions to bring recalcitrant tribes to book were of frequent occurrence;

while no expedition set forth without one or more companies of the Bengal Sappers to overcome the difficulties of terrain certain to be met.

Hence, Stockley was initiated into the methods of mountain warfare early in his career, serving with the Bengal Sappers and Miners in the Hazara Expedition of 1891, for which he received the medal and clasp. The next year he took part in the Isazai Expedition ; while two years later he accompanied the 5th Company on the Waziristan Expedition of 1894-95, for which he received another clasp to his Indian Frontier medal.

The 5th Company was then commanded by Capt. G. A. Travers, with Lieuts. Stockley and S. H. Sheppard (the noted racquets player) as his two subalterns, the present writer bringing it up to war strength. Thus in Stockley's recent death occurs the first break in the 5th Company band of R.E.'s that served together in the wilds of Waziristan 40 years ago.

It was not long before Stockley again found himself on active service in command of the 4th Company, as the whole of the N.W. Frontier broke out into a blaze in 1897. The ensuing operations entailed much stiff fighting before order was restored in those turbulent regions, and the 4th Company were in the thick of it, as evidenced by the fact that two of Stockley's subalterns, T. C. Watson and J. M. Colvin, gained the V.C. For his share in the operations about the Malakand Pass, in Bajaur, and in the Mohmand country, Stockley was mentioned in dispatches in the *London Gazette* of 18-3-98, and again after the capture of the Tanga Pass in the *Gazette* of 22-4-98. He also received the new Indian Frontier medal with clasp. In July of the same year he was promoted to captain.

At the close of operations, Stockley came home and attended a "refresher" course at the S.M.E. in May, 1898, during which time he played for the R.E. Cricket XI, and returned to India a few months later. Not long afterwards, the Boxer rebellion broke out in China and Stockley accompanied the Expeditionary Force sent from India in August, 1900. His varied services in that country for nearly a year again received a mention in the *London Gazette* of 14-5-01 and the award of the China medal.

Whilst home on leave during 1902, besides playing cricket, he spent much of the summer in London working for the Staff College, Camberley ; and though he passed the examination with success he was not fortunate enough to obtain one of the few places allotted to R.E's, so returned to duty with the Bengal S. and M. in India.

When next on leave in England, Stockley married Edith Beatrice, the only child of Lieut.-Colonel William Capel, The Grove, Stroud, in Gloucestershire. On returning to India after his marriage, he was appointed D.A.A.G., Presidency Brigade, Calcutta, where he served under another distinguished R.E. officer, the late Major-General Sir Ronald Macdonald; and this appointment he held for three years, until February, 1908, being promoted to Major in July, 1906.

He came home on leave again in the spring of 1909, enjoyed much cricket with the Free Foresters, and spent some months on courses at the S.M.E. and Aldershot before returning to Roorkee with his wife and children in October of the same year. He was next employed for some time in the Intelligence Branch at Simla; but when the King and Queen set out from England for the Delhi Durbar and their tour of India, 1911-12, Stockley was selected as one of the Assistant Military Secretaries to His Majesty, and joined the royal party on their arrival at Bombay. He accompanied their Majesties throughout their stay in India, and received the C.I.E. in recognition of the valuable services rendered by him during this period.

On the departure of their Majesties, Stockley resumed his duties at Simla, where he was appointed G.S.O.2 in the Intelligence Dept. in March, 1912; and this appointment he held at the outbreak of the Great War, being promoted to Lieut.-Colonel on October 30th, 1914. Early in 1915, however, it was realized that the heavy losses among officers of the Indian Army in France could not be replaced by cadets trained at Sandhurst only, and it was accordingly decided to start an Indian Sandhurst at the Staff College, Quetta, which had been closed down soon after hostilities commenced.

This new college was opened on April 1st, 1915, for the reception of 100 young gentlemen sent out from England for six months' intensive training to qualify for commissions in Indian cavalry and infantry regiments; and Stockley was appointed Assistant-Commandant to the present writer in this new venture. Since Quetta could but turn out 200 young officers for the Indian Army in a year, it soon became apparent that this would not meet the likely demand. Some months later, therefore, it was decided to start a second similar College at Wellington in Southern India. Stockley was selected to undertake this task as Commandant, and during the next two years several hundred cadets passed through his understanding and experienced hands at Wellington to receive commissions in the Indian Army.

At length his labours seemed about to be rewarded by his being sent overseas to join the G.H.Q. of the Mesopotamian Expeditionary Force in July, 1917. Here, as A.A.G., he soon came under the personal notice of Sir Stanley Maude, who formed a high opinion of his abilities, and appointed him C.R.E. of the 17th Division. He was holding this promising position at an important juncture when, to his great disappointment, he was summoned back to India in

October, 1918, to take over the post of Inspector of R.E. and Pioneers in India, with the rank of Brigadier-General.

Thus all chance of participating in the final overthrow of the Turkish forces in Iraq was denied him ; but for the next two years he carried out, with his usual thoroughness, the new and onerous duties that devolved upon him. These entailed much tiresome railway travelling and heavy responsible work throughout the length and breadth of the Indian peninsula, and his health suffered in consequence.

Stockley closed his long and distinguished Indian career as Assistant Director of Military Works of the Central Provinces District, and finally retired on an Indian pension on October 30th, 1922, with the honorary rank of Brigadier-General, having been promoted Substantive Colonel as from October 30th, 1918.

Shortly after his retirement he took his wife and two daughters out to Switzerland, and there, most unhappily, developed empyema (the King's recent illness), from which he nearly died, his life only being saved by a severe operation at a Home. He returned to England in June, 1923, but the decline in his health has been steady and sure during the subsequent years ; while latterly the end was accelerated by very serious bronchial trouble which, notwithstanding his wonderful pluck and cheeriness, caused him much suffering from breathlessness. Finally, after three weeks' sharp attack of influenza, and despite the devoted nursing of his wife, the strain became too great, and his brave heart ceased to beat.

In his younger days Hugh Stockley was an ardent *shikari*, and spent such short leave as he could obtain in India shooting in the Himalayas. Although he nearly died from typhoid once at Roorkee, this did not deter him, when barely convalescent, from setting forth on one such expedition. This naturally entailed much hill-climbing and long strenuous days ; and to this occasion is probably due the trouble he often experienced with his internal organs during later years. Those who are interested in big game shooting in the Himalayas will greatly appreciate an article, entitled " Kashmiralgia," written in facile style by Stockley, and which appeared in *The Field* of May 24th, 1928, under the pseudonym of " Kagazi."

As a practical all-round engineer on field service, Stockley stood in quite the front rank ; and it is probable that he looked back with most justifiable pride to the construction of the Gairat bridge and fortified post, which he carried out with the 4th Company Bengal S. and M. The bridge had to be thrown across a precipitous rocky ravine, the difficulties being greatly accentuated by every bit of material having laboriously to be hauled up the steep cliff sides to the bridge site from the river-bed below. Before me as I write are photographs of this graceful, ingenious structure spanning a grim cleft in the mountains, clearly demonstrating the resource and skill of its designer and builder; for Stockley was a draughtsman of ability and imagination.

During his retirement, Stockley held the joint office of President and Chairman of the Stroud Valley Branch of the British Legion, and he was also Chairman of the Stroud Branch of the League. His death is thus much mourned by a body of men who universally respected him, and looked to him for guidance and advice. He was an active and influential member, too, of the mid-Gloucestershire Conservative and Unionist Association.

The above is but a bare outline of the many noteworthy services rendered to the State by an extremely competent and modest man, who studiously avoided the limelight and abhorred anything approaching self-advertisement. To fortify the opinions already expressed, however, the appreciation of some of his distinguished brother-officers may suitably bring this memoir to a close.

Lieut.-General Sir F. J. Aylmer, Bart., V.C., K.C.B. writes :—

> "I served with him for a long time in the 1st Sappers and Miners, and for several years he was my subaltern in the 4th Co. so I knew him intimately. He was a splendid officer in every way and his services to the State were always most distinguished. Had he got what he thoroughly deserved he would have received promotion to the highest rank."

Major-General S. H. Sheppard, C.B., C.M.G., D.S.O., also writes :—

> "'Stockles' and I served together in the Bengal S. and M. for a good many years. He was one of the best friends I ever had. We were on active service together in Waziristan in '94-95, and shot together in Baltistan. I always looked up to him as a thoroughly dependable pal in war or peace, and as a man of sterling character, with the most unflinching ideas of right and wrong. We all considered him the 'pick of the bunch' at Roorkee, and I am certain that—but for the handicap of indifferent health in later years—he would have risen to the top of the tree as a soldier."

Many letters from brother-officers, couched in somewhat similar strain, have been placed at my disposal, and all speak of Stockley's sterling qualities and fine character. Space only permits extracts from a few, though one from Major-General Sir Theodore Fraser, K.C.B., succinctly sums up the subject of this memoir in "He was a MAN indeed, and will be widely mourned among men."

It will serve to give an impression of Stockley's influence on the rising generation when Commandant at Wellington, however, to quote from one of his young pupils of those days as follows :—" As one of the cadets who was at Wellington during the first course in 1915, I always remember how very kind General Stockley was to all of us; and my six months under his command are among the pleasantest memories of my nineteen years in the army."

From other walks of life, too, numerous letters show how universally liked and respected was Stockley among his wide circle of friends. With this thought in their minds, and the assurance that their sorrow is shared by many, it is the sincere hope of all who knew him that this blow of the departure of a loved one may fall more gently on his bereaved wife and family.

Stockley leaves behind him a son and two daughters, one of whom is married; while the son, a subaltern in the Northumberland Fusiliers, seems likely to prove a "chip of the old block." When A.D.C. to General Sir A. Wauchope, the High Commissioner for Palestine, this young officer received rather an exceptional order, for one of his years, from the late King of the Belgians, who was staying at Government House in Jerusalem.

Stockley's last days on earth thus derived much pride and comfort from his son's promise. Here then it seems fitting to bid farewell to a very faithful friend and gallant gentleman, whose memory will long remain green.

H.H.A.

CORRESPONDENCE.

UNIFORMS OF THE CORPS OF ROYAL ENGINEERS.

To the Editor, *The R.E. Journal.*

Loders Court, Bridport.
12th December, 1934.

DEAR SIR,

May I point out an error in the plate of full-dress headdresses in Colonel Kealy's article in *The R.E. Journal* for December.

The cocked hat for the last 20 years or so before the war was not worn by all officers not serving with units, but only by field officers not so serving.

Yours truly,
E. P. LE BRETON, *Lieut.-Col.*

To the Editor, *The R.E. Journal.*

Randle House, Corbridge,
Northumberland.
5th December, 1934.

DEAR SIR,

In the article " Uniforms of the Corps of R.E. up to 1914," in the December issue of *The R.E. Journal*, there is an illustration of " Busby, 1870–1878, with Troops." The inference is that this is a picture of an officer's headdress.

The actual picture seems to me to show the headdress worn by the *men*. I can remember it well and saw it being worn in 1875–77. The officers' hat which was worn by my father, then a subaltern in what is now the T.B., was bigger, more hairy and had *gold* lace ornaments. The plume was longer than the one shown and was not like a shaving brush.

I must apologize for troubling you, but if I am right in my opinion the record should be amended.

Yours faithfully,
G. WALKER,
Maj.-Gen. (*Ret.*).

[General Walker is quite correct. A description of the officer's busby of the period was given on page 511 of the December *R.E. Journal*, and does not correspond with the plate, which was taken in 1929 from an N.C.O.'s busby in the R.E. Museum.—ED., *R.E.J.*]

A BATTLEFIELDS TOUR.

To the Editor, *The R.E. Journal.*

Army Headquarters, India,
Engineer-in-Chief's Branch.
27th March, 1935.

DEAR SIR,

Major Worsfold's interesting account of "A Battlefields Tour" in the March *R.E. Journal* is open to some criticism. Of the crossing of the Aisne, he says that "none of the divisions seems to have thought of sending R.E. reconnaissances ahead. . . ." This is certainly not true of the 1st Division. Early on the morning of the 13th September specific (verbal) orders for an Engineer reconnaissance of the river were issued. The writer and Lieutenant (now Lieut.-Colonel) Stafford, 23rd (Field) Company, got into touch with the advanced Cavalry Brigade H.Q. and ultimately reached the river with the leading cavalry patrols.

In the same paragraph it is suggested that the bridging train should have been sub-allotted to divisions according to probable requirements. This would not have been welcomed by divisions at the time, and the bridge train vehicles would have probably been left by the wayside; it was difficult enough to get forward the divisional vehicles. It must be remembered that, at that time, each field company carried two pontoons and two trestles, and a division, from its own resources, could just bridge the Aisne. I always thought, and still think, that the bridging train came up at exactly the right moment, and that to have sub-allotted it earlier would have been a grave error of judgment.

The note on "the fight for the Chemin des Dames" suggests that G.H.Q. orders may not have been fully appreciated. For the 12th, 13th and 14th they were simply to continue the present entrenching, as a preliminary to a further advance which was not ordered till the 15th. It is not quite fair to say that the Coldstreams and Queens failed to get back information; 1st Bde. H.Q. certainly knew the position pretty accurately; and it was not information but reserves that were lacking. The official history summing up is:—"With a few fresh battalions to put life into the fight, the results might have been widely different." I suppose it is practically impossible for anyone who was not an actual participant to visualize now the conditions of open warfare that came to an end on the 14th September, 1914.

Yours faithfully,

G. H. ADDISON, *Maj.-Gen.*

ON ELEPHANTS.

To the Editor, *The R.E. Journal.*

DEAR SIR,

The following story, which was told by an American at an international gathering in Warsaw last summer, seems to sum up national characteristics, as envisaged by others, so admirably that you may perhaps consider it worthy of publication.

There was once a newspaper editor who, at the end of some correspondence in his journal on the subject of elephants, decided to sum up the matter in a short " leader." He thereupon instructed his four " rewrite " men to produce about a column on this subject, adding that he would select the most satisfactory.

The men concerned were an Englishman, a German, a Frenchman and a Pole.

In due course the Englishman submitted an article entitled, " A Practical Method of Shooting Elephants " ; the German produced " A Hypothesis of Elephant Development from Pre-Mammalian Times to the Present Day " ; the Frenchman called his product " L'Eléphant et ses amours " ; the Pole, however, produced four columns on the " Elephant and the Polish Question."

I am, Sir,

Yours, etc.,

J. C. T. WILLIS, *Capt.*, *R.E.*

IRRIGATION PROBLEMS OF EGYPT.

To the Editor, *The R.E. Journal.*

11, Hornton Street, London, W.8.
20th February, 1935.

DEAR SIR,

I have recently seen *The R.E. Journal* of December, 1934, and having served in the Egyptian Irrigation Department in the Sudan until recently, found much interest in the article by Captain Noakes, R.E.

Captain Noakes has given an excellent outline of the vast subject of his article, but, if I may be allowed the privilege as a one-time R.E. officer, I should like to amplify a few of his remarks in order to remove certain ambiguities arising from his necessary brevity.

(1) He states that the Nile " enters Egypt at Aswan." The Egyptian boundary is near Wady Halfa, about 200 miles South of Aswan, but excepting very small patches the cultivated area of Egypt begins at Aswan.

(2) Regarding the Aswan Dam (position up to 1921), Captain Noakes states that the reservoir "was filled in March and then gradually emptied. . . ." It may be said that the reservoir was "full" in March: the process of filling began in November and ended in January, and drawing upon the reservoir began (and begins) in March or April.

It is interesting to note, in connection with Captain Noakes' remark (on page 531) referring to the inadequacy of supply in a year like 1913, that, despite previous objection to storage of silt-laden water, it is now proposed to begin the filling of the enlarged reservoir at a time of year when the water will usually contain a considerable amount of silt. It is considered that any possible deposit of silt will have no appreciable effect on reservoir capacity for, say, 1,000 years, and it seems scarcely practical to carry to this length of time the principle of "building for posterity."

The enlarged reservoir was brought into use in 1933/34 but was not filled to maximum capacity.

(3) In Section (5), Captain Noakes states that the principal feeder of Lake Albert is the Semliki River. This river actually contributes far less than the Victoria Nile which, joining Lake Albert, just south of the Lake "outfall" to the Bahr el Gebel, contributes an estimated average annual discharge of 20 milliards of cubic metres from Lake Victoria.

(4) In Section (6) the reader is left with the impression that the huge loss in the Sudd swamps occurs in the Bahr el Ghazal system.

It is true that a very large (unknown) proportion of the water flowing from the Nile-Congo watershed *via* the Bahr el Ghazal is lost in the swamps formed by that river. But it is the 14 milliards annual loss in the swamps of the Bahr el *Gebel* (from the 27½ milliards average passing Mongalla) which it is hoped to avoid by the combined project of the Lake Albert Reservoir and the Sudd Channel.

The air survey recently completed was undertaken to assist the investigation of one of the many possible lines for the Sudd Channel, and much more air survey will probably be carried out. One most important result of complete survey of the difficult Sudd region (most rapidly done from the air) will be a definite knowledge of the area of swamp.

(5) The last paragraph of Section (6) presumably refers to the projects mentioned under the heading "Distribution," on page 533.

Yours faithfully,
ROBERT F. WILEMAN.

All Reviews of Books on military subjects are included in the provisions of K.R. 522c.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

HISTORY OF THE GREAT WAR.

MILITARY OPERATIONS, FRANCE AND BELGIUM, 1918. THE GERMAN MARCH OFFENSIVE AND ITS PRELIMINARIES.

Compiled by BRIGADIER-GENERAL SIR JAMES E. EDMONDS, C.B., C.M.G., R.E. (retired), *p.s.c.* Maps and Sketches compiled by MAJOR A. F. BECKE, R.A. (retired), Hon. M.A. (Oxon).

(Macmillan and Co., Ltd., London, 1935. Price: Text 12s. 6d., Maps 5s. 6d., vol. of Appendices, 6s. 6d.)

(Continued from March, 1935, issue of The R.E. Journal.)

"*East*" *v.* "*West*" *in Germany.*—Despite the initial failure to break the Allied Front in the West in October and November, 1914, there never was any question in the minds of the German General Staff of a decision being possible elsewhere than on the Western Front. There was perhaps a moment towards the end of August, 1916, when Hindenburg made his first visit to the Western Front and found it shaken by the effect of the failure at Verdun and the hammering of the British offensive on the Somme, that he might have entertained the idea that it would be easier to achieve a final victory in the East. Whether Ludendorff discouraged the idea, or not, it was dropped, and the Westerners had to wait until sufficient troops could be released from the Eastern theatre. Meanwhile the problem—where best to strike in the West—continuously occupied the minds of the General Staff in 1915, 1916 and 1917.

In a campaign on interior lines the German General Staff had, compared with the Allies, a simple task, but it is to their credit that only necessary detachments were made to subsidiary theatres: they were limited to an absolute minimum in numbers: and they justified themselves by drawing far superior numbers from the Allied Armies.

General Edmonds summarizes the various schemes put forward by the Commanders of the Western Armies in anticipation of another offensive, and traces the origin and development of the plan eventually adopted in 1918. It was early recognized that AMIENS was the objective offering the best prospect of success, for a thrust in that direction might separate the French and British Armies.

So long, however, as the Hindenburg-Ludendorff combination continued to be victorious in the East, it was accepted that the necessary forces would not be available for another offensive in the West, although it was obvious that every postponement meant that larger numbers would be required to ensure success in that theatre. Even new formations were directed to the Eastern frontier, and von Falkenhayn is reported to have exclaimed: "The East gives nothing back." The Westerners had to wait.

In 1916, the Germans were forced to launch a limited offensive—with limited means—to forestall an Allied offensive in the West. Verdun was selected as the objective. But at Verdun the Germans could not hope for a break-through; for that implied a surprise attack on a wide front, supported by an immense force of artillery and backed up by large reserves to exploit an initial success.

Verdun was not captured. The Franco-British offensive on the Somme had relieved the pressure on the fortress, and the Germans found themselves thrown back on the defensive in both theatres. They discovered that fighting a defensive battle entailed heavier losses than they had suffered during their advance on Verdun. It is to Sir Douglas Haig's everlasting credit that he was a steadfast believer in the offensive, and that despite the heavy British losses on the Somme he never weakened in his conviction that the war could be won only by taking the offensive at the earliest possible moment. Victory by attrition was, with him, not an object: it was a consequence of offensive fighting.

General Edmonds shows how fundamentally erroneous were the ideas of the Prime Minister on the conduct of war. The appearance of this volume of the *History of the War* shortly after Mr. Lloyd George had made public his views on the leadership of the late Sir Douglas Haig was most opportune, and detracted greatly from the effect of his utterances on the minds of his listeners.

It was not till October, 1917, on the eve of the Caporetto offensive, that the German General Staff felt justified to put forward proposals for a great offensive in the West in 1918. The rapid weakening of Russia had made it possible: the disaster of Caporetto made it practicable: but it was not till January 21st, 1918, that Ludendorff, now in command, as First Quartermaster General, in the West, gave his formal approval to the plan, when it was certain that fighting in the East had ceased. He had, in the intervening three months, allowed the preparations to proceed and the transfer of troops from East to West to go on at the maximum capacity of the railways. He knew, and the Allies knew, that the longer the attack could be postponed the greater would be the forces, especially artillery, available for the offensive. The Allies expected the attack to come before the end of February; they feared it might be postponed until May.

Ludendorff had to weigh various factors: he knew that the British were extending their front southwards, and that every day meant that the new front would be strengthened. He knew that an attack in the early spring in the north might be adversely affected by weather: he knew of the arrival of American troops in France; he knew the capabilities of the German railways bringing troops from the East. Much as he might have wished to wait till the German numbers reached their maximum in May, he could not afford to wait—because the Allies might anticipate his attack: but he could rely on his reinforcements continuing to arrive in a steady stream if he launched his offensive earlier. On March 10th, he issued the final order fixing the date and zero hour.

It was with a feeling of infinite relief that the British Higher Command heard the bombardment open on March 21st; the tension had been tremendous. They realized that the weight of the extra troops and guns which might have been available for the enemy had the attack been postponed would have far exceeded the value of the work that could have been done on the defences, and of the additional, but untrained, American troops which could have reached France during the period.

When studying General Edmonds' account of the discussions that went on in the German General Staff over the plans for the attack, the reader should turn to Appendices 19 and 20 in the separate volume of Appendices.

Appendix No. 19 gives the gist of the Report of the Parliamentary Commission appointed after the war to inquire into the responsibility for the decision to launch the attack in March, 1918, and for the subsequent collapse. The conclusions of the Commission were to the effect that Ludendorff was not justified in staking the fate of the Empire on a knock-out blow for which he had not the forces to ensure the success of the initial attack, *and* to exploit that success. He should, in their opinion, have contented himself with a limited success, to obtain which he had sufficient means, and then—in view of the effect of that success on the Allies—it would have been possible to negotiate " a peace of understanding." In this connection the reader is referred to *Hindenburg*, by Emil Ludwig (translated), in which Ludendorff's behaviour, when giving evidence before the Commission, affords interesting reading and a sidelight into his character.

It must be remembered that Ludendorff had his own ideas about peace, and was determined that there should be no peace until Belgium was secured to Germany—as a base for the next phase in the series of wars for world-domination by the Germans. There is little doubt that he was convinced that he would be able to smash the British, but he was out of touch with the German people and did not realize that they had lost the will to conquer. The extension of the British front had made the task allotted to the German Eighteenth Army far easier. General Edmonds quotes from a letter written on the 18th January, 1918, by the Chief of Staff of that Army to Lieut.-Colonel von Wetzell, in which that point is mentioned, and which continued :—

" The offensive is principally intended to smash the British. . . . It need not be " anticipated that the French will run themselves off their legs and hurry at once " to the help of their Entente comrades. They will wait to see if their own front is " not attacked and decide to support their Ally only when the situation has been " quite cleared up. That will not be immediately, as demonstrations (Sir J. Edmonds interpolates the words " only too successful ") will be made by the " German Crown Prince's Group."

The writer, General von Sauberzweig, had studied the character of his opponent ! General Edmonds describes the steps taken to deceive the French, and makes several references to the attitude of General Pétain throughout this period, and his refusal to support the Fifth Army—until he was forced to do so—during the opening days of the German offensive.

Appendix No. 20 is perhaps one of the most interesting portions of this part of the Official History. It contains the appreciation by Lieut.-Colonel von Wetzell, who was then sub-chief of the General Staff, on the situation on December 12th, 1917. It is summarized by General Edmonds on pp. 141 and 142 of his volume, and he concludes his remarks on it in the following words :

" Fortunately for us Lieut.-Colonel Wetzell's proposals were not accepted (by " Ludendorff), although, in the end, after the first offensive had come to a standstill, " Ludendorff, having them in mind, did order the second attack (in the north)—too " late."

Strength of the British Front.—It may be asked why, when there was such ample evidence of the impending German offensive and its probable objective, more was not done to strengthen the threatened front.

To this, there can be only one answer. There were not sufficient British troops in France to hold the extended front and simultaneously to work on the necessary defences in depth everywhere. In view of the vital necessity to prevent a break-through aimed at securing the Channel ports, Sir Douglas Haig had to take risks farther south. His plans were so designed that he might be ready to meet a great offensive in Flanders at short notice, being prepared at the same time to deal with an attack against the Fifth and Third Armies between the Oise and the Scarpe, until reinforcements (French as well as British) could reach them. He gave the Fifth Army every man and gun he could spare.

On the eve of the offensive the Fifth Army held a front of 42 miles from Barisis to Gouzeaucourt. For the defence of this long line General Gough had 12 divisions, 3 cavalry divisions (each counting as a brigade dismounted), and 1,566 (515 heavy) guns and howitzers. Nearly 10 miles of the front were covered by the River Oise, and it was unlikely that an attack would be made across the 4 miles on the extreme right, south of the Oise. For the sake of comparison it is interesting to know that on the Second Army front (Armentières to the right of the Belgians) there were the same number—twelve—infantry divisions on a front of 23 miles, which could be reduced to 20 miles by abandoning the forward part of the Ypres salient and falling back on the Polygon Wood—St. Julien line, thus saving two divisions. On its right the First Army with 1,450 guns and howitzers had 14 divisions on a front of 33 miles, and the Third Army had 14 divisions with 1,120 (461 heavy) guns and howitzers on a front of 28 miles.

The disquieting feature was the small number of troops in reserve. Including the G.H.Q. reserve of eight divisions the reserves worked out at one division to 18,000 yards on the Fifth Army front; one to 8,100 yards on the Third Army front; one to 14,500 yards on that of the First Army, and one to 8,200 yards on the Second Army front. General Edmonds considers that the distribution was sound, based on the strategic importance of the sectors, but it took no account of the relative strength of their defences.

Man-Power.—On pp. 50 and 51 General Edmonds examines the question of the man-power available, and the numbers which might have been sent to France. His remarks are important:—

1. The Cabinet Committee on man-power did not include a single soldier.
2. At the most critical moment, the War Cabinet came to two decisions which jeopardised the security of the Western Front. The first was to refuse the reinforcements demanded by Sir Douglas Haig, thus leaving the British Armies in France weaker than they had been a year before (1,097,906 men as against 1,168,466 in January, 1917). During the autumn of 1917 Sir Douglas Haig had constantly urged that all available troops should be sent to France, there to be trained for immediate incorporation in the units in that theatre.

   The second was to order the reorganization of the divisions in France on a reduced establishment, and with only three battalions instead of four to an infantry brigade.

The Prime Minister gave as his reason for supporting the refusal to send the men to be trained in France that if more men were sent to France they would be used up in indecisive operations.

This provoked a strong protest from the Army Council, who pointed out that the enemy would certainly force the fighting in 1918, and that the War Cabinet's assumption that fewer losses would be incurred by adopting a defensive attitude was contrary to experience.

As regards the reduction of establishments, General Edmonds considers that "it was not so much the nature of the change—which would increase the proportion of guns per 1,000 infantry, which was eminently desirable—but the time selected for it which was open to criticism. That the hurried reorganization had an adverse effect on the fighting efficiency of units is beyond question." The Dominions adhered to the original organization, but they were able to make up the additional numbers required—by breaking up their reserve formations in England.

General Edmonds concludes with the following statement:—"It is obvious that the British Armies in France could have been brought up to full establishment before 21st March, 1918, without unduly weakening the forces elsewhere had the Government so willed." It is as well that the responsibility should be fixed, although the disastrous consequences of the Government's refusal to reinforce the B.E.F. *before* the March offensive are brought out clearly enough in the narrative of the fighting on March 21st—26th, and would convince most readers of the danger of allowing politicians to intervene in what was the responsibility of the man on the spot, the G.O.C. B.E.F. in France.

The Narrative.—General Edmonds and his assistants must have had a very difficult task in compiling the narrative of the fighting in March, 1918, especially on the front of the Fifth Army. In a general retreat under the conditions that existed, war diaries were meagre—if they existed at all. He has, however, been able to arrive at the main facts, thanks to information obtained from survivors and from the statements of prisoners who were overwhelmed and captured in the German onslaught. Possibly more detailed information may be available when the German official account is written, but General Edmonds has already had access to most of the German sources of information. The instructional value of the narrative to regimental officers would be greatly enhanced if more details could be found and embodied in it.

General Edmonds divides the fighting from March 21st to March 26th in two portions—that on the Fifth Army front and that on the Third Army front. At the end of Chapter X he gives a summary of his remarks on the fighting on the 21st March, and it is understood that in the next volume to be published he will give us his criticisms on the whole battle.

In his remarks, he emphasizes the fact that loss of ground in the north meant that the B.E.F. would be driven back on the coast, while the Fifth Army could afford to give up a good deal of ground without, perhaps, excessive danger. He has a good deal to say about the fog which existed, especially on the right of the Fifth Army, not only on the morning of the 21st March, but on the later days of the battle. In his book *The Fifth Army*, General Gough expressed the opinion that, on the whole, the fog on the morning of the 21st March was not as unfavourable to the defence as was generally believed. General Edmonds gives his views on pp. 256 and 257. He considers that the fog favoured the bold " infiltration " tactics in which the troops had received special training, and enabled parties of the enemy, working independently, to pass through the intervals in the forward defences and to reach the battle zone much more quickly than they would otherwise have done. The fog, the destruction of communications by the bombardment, and the unexpectedly early appearance of the Germans before the battle zone prevented the British artillery from playing its full part. The deadly rapidity of the enemy's advance was assisted by the practically undamaged surface of the ground, quite unlike the laboured progress of our troops over the cratered surfaces and clinging chalk of the Somme, or the liquid mud of the later stages of Paschendaele. The effect of the fog on air observation rendered co-operation between the R.A.F. and the artillery in most cases impossible. Over the Fifth army area south of the Flesquières Salient air observers could see nothing except in isolated spots until after noon on the 21st March. On the ground the fog was so dense that columns of troops were invisible in the earliest hours of the morning at a distance of 10 or 12 yards; whereas, on the IV Corps front, Third Army air observers were able at 6.30 a.m. to see and report much of what was happening.

General Edmonds has some interesting remarks to make on the shortcomings of the system of defence adopted by the Fifth Army. He considers that the distribution of troops in small packets—the " blob " system of defence as it was termed before the war—is a doubtful expedient in the absence of strong reserves to counter-attack the enemy if he penetrates the intervals. The majority of experienced fighters, he writes, would have under such conditions preferred a definite line of resistance in each zone, with posts, machine-gun nests, and switches, arranged in depth behind it to limit any enemy entry into the line.

" The British soldier has times without number defended isolated posts to the " death: he did so on March 21st, 1918, and was to do so repeatedly during the next " week. For its numbers, the III Corps, which was disposed in line in the battle " zone, rather than in depth like the XVIII Corps next to it, may be held to have " done remarkably well. There is general testimony that all the German frontal

"attacks failed; it was by finding a way round that the enemy succeeded. . . .
"To British troops, whose instinct is to fight it out where they stand, there came no "thought of 'elastic yielding' . . . . Some even of the best of the new officers did not "realize that they must use discretion as being 'the men on the spot,' and that "orders to hold on may in extreme circumstances be disregarded.

"There were too many inexperienced young officers and too many untrained "young soldiers to ensure a reliable garrison for every post, even without the special "trial to which the fog subjected them.

"No warning seems to have been given to any brigade or battalion commanders "that in certain circumstances there ought to be an ordered retreat; divisional "routes had been reconnoitred for this, but information of such nature was certainly "withheld from regimental officers.

"So the garrisons of the posts fought to the end, taking heavy toll of the enemy, "slowing but not stopping his progress.

"The fog prevented mutual support by fire, and this was the main cause of our "failure to hold up the attack."

On page 259 there is printed a Summary of Information published in May, 1918, from statements obtained from about 70 British officers, mainly from the 16th Division, captured during the first days of the German offensive: the final paragraph reads: "The attack was not a surprise. Units had been warned that there could "be no retreat." General Edmonds concludes his remarks by saying: "The fog "was the German luck and, whatever dispositions had been made, the British would "have had to give ground in face of an attack delivered in such heavy numbers "under such conditions."

Space does not permit of discussing many other interesting points, but attention must be directed to General Edmonds' conclusions on one of the most important. That the Flesquières salient was hung on to too long by the Third Army is now obvious. "In accordance with instructions issued by Sir Douglas Haig after an "inspection in December, and repeated on the 10th March, the salient was only to be "held as a false front, in sufficient strength to check raids: the troops occupying it, "if seriously attacked, were to fall back on the battle zone, the front of which was "sited approximately along the base." The order of 10th March is given at the end of Appendix No. 6 and is explicit. The salient was not heavily attacked on 21st March, the German plan being to push in on both sides of it and pinch it out. It may be that General Byng was encouraged to defer evacuation by a too optimistic report of the situation on the Fifth Army front which he received late in the evening of 21st March; and it can be understood that the troops of the Third Army would be very loath to give up an inch of the ground they had won so hardly in the Cambrai offensive in November, 1917.

It is curious that the same problem should have had to be faced in two sectors of the same Army front. The Monchy-le-Preux salient had unequalled facilities for observation in *all* directions, and for this reason Sir Charles Ferguson was most anxious to retain it. It was held by one (the 15th) of the two Divisions (37th and 15th) which had captured it on April 11th, 1917. He was over-ridden, however, by Third Army, which ordered its evacuation late on the evening of March 22nd. General Edmonds is inclined to think that in the circumstances evacuation was hardly justified:—"The enemy was presented with a perfect position from which to pursue "the further operations against Arras, which, as we now know, was to be the next "move." He adds, in a footnote: "There was observation from it not only over "the German lines in the vicinity, but as far as Cambrai no enemy gun for miles "round could be fired without the position being spotted from the two observation "posts in the ruins of the village using giant periscopes." Once in German hands the enemy could see for 20 miles to the west, north and south.

Monchy-le-Preux would appear to have been sacrificed because the Flesquières

Salient was retained. The relative value of the two salients could not be compared. Monchy-le-Preux was evacuated because there was only a weak cyclist battalion left to form a defensive flank to the south. Again the same story—no reserves.

Finally, there is the story of the Péronne bridgehead, the retention of which was of such paramount importance. There were no reserves to counter-attack the enemy, who penetrating farther south and turning northwards had pushed between the river and the exposed right flank of the XIX Corps. The story of the XIX Corps, commanded by that fine fighting soldier, the late Lieut.-General Sir Herbert Watts, is an epic in itself. With its front unbroken it had put up a magnificent defence, covering Péronne, but now found itself in the air.

Sir James Edmonds must be warmly congratulated on producing this account of the greatest battle of modern times. It is fitting that his outstanding work on the Official History should have been recognized by the bestowal on him of the Degree of D.Litt. *honoris causâ* by Oxford University.

It remains only to mention that the maps produced by Major A. F. Becke are up to the same high standard to which we are now accustomed, and that the Index is infallible. This volume must be read. No review can do it justice.

H.B.B-W.

HISTORY OF THE GREAT WAR.

Order of Battle of Divisions.

Part I. The Regular British Divisions.

Compiled by Major A. F. Becke, by direction of the Historical Section of the Committee of Imperial Defence.

(H.M. Stationery Office. Price 7s. 6d., postage extra.)

This is the first of a series of Orders of Battle, which will be continued by Part II—Territorial Force Divisions, Part III—New Army Divisions, and Part IV—Dominion and Indian Divisions. The present issue deals with the three cavalry and with twelve infantry divisions (Guards, 1st–8th, 27th, 28th and 29th).

The section devoted to each division contains :—

1. Nominal rolls, with dates, of the G.O.C's, the principal staff officers and brigade commanders.

2. General notes, mostly indicating units which served only short periods with the division.

3. A tabular Order of Battle, showing the units of each arm, composing the division at its mobilization or formation and each subsequent year ; with notes as to all changes.

4. A short statement of the mobilization or formation of the division, the actions in which it took part (showing Corps and Army at the time), its position at the Armistice and its history during the post-Armistice period.

Finally, there is a tabular summary of the changes in composition of a British division on the Western Front during the War.

The value of this series to the student of the Great War is obvious. It need only be added that it is impossible to see how the book could have been made more clear and concise.

E.V.B.

THE WAR OFFICE.

By Hampden Gordon.

(Putnam. The Whitehall Series. Price 7s. 6d.)

This is the first volume of the Whitehall Series to deal with a defence ministry. The author by his experience is well qualified to deal adequately with the subject, having served in the department for 26 years, during which time he has held the appointment of Private Secretary to the heads of the Civil Service in the War Office, Sir Edward Ward, and Sir Reginald Brade, for two years before and for two years after the declaration of war in 1914. As a man of letters he is also distinguished, having been a scholar of Haileybury and of Hertford College, Oxford, a "double first," editor of the *Isis*, and the author of several volumes of verse and fairy tales.

It is possible that it will be under this last category that readers who have not had the fortune—or misfortune—to serve in the "Temple of Tragedy and Comedy," as a distinguished R.E. officer once called the War Office, will approach the book. If so, in the wealth of fantastic figures they will not be disappointed. They will also quickly realize that for complexity of occupation the War Office would rival the labyrinth of Minos.

Mr. Gordon deals in five chapters of 94 pages, in a marvellously condensed form, with the history of the Central Control of the Army from earliest days to the opening of the Great War.

In the next chapters the composition and duties of each department of the War Office are described in considerable detail; too great detail for the man in the street, or the soldier of the Army "which cleans its buttons," but interesting to those with some knowledge of the intricacies of branches and who wonder sometimes what all the other people do with themselves from 10 a.m. to—well, some time between 5 p.m. and midnight.

The last chapters bring us up to date through the enormous inflation of the war, back to the cheese-paring days of peace.

What will interest most readers is the relationship between soldiers and civil servants, and between military command and civil control. Soldiers may with some reason curb at the description of the War Office as "the department of the Civil "Government which administers—the British Army." While it is true the Government of the country is civil, and therefore any office which carries out its policy is a department of the Civil Government, the wording of the above phrase is open to misconception if it were not amplified by the author elsewhere, and more particularly by the Secretary of State, Lord Hailsham, in a most interesting introduction. The latter opens with a story of Sir Henry Wilson's explanation to Marshal Foch of the policeman riding at the head of the Victory procession: "There you have the British "Constitution in a nutshell—the subordination of the military power to civil "authority."

While soldiers may be restive at civilian control, and sometimes complain of the difficulties put in their way by civil branches, Lord Hailsham claims with justice that "nowhere will you find better team work and closer co-operation," and points out that the mixture of peripatetic soldiery with sedentary civil servants results in "an "alertness and keenness and freshness of outlook which make the War Office a very "live department."

The author has condensed a great mass of information into a small space. Too much for a fireside book, and too little for a book of reference. A good deal of the external history of the Army as apart from the controlling office might with advantage have been omitted: it is better placed in a history of the army. In achieving condensation the book is sometimes misleading, more particularly in confusing the duties of the staff in the field with those carried out by the Central Control. Certain small errors have crept in—for example, the Director of Military Training is not charged with the production of training manuals (page 107). No post-mobilization training is counted on for S.R. (page 122). They either do military training in peace, or are noted for such employment in war that their civil occupations fit them for immediate employment.

The social life of the W.O., its games clubs, luncheon club, dramatic society, horticultural society, etc., are discussed in a sentence if referred to at all. All work and no play makes a book, like Jack, a dull boy.

This book is to be recommended to those who have received, or are serving, a sentence of so many years' hard, or a life sentence, within the "temple" walls, so that they may understand how it all happened and happens; to those outside who scoff—so that they may realize that it is not so easy as it looks; and to budding Secretaries of State—so that they may understand quickly the machine they are to direct, that they may be enabled to oil the machinery, and rebuild efficiently where necessary.

R.P.P-W.

THE ARMY IN MY TIME.

By Major-General J. F. C. Fuller.

(Rich & Cowan, Ltd. Price 6s. net.)

This is one of a series of similar publications. The author divides it into "Yesterday," "The Boer War," "The World War," and "To-morrow," and to most readers, the last two parts will be the most interesting. It is an irritating book. General Fuller, as usual, has many interesting things to say, but also, as usual, says them with such bias and cynicism as completely to spoil his case. The existing army he considers to be "the military instrument of a bankrupt age. . . . It belongs to "the civilization of the plough and not of the field tractor, of the cab and not of the "motor-car." He wants to see a highly-trained *gendarmerie* for policing purposes, a completely mechanized tank-striking-force as the expeditionary force, and a separate army in India, organized as a "Mechanized force of armoured fighting vehicles and "aircraft, and a mountain-warfare force of Sikhs, Gurkhas and men of other martial "races." His mechanized expeditionary force is to be organized as "pack-up-able "and pack-down-able mobile fortresses," from which can emerge the striking-tank force.

These reorganizations sound delightful and he waxes lyrical over them, but all existing difficulties of possible and probable campaigns in different parts of the world are completely ignored. There is much that is tactically sound, and much that is actually being gradually put into being to-day, but reorganization has to bear some relation to actual national commitments.

General Fuller ends with two chapters on the soldier and on command. He writes as the complete authority on the modern soldier and officer, but what really stands out is the obvious fact that he is singularly out of touch with the modern soldier and young officer.

As indicated, General Fuller may irritate, but at the same time he does stimulate thought, and for this reason this book is to be recommended to all military readers.

SECURITY? A STUDY OF OUR MILITARY POSITION.

By Major-General H. Rowan-Robinson, C.B., C.M.G., D.S.O.

(Methuen. Price 5s.)

This short study of our military situation to-day is published at a timely moment. After many years of futile discussion and striving after vain hopes, we are becoming more aware of the hard facts which history should have taught us long ago to recognize. Germany's recent disclosure of her intention to see to her own security and lay her own plans for the future must surely do something towards clearing the atmosphere, and there ought to be a great many readers ready to welcome Major-General Rowan-Robinson's contribution to the most important subject of to-day, if only for the freshness of his views.

The author does not believe in the theory that the next war will be anything like the last; and he strenuously advocates emergence from the grooves. He wants the maintenance of the League of Nations, but he deplores the wasting of its time in endless wrangling over schemes of material disarmament. He recognizes the difficulties confronting other nations, and has patience with them, but he urges that we should lose no time in strengthening our defences so that in any collective action we may be able to play our part.

The situation has indeed changed to a great degree in the last few months; and our past willingness to disarm ourselves almost to the skin is likely to invite war rather than avoid it. A powerful Britain—linked to a powerful America—is more likely to preserve peace than all the pacts drawn up by statesmen whose signatures nobody seems willing to accept, for if signatures counted, the Kellogg Pact alone would have abolished war. If a nation with thoughts of aggression is confronted with the absolute certainty of the retaliation, within 48 hours of the committal of the first act of aggression, by an overwhelming Air Force contributed by all the other powers who are ready to back their signatures, without waiting for a committee-burdened League to call upon them—then there is more hope of avoiding war than is likely to result from the cumbrous methods of to-day. Such a policy would not involve intolerable burdens—indeed, Major-General Robinson considers that we could obtain a much more powerful Air Force by cutting out battleships, reducing land forces, abolishing heavy guns and heavy tanks, and amalgamating the three Services under one Ministry of Defence. But it would still involve agreement as to collective action.

Whatever may be our opinions on these problems, there will be few who disagree with the author that our first line of defence is now the Air Force. The chief point of his book is that we should re-cast " the quantitative relations of the Air Force and the Army," and leave the Navy at its present strength (but also re-cast).

Although a Gunner, he is ready to abolish the horse-drawn gun, the dragon-drawn gun and the pack artillery. He prefers the gun-carrying tank. He sees the role of infantry in continental warfare restricted to defence.

He is bold enough to attack the naval problems, but his arguments are temperate. His proposal that we should give up our preponderance in the Mediterranean, and develop naval bases on the Cape route to India is likely to meet with staunch opposition, but we have a good school in which to thrash out such questions.

Throughout his book he does not rail against the Government—either the present one or any other. His purpose is to call attention to the vital problems of National Security and to direct public thought into new channels. He does not believe that we have security; or that we are heading for it. But he does not propose action which calls for any upheavals, or for any vast expenditure which the country will never tolerate. There is nothing of the arming of the nation about his schemes. But he warns us that we must lose no time in meeting our responsibilities.

The chapter on the Ministry of Defence takes in turn each of the well-worn objections that have so often been advanced against amalgamation, and discusses them briefly. Many of these objections are weakening with the course of time. But there seems to be no insuperable objection to the time-honoured British way of compromise; and the amalgamation of many of the departments common to the three Services should be within practical politics. General Rowan-Robinson is, however, more concerned for the need of combination in the Higher Direction. With us, war is now a matter of defence, and he holds that a Ministry of Defence is the best agency for the purpose. It has, at any rate, a better name in these pacifist days than a Ministry for War.

In the tables given in the Appendix outlining the distribution of duties in the proposed Ministry, the Minister of Defence is shown controlling military branches only; the Navy and the Air Force vanish after Table I. But the author combats the notion that the Chief of the new Staff would be overwhelmed with daily detail. Unlike the old-time Commander-in-Chief, he would deal mainly with war-plans which had been worked out by others. There is without doubt need for revision in our present system with its triplication of effort.

War to-day is so much a factor affecting the lives of every individual in the nation that security is more vital to us than social reform, for without security there can be no lasting improvement in the conditions of life. The author urges the Government to explain the situation now to the electorate: to take the people into its confidence. " It might be made clear that, with our great wealth and relatively high standard of living, we are the envy of other nations, and that, therefore, crying for peace will not bring peace but a sword, just as the bleat of the sheep attracts the wolf."

This book, in fact, urges security now, while there is time. It is not militarism that the author preaches. The greater confidence that would result from our national security would do more to restore prosperity and abolish unemployment than all the conferences, committees, pacts and other devices whose constant failures only aggravate the feeling of insecurity. Those methods have been tried and found wanting; let us now try a more logical method; it will be far cheaper than war.

Such are doubtless the thoughts of most soldiers, sailors and airmen; but it is not to be assumed from this book that nothing is being done in these directions by those in authority to-day; on the contrary, there are many signs that the Government is fully alive to the situation, and would indeed move faster if the public were better educated in the matter of National Defence. So they will be, if they read such books as this one.

W.H.K.

"HARK BACK."

By Colonel Wilfred Jelf.

(Murray, price 5s.)

The author of this little book was a distinguished soldier. In a preface written by three of his friends in widely different walks of life, his history, the strength of his character, his courage, enthusiasm and loyalty are well portrayed. Born in 1880, the son of a distinguished Sapper, Wilfred Jelf was educated at Eton and the Shop and became a gunner, his reasons for doing so being set out in his final chapter. He fought in South Africa and in the Great War with distinction and became Assistant Commandant at the Shop and Chief Instructor at Weedon.

He was in the War Office in 1928 where the insidious disease, which eventually proved fatal, began to make itself shown. He bore his sufferings with the courage one would expect from so gallant and chivalrous a man. It was during the final stages of his illness that he wrote this book. No one could come into contact with him without feeling the better for it. His personality, enthusiasm and cheerfulness were infectious. In addition he was a man of real ability.

The charm of his stories to my mind lies in their intensely human touch. His powers of observation and description were remarkable. What student of Wellington's campaigns would be content with bare history of fact and date? It is the human element he wants to capture; what a soldier thought and suffered, how he lived and died. This he obtains from such books as *The Subaltern*, *The Diary of Rifleman Harris* and Mercer's *Story of " G " Battery at Waterloo*—and this is precisely what Jelf supplies.

From his South African sketches it is easy to recapture or imagine the great open veldt, the almost limitless area terminating to the North in the scrub round Pietersberg. They show the rough-and-ready discipline of the Irregular Mounted Troops and the extreme difficulty of dealing successfully with that expert Mounted Infantryman, the slim and elusive Boer.

Poignant scenes of the Retreat in 1914 are vividly told and show only too clearly the fearful strain it imposed on our men, a retreat which would have proved fatal to any army with less grit and discipline than our own. Personally I like " The Master Hand " best. This story tells of the collection of our worn-out infantrymen in St. Quentin and their transportation to the rear in horse-drawn furniture pantechnicons.

The sad thing is we shall have no more of these stories, and he could have told so many more.

To sum up I cannot do better than quote the words used by Field-Marshal Lord Milne.

> "I recommend this book—to the old for its memories, to the younger generation for its studies in human nature."

The value of these stories can hardly be assessed at present. The book may well become an epic.

G.M.S-S.

MODERN SURVEYING FOR CIVIL ENGINEERS.

By H. F. BIRCHAL.

(Chapman & Hall, Ltd. Price 25s. net.)

It is frequently alleged that the civil engineer is apt to ignore the necessity of an accurate survey before commencing any work of importance, and that, in many cases, where a survey has been dispensed with, the money so saved has been expended many times over at a later stage in correcting errors of layout which would have been avoided had the survey been put in hand at the outset. It is true that this charge is most often brought forward by surveyors themselves, who are, in many cases, countered by the reply that once it has been decided to undertake an engineering project, it is seldom possible for the civil engineer to sit down and wait whilst the surveyor starts to put his work in hand. The argument exists and suffices to make a book on survey, written by a civil engineer, and for civil engineers, of more than ordinary interest.

The author of this book has set himself a very big task, stating quite clearly at the outset that "it is unfortunately a fact that expenditure on accurate survey is too "often grudged by the financiers of an engineering scheme . . . the engineer himself "is inclined to get on with the construction from inadequate surveys and adjust any "errors as they appear."

With the praiseworthy object of adjusting this state of mind, the author has produced, in about 500 pages, a comprehensive book dealing with every branch of survey with which the civil engineer is likely to come into contact. On every page one gains the impression that it is written by a practical man with full personal knowledge of the difficulties he is discussing, and bearing in mind the immense amount of ground which is covered, it would be invidious to pick on any special points for criticism. There are, however, one or two small matters which call for comment. Where the scope is large many subjects are necessarily somewhat sketchily dealt with, and a list of suitable books for further reference might well have been included at the end of each chapter. Again, it is difficult to understand why the Zeiss and Wilde theodolites are discussed to the extent of seven and a half pages, whereas the excellent British counterpart, the Tavistock, is dismissed in three and a half lines.

The chapter on Air Survey, quite obviously "inspired" by a member of a civil air survey firm, is the least satisfactory part of the book. The author, himself a railway engineer, comments on the Arundel photo plot method as follows:

"I am satisfied that this system will provide all that will be required by the railway "engineer previous to the final survey and precise levelling."

The index is adequate, and the new "flexible back binding" is particularly satisfactory in a book of this size. It is a volume which should be of great value to R.E. officers and not only to those whose main interest lies in survey matters.

Considered in relationship to the pocket of the young engineer and not to the value of the subject matter, the price seems rather high.

J.C.T.W.

AN INTRODUCTION TO STRUCTURAL THEORY.

(Second Edition.)

By H. SUTHERLAND and H. L. BOWMAN.

(John Wiley, New York, and Chapman & Hall. Price 17s. 6d. 1935.)

This is an American handbook containing very up-to-date methods of treatment of most of the problems encountered in the design of structures. It is unlikely that Royal Engineer officers will be called upon to undertake the calculations required for some of the larger frameworks dealt with, but the book undoubtedly contains, in a small compass, a very large amount of useful information for solving statical problems.

For use as a book of reference it can be heartily recommended, as the general layout of the letterpress, and especially that of the diagrams, is exceptionally clear, and there is a quite unusual consistency throughout in the use of symbols and notation. The treatment of the various problems does not stop at the theoretical general solution, but examples are given in nearly every case of how to use the formulæ derived, and how to tabulate the computations so as to reduce labour and eliminate errors. In the case of the more difficult structures, both accurate methods and less laborious approximations are gone into, and considerable care is devoted to showing what the probable errors involved in the use of these short cuts will amount to.

The work does not touch upon questions involved in the actual design of individual members, but this is to be the subject of a coming volume, " Structural Design." If this book is as carefully written and as clearly set out as the one under review, the two volumes should form a very useful textbook, not only for the student, but for the practical man who may have forgotten many of the methods available to those called upon to design modern bridges, steel buildings, etc.

E.F.T.

HANDBOOK OF THE COLLECTIONS ILLUSTRATING ELECTRICAL ENGINEERING.

II.—RADIO COMMUNICATION.

By W. T. O'DEA, B.SC., A.M.I.E.E.

Part I. History and Development.

(Published by H.M. Stationery Office. Price 2s. 6d.)

This little handbook is one of a series produced by the Science Museum at South Kensington. Each one deals with some section of the Museum, and in this case Part I gives an historical survey of the branch of science considered and Part II is a detailed catalogue of the exhibits to be seen. It is to be noted that these handbooks do not attempt to be textbooks in any sense of the word and mathematical treatment is entirely omitted. On the other hand anyone proposing to visit the radio section of the Science Museum would be well advised to study this volume before doing so, in order to be able to understand in full measure the interest and scientific value of the apparatus displayed. In fact, so well is it illustrated that we might almost say that having read the handbook there is no need to visit the section in question at all, were it not for the twenty-seven foot exponential horn loudspeaker driven by a demonstration set designed and made at the Museum, to hear which is in itself a justification of a visit. The volume under review describes in simple language the developments of radio communication from its very beginning. Starting with a reference to Clerk Maxwell's mathematical predictions published in 1864, the story brings into their true relationship with each other the work done by Hertz, Lodge, Heaviside, Marconi and Fleming, together with that done by many workers whose names are less well known to the lay public. The earliest oscillators and detectors are described and illustrated and the development of technique is traced through the various types of spark and continuous wave oscillators, coherers, crystals and early thermionic valves for use in connection with wireless telegraphy down to the latest developments of broadcasting, broadcast reception and short-wave radio-telephony. There is even a chapter on television. Perhaps one of the most interesting chapters is that dealing with the early W/T experiments—starting at a range of two to three miles in 1895 and culminating in the first successful transatlantic transmission in December, 1901. It is, however, surprising to find a writer who has had a scientific training stating that this achievement occurred at 12 p.m. on December 12th; presumably midnight on the night of 12th/13th December is meant by this cryptic statement, but even so, we are not told on which side of the Atlantic the time was taken. A further mild criticism which has to be made is on the subject of the terminology used in the section on valve development. It is assumed that a "double-diode variable mu pentode," for instance, is well-known to all of us and very little explanation has been thought necessary. None the less these are only small points and the fact remains that this little book is an excellent guide to the exhibits of radio development and a useful history of this comparatively new branch of knowledge.

F.J.R.H.

HIGHER SURVEYING.

By BREED and HOSMER.

(Chapman & Hall. 1934. Price 21s. 6d.)

This volume, bound in limp imitation leather and printed on India paper with gilt edges, induces a feeling of respect, if not reverence, even before it is opened. The scope of the contents does much to enhance this feeling. The volume opens with a comprehensive chapter on triangulation, describing and illustrating much of the present-day methods and apparatus of the U.S. Coast and Geodetic Survey. Here, as elsewhere in the book, it is of interest to study the methods of our neighbours, even if their problems and the materials they use to solve them are never likely to become our own. This is particularly noticeable in the chapter on Air Photography, where considerable stress is laid on the efficient functioning of the multi-lens camera, a stress which, in the absence of definite information, is likely to strike the reader as being somewhat optimistic. Astronomy is dealt with fairly fully in Chapter II, but in a manner which conveys an impression that the book is written for the man who has to face the prospect of written examination. Perhaps this is a little unfair, but the "Test Papers" supplied at the end of each chapter certainly lend weight to that impression. A chapter on Levelling with some interesting notes on barometers completes Part I. Part II is devoted to Topographic Surveying and considerable stress is laid on the use of the plane-table. This is unusual, as it is a subject which has been somewhat overlooked by American handbooks, and, as the preface rightly states, "it has advantages that are not appreciated by many surveyors."

Photographic surveying from ground stations is followed by a chapter on Geology as applied to topography. Part III deals with Hydrography and Stream Gauging, which latter includes a comprehensive account of various forms of current meter. Map projections are dismissed in a few pages. "Plotting and Finishing Maps" covers an immense amount of ground and a final section is devoted to stereo-plotting machines of all sizes and types. Eighteen pages of assorted tables and several appendixes complete the publication and leave the reviewer slightly stunned by the immense scope of the book and by the extent of the bird's-eye view which he has been vouchsafed. It covers the same ground as such hardy annuals as Close's *Textbook*, *Field Astronomy*, *Survey Computations*, several of the Air Survey Committee's publications, a handbook of geology, some assorted instrument makers' catalogues and (*mutatis mutandis*) the *Ordnance Survey Notes on Minor Trig*. It has over 600 pages and it is called a pocket-book.

J.C.T.W.

THE MAP READING "INSTRUCTOR."

By Major C. A. Wilson.

(Sefton Praed & Co. Price 5s. 6d.)

This further addition to the large number of books on map reading has been written with a view to dealing with the subject in such a simple way that the average soldier can understand it, if necessary, without an instructor. It also suggests a method of teaching the subject in a simple and logical manner. It does not deal with the use of air photographs and air survey, which is unfortunate in view of the rapid growth in importance of both. It does, however, contain sufficient information to enable anyone to pass the present army map-reading examinations.

Part I is an elementary introduction to the subject and includes Conventional Signs, Measurement of Distance, Map Reference, Relief, Maintenance of Direction, Map Enlargement and Map Reduction.

Part II deals with the same subjects in further detail and also includes the construction and use of various scales.

Part III is an introduction to the subject of Field Sketching and contains all the information on this matter likely to be required by an N.C.O. or soldier.

The arrangement of the book follows very closely that used in modern correspondence courses. After a brief simple explanation of the subject under discussion, there are questions and practical exercises which can be carried out on the ground. A copy of part of Sheet 117 (East Kent) of the 1" O.S. Popular Edition is contained in a pocket at the end of the book, and all the questions and examination papers are based on this map.

Although the chapter on the Magnetic Compass begins on page 27, no mention is made of the effect of local attraction until page 35, and there is no explanation of the reason for rifles, steel helmets and box respirators being removed to a distance. It is essential that the N.C.O. or soldier should clearly understand why the compass should be kept clear of certain metals, otherwise he is certain, sooner or later, to take bearings when standing on a railway line, telegraph line or on the top of a gasometer, with disastrous results.

The whole of this book is based on the 1" O.S. Edition and no instructions for map reading on other types of maps are given. It is, however, interesting to note that the author, on page 81, remarks on the fact that "we are rather apt to overlook "the possibility of having to fight in badly-mapped or unmapped country." It is certainly open to question whether we are not tending to depend so much on the efficient O.S. productions that all branches of the Army will be quite incapable of performing efficiently when no such maps are available.

The special Royal Air Force conventional signs given on Plate 5 are now out of date, and these should be revised as soon as possible.

One object of this book is to enable the N.C.O. or soldier to pass his army map-reading examinations. After studying it carefully and answering the various questions and examination papers, it is difficult to visualize the possibility of a failure.

W.H.S.

THE BOOK OF SPEED

The publishers (B. T. Batsford, Ltd., price 5s.) describe this volume as "primarily a picture-book of modern achievement," and it is a very fine picture-book indeed. There are many excellent examples of the photographic art, whilst the two war pictures of actual air combats must be quite unique.

The introduction by Stephen King-Hall is very well written, and worth the close attention of those interested in the more immediate problems of the future.

The main text of the book consists of a collection of short articles by experts in their various spheres, and these articles may be conveniently divided into two categories (a) historical (b) personal.

Of the historical articles, readers of the *Pickaxe* may be most interested in Major-General Fuller's contribution on "Speed in Modern Warfare." His contention that war speed is braked by fear, and that therefore mobility in war cannot be increased indefinitely, is probably a new idea to many, and is worth serious consideration. He believes himself that, for this reason, the next great war invention will be the unmanned aeroplane, a flying bomb or a torpedo directed towards its target by wireless; in short, that the object of future inventions will be to eliminate the human factor from the field of battle.

All of the other historical articles are of interest, but in a few cases they are little more than a chronological collection of facts, and so read rather like a list of the Kings of England, with dates.

The personal narratives naturally make more interesting reading, and comparisons are invidious. "The Non-Stop Run to Scotland," by Engine-driver C. Peachy, of the "Flying Scotsman," is, however, noteworthy because of the breezy and amusing style in which it is written. Hubert Scott-Paine's article on "Speedboats and Racing" is also well worth close study, especially by those interested in the sport, because all his facts must be new to most readers. His statement that a dead-flat calm is the most treacherous of all surfaces for racing will surely surprise many people. Colonel Etherton's account of a trip to South America in the Graf Zeppelin is, perhaps, a little disappointing because it does not give any description of life in this marvellous airship, nor does he tell us whether any of the passengers suffered from air-sickness—an important point for anybody contemplating making the trip!

It seems a great pity that some parts of such an interesting volume should be marred by the use of indifferent type.

W.H.S.

MAGAZINES.

REVUE MILITAIRE SUISSE.

(*January*, 1935.)—1. *Le service d'ordre militaire.*

Colonel Sonderegger considers that incidents that occurred during the riots in Geneva on the 9th November, 1932, when Swiss troops were called upon to play a humiliating part, were injurious to the reputation of the army, both at home and abroad.

Duty in aid of the civil power is the second mission allotted to the army by the Constitution. Troops are called upon to take action when a mob tries to carry out an illegal act by force.

An improvised force should not be used for such a purpose, but regular troops only, and preferably those from a canton other than that in which the disturbance takes place.

Although the regulations lay down that troops should form a reserve to the police force, the writer thinks that such a rule is unfortunate. Troops are not trained in police duties, and should act in their military capacity, and with their normal weapons. Hydrants may be used by the police, but should not be used by troops. A soaking will merely exasperate an angry mob. Firing with blank cartridge and firing over the heads of the rioters are forbidden.

2. *Conditions du service à court terme.*

General Rouquerol is in favour of long service, *i.e.*, a minimum of two years, as opposed to short service, *i.e.*, a maximum of one year. It is essential that the army should be thoroughly trained for its duties when war breaks out. It is true that the British were able to increase their army from seven divisions in August, 1914, to sixty divisions on the west front two years later, but this was only possible because France was better prepared than her allies when the war broke out.

General Brialmont had proposed additional works in the gap between the Liége forts and the Dutch frontier, but budget requirements compelled him to forgo the construction of these works, and it was through this gap that the German cavalry was able to force its way on the 2nd August, 1914. This instance is quoted as an example of the necessity for thorough preparation in peace-time.

3. *Le front rouge à l'affût de l'armée.* By Lieut. Naef.

In the sixteen years that have elapsed since the armistice, Bolshevism has become an ally of Swiss revolutionary socialism and has acquired a stronghold in the country.

Young men are often worked upon before they enlist, but most of the anti-military and anti-national propaganda is employed on men who have already joined up.

The writer, who does not wish to be an alarmist, thinks that the state of affairs that he portrays is by no means exaggerated, and invites his readers to read not only articles published by the red Press, but the many leaflets distributed under the sign of the sickle and hammer. Their contents are eminently suggestive.

(*February–March*, 1935.)—1. *Un émule de Jomini.* By Lieut.-Colonel Mayer.

The death of Colonel A. Grouard passed almost unnoticed in the military world, in spite of the fact that he had made his name by his works on strategy. He was a disciple and a fervent admirer of Jomini, whom he considered as much superior to all other military writers of the nineteenth century, as Napoleon was to all other generals. He had made a special study of Jomini's works, at a time when the instruction given in the French military schools exalted the doctrine of the German school, as expounded by Clausewitz.

Grouard entered the Polytechnic School in 1863 and passed out as an officer in the artillery. A first-rate mathematician and scientist, he made a special study of military history and strategy, and wrote numerous works on the latter subjects. In 1897, as a Lieut.-Colonel, he was Director of Artillery in Corsica, but was compelled to retire soon afterwards, under the age-limit rule. The army thus lost the services of the best strategist of his day.

In 1913, at the age of 70, he wrote, with the vigour of youth, *La guerre éventuelle.* In this he foresaw a German invasion through Belgium, and he laid down, as a rule that should entirely dominate the conduct of the operations of the French army, that it should give up all idea of an initial offensive, and only proceed on the principle of parrying and thrusting. Eighteen months later he had the sad satisfaction of knowing that he had been right.

2. *Le service de l'ordre militaire.*

Colonel Sonderegger concludes the article that was begun in the last number, relating to the riots in Geneva of November, 1932. The Federal Military Department, having ordered an enquiry, decided that the officers and men were justified in the action they had taken.

The writer considers that the rules on the subject of troops called out in aid of the civil power should be more explicit. Troops should not wait till the trouble begins, but should leave their barracks with bayonets fixed and rifles loaded. Officers should carry swords as well as pistols, but should not fire before the men do. Heavy machine-guns should accompany the troops.

The question of the use of fire or the bayonet will depend upon circumstances and the numbers available. Troops should not charge with the bayonet unless they can take up the whole width of the space occupied by the mob; and, when in line, they should always be in double rank.

Various other points of importance are noted. The action taken at Geneva in 1932 compares unfavourably with that taken at Zürich in 1918, when the writer was in charge of the operations.

3. *Les armes lourdes de l'infanterie.* By Major Perret.

In course of time every Swiss battalion will have a special company (*compagnie d'armes lourdes*) consisting of the following :—

1 section of 2 anti-tank guns.
1 section of 4 anti-aircraft machine-guns.
2 sections of 2 mortars (*lance-mines*) each.
1 ammunition section.

The anti-tank gun has a calibre of 47 mm., and weighs in battery 270 kg. It has a maximum range of 5,000 m. ; the elevation ranges between – 10° and + 55° ; the lateral field of fire is over 45°, and the rate of fire is 15 to 20 rounds a minute.

The mortar is a French pattern Stokes-Brandt mortar, with modified ammunition. It will fire the ordinary projectile with seven different charges up to 3,000 m., and a "mine" shell with four charges up to 1,200 m.

The method of using these weapons is fully described.

4. *Vingt ans après.* By Major Masson.

This article begins with a brief summary of the rearmament, since the Great War, of Switzerland's neighbours. Germany, ignoring her obligations under the Versailles treaty, can now count upon a Reichswehr with an effective strength of 600,000 men, and has 4,000 air pilots, together with a vast quantity of air material. France finds herself in an awkward situation owing to the big drop in available effectives between 1936 and 1940 (owing to the fall in the birth-rate between 1914 and 1918), and is obliged to revert to two years with the colours. Italy has become intensely militarized under the Fascist régime, and even Great Britain has recognized that her frontier is on the Rhine.

Compared with the above, the Swiss army has made little progress in the 20 years since the war. The automatic rifle was not introduced till 1926, *i.e.*, 12 years after it appeared on the battlefield. Anti-tank guns and mortars are not yet part of the regular equipment of the troops. The artillery has no anti-aircraft guns, no armoured cars have been provided, no fortified works have been built on the north and north-west frontiers. The air force is short-handed, and very little has been done to train the civil population against gas attacks. To make matters worse, there has been a steady fall in the birth-rate since 1902.

5. *L'école et l'armée.* By Lieut. Naef.

Since the world war there has been a great deal of anti-military and pacifist propaganda. The writer is not referring to communists and anti-patriots, whose tactics are well known, but to people who are genuinely sincere, who have allowed themselves to indulge in Utopian and false theories, which they inculcate not only on their *entourage*, but also on the youth of the country.

The young man of twenty knows that he has to submit to certain military obligations, but he does not know the reasons why national defence is incumbent on the Swiss, both on account of recognized international obligations and for the protection of their own interests.

Boys receive no instruction on such matters at school, and it is very necessary that this gap in their education should be filled.

A.S.H.

RIVISTA DI ARTIGLIERIA E GENIO.

(*December*, 1934.)—1. *Alcuni problemi d'artiglieria.*

Colonel Marras discusses a number of artillery problems. The conclusions he arrives at are that the new infantry weapons and their development have not in any way diminished the part that artillery will take in battle. As far as we can foresee, artillery will, in a future war, encounter greater difficulties than ever in carrying out its duties.

2. *La triangolazione aerea a servizio dell'artiglieria.*

Colonel Toraldo di Francia describes methods of utilizing aeroplane photographs to give the accuracy required for artillery work. He refers especially to the Santoni system, which was first thought out in 1919. A series of photographs is taken, with 60 per cent. overlap. There is a special device for recording the position of the sun with each photo taken. The position of any desired point can then be ascertained by means of an instrument known as a photogoniometer. Another instrument, known as a triangulator, has been brought out and has been tested in the Pisa hills. In both instruments the amount of error is very small.

3. *Occultamento e mascheramento.*

In this article Lieut. Contadini deals with the question of concealment and camouflage on the field of battle. In the introduction he explains their object both in defence and attack. The rest of his article is subdivided into three parts: (1) the characteristics of different objects, (2) materials and methods, (3) camouflage on the battlefield. An appendix explains the practical application of colour to screening materials.

In the first part the writer deals with the study and reproduction of form, with its relief effects and shadows, and with colours, their classification and properties. It is possible, with photographic plates sensitive to infra-red rays, to photograph distant objects concealed by mist and invisible to the naked eye. Mineral colours, used for camouflage purposes, will show up strongly if photographed with such plates. Colours with a vegetable base will not show up in the same way.

With regard to materials, if growing trees or shrubs are not available in the right spot, they may either be transplanted or cut; grass sods may be used, or grass seed sown. Various artificial materials may be used, viz., rabbit wire or string netting, raffia, hessian or coarse cloth, cork, asbestos (where there is risk of fire) and "*truciolo*" (*i.e.*, fine shavings of willow or poplar). Supports for the screens may be ordinary wooden pickets or small steel pipes. A description is given of the method of making netting and hoods for concealing personnel.

In the third part the writer deals with the concealment of wire entanglements, trenches, machine-gun and gun positions. The slope of a covering screen should not exceed 1 in 4. What gives away the site of a gun position more than anything are the wheel-tracks leading up to it. It is best to make the tracks to lead up to a false position, and then to carry them on under cover to the correct one.

The appendix gives a detailed list of colours and the method of applying them, also a list of materials suitable for a camouflaging unit in the field.

4. *La frenatura degli autoveicoli a trasmissione libera e bloccata.*

Major Amione describes the theory of the braking effect exercised upon a motor vehicle by various outside influences. These are shown by means of diagrams, and some useful hints for driving are deduced from them. At the end of the article a table is given showing the results of certain experiments carried out with military vehicles, to ascertain the distances in which they can be pulled up. The main conclusions arrived at are:—

(1) The brakes have a very much greater effect in pulling up a vehicle than all other means put together.

(2) A very high co-efficient of adherence can be counted upon when the brakes are applied.

(3) The braking power of the engine, of the resistance to rolling motion, and that of the air, are trifling.

(4) The resistance to rolling motion and that of the air are slight in comparison with the braking power of the engine.

5. *Gli errori nella misura del tempo ed il problema fonotelemetrico.* By Prof. Odone.

A technical article on the errors that may occur in sound-ranging.

6. *Guerra di mine.*

Major Tosti intends to bring out a book shortly on underground warfare, in which will be recorded the main episodes of mine warfare on the Austro-Italian front during the World War.

7. *Il nuovo armamento dell'artiglieria svizzera.*

A detailed *résumé* of an article on the new armament of the Swiss artillery that appeared in the *Revue Militaire Suisse* of October, 1934. (Reviewed on page 139 of *The R.E. Journal* for March, 1935.)

(*January*, 1935.)—1. *Scienza e industria per la preparazione militare del paese. Gli aggressivi chimici.*

Major Mameli deals with the relationship between chemical research, chemical industry in peace-time, and chemical industry in time of war. It was due to the close relationship between chemical research and industry in Germany that that country had, at the beginning of the war, an overwhelming advantage in the supply of chemical products over every other country in the world.

Chemical warfare began in 1915 with the use of chlorine, which is mainly obtained in the manufacture of caustic soda by the electrolytic method. At the end of that year phosgene (or carbonyl chloride) came into use. Yperite (mustard gas) has been known since 1822, but it was never prepared industrially until the Germans made use of it in 1917. Besides the above, the arsine compounds, with their irritant and sternutary effects, came into use in 1917 and 1918.

Chemical warfare was introduced on a large scale, for the first time, on the 22nd April, 1915, against the British and French trenches, causing effects that baffle description. Fortunately, in spite of the heavy casualties, the Germans failed to take advantage of the situation.

On entering the war, the Italians omitted to profit by the experience of the Allies, and allowed themselves to be surprised by an Austrian gas attack on the Carso in 1916. Here, too, the tactical result was negligible, although the Italian casualties were very heavy.

As regards out-turn of chemicals for war purposes, Germany maintained her lead throughout the war. She turned out 100,000 tons of chemicals. France and Britain were only able to turn out 50,000 tons each, and Italy only 13,000. Germany's peace-time output of 40 tons of chlorine in a year was increased to 60 tons a day.

The experience gained in the Great War points to the necessity for developing chemical industries and for training troops in chemical warfare.

2. *Rilevamento aereo di obiettivi e possibilità di tiro.*

Major Verney examines six different methods by which targets can be located by aeroplane observation, and discusses their relative merits. Photography gives the best results, but it involves delay.

In future warfare objectives will be so well concealed and camouflaged, that aeroplanes will be almost the only means of revealing their position to corps and army artillery.

3. *Le teleferiche militari.*

Brig.-General Bellusci continues the study of the theory of wire ropeways for military purposes that was begun in the November number. The standard carrying rope has six strands of seven wires. General Bellusci gives formulæ for ascertaining the sag in a rope stretched between two standards at different levels, with a single concentrated load placed at any point in the span. He next discusses the profile of a line built of the standard equipment. The following are some of the points to be noted. The normal spacing of the standards is 80 m. apart; their mean height should be 6·60 m. from the ground to the points of bearing of the carrying rope; the rollers carrying the hauling rope should be 5 m. from the ground. The change of gradient between one span and the next should not exceed 6 per cent. To ensure an even gradient, the height of the standards may be varied by sinking them in the ground, or, as an alternative, using either half standards or double standards.

4. *Sulla stabilità dei proietti.* By Captains Cavicchioli and Ravelli.

During the war and in the post-war period the tendency has been to increase the range of guns by tapering the projectiles, rather than by increasing their weight and initial velocity. The writers have made a thorough study of the various causes that affect the flight of projectiles, and quote American, French and Italian authorities on the subject. It has been shown that when the velocity of a projectile exceeds that of sound, perturbations are formed, known as "ballistic waves," that absorb the energy of the projectile and increase the resistance to its motion.

5. *Impiego della luce come mezzo di offesa.* By Lieut.-Colonel Gatta.

Investigations are being made in France into the use of light as a means of offence, and the question has also been taken up in the daily Press. The writer describes the structure of the eye, and the rays that affect it injuriously. The eye can be irritated by visible rays, either by flashes of intermittent light or by dazzle. Flashes at intervals of 1/30th of a second appear as a continuous light, but rhythmic flashes at longer intervals are exceedingly disturbing to the eyesight.

Light emanating from a gaseous source, such as that of a mercury vapour lamp, emits rays with a non-continuous spectrum, and does not irritate the eye, whereas light emanating from a solid body, such as that of electric arc or incandescent lamps, that emit rays with a continuous spectrum, can be irritating to the eye. But for practical work in the field the writer considers that the substances used in firework manufacture are most suitable, both on the ground of efficiency and economy. A shower of rockets bursting round an aeroplane would dazzle the pilot to such an extent that he would lose his sense of direction altogether.

6. *Considerazioni tecniche sulla candela d'accensione.* By Major Paravagna.

An article on sparking plugs, of interest to motorists, or to anyone having to do with internal combustion engines. Sparking plugs are of different kinds, and every engine requires a plug suited to its special requirements. Roughly speaking, they are divided into two classes; "hot" sparking plugs, that are easily raised to a high temperature, and "cold" sparking plugs, that readily part with the heat that they receive from the combustion of the mixture. The former have a long central electrode and long and slender outer electrodes; the latter have a short central electrode, and short, squat outer points. The insulator is the most delicate and the most important part of the plug.

The importance of attention to the plugs and to the use of a correct mixture, the advantages and disadvantages of one or more points, the pros and cons of battery and magneto ignition, are worth study.

7. *Opinioni di scrittori tedeschi a proposito di impiego d'artiglieria.*

Various German articles on the employment of artillery are here quoted, that have appeared in *Wehr und Waffen.* Some of these have been reviewed in *The R.E. Journal*, *e.g.*, "Future Cares and Duties of the Artillery" (*W. u. W.*, November, 1933; *R.E.J.*, March, 1934), and "Organization and Circumstances of Command of the Artillery in the Attack," by Major Schneider (*W. u. W.*, May, 1934; *R.E.J.*, September, 1934).

(*February*, 1935.)—1. *La pratica nell'organizzazione di una scuola di tiro d'artiglieria.*

General Caracciolo gives his views on the organization and the form of instruction to be adopted in a school of gunnery.

2. *Reticolati elettrificati.* By Major Montanari.

Electricity is likely to find an extended use in wire entanglements in the future, even in mobile warfare. The amount of energy required to electrify an entanglement is not large; under favourable conditions 1 kw. is sufficient to electrify 800 square metres of entanglement. The lowest wires should be raised at least 15 to 20 cm. from the ground. No insulators should be used: the wire should be covered with insulating tape at the points of support.

The effect of an electric shock on the human body is the stoppage of the action of the heart and the lungs. It has been observed that the higher the tension, the higher is the intensity of current that the organism can endure. With a relatively low tension, a body can stand about 90 milliamperes without fatal results, but, with a tension of over 100 volts, it can stand a current of 4 to 5 amperes.

The writer recommends an installation on the following lines, suitable for work in the field :

A three-phase alternating-current generator of about ½-kw., driven by a 1-H.P. internal combustion engine ; a low-frequency current (10 periods per second) ; a low-tension current (600 volts). This plant will electrify a front of 200 metres.

3. *Organizzazione generale dei calcolatori per tiro contra aerei.*

Lieut.-Colonel Giorgi describes the working of "calculators" in anti-aircraft gunnery, and gives his reasons for preferring telephone connection between the observer working the calculator and the gun, to an automatic electrical connection.

4. *Ripristino di due viadotti ferroviari con travate di ponte metallico regolamentare.* By Lieut. Bardi.

This article is taken from one that appeared in *Militärwissenschaftliche Mitteilungen* for April, 1934 (reviewed on pp. 492 and 493 of *The R.E. Journal* for September, 1934), and describes the replacement of the Jaremcze and Jamna viaducts on the Galician front.

5. *Le caratteristiche degli autocarri militari e il loro rendimento.*

Lieut.-Colonel Amione makes a comparison between different types of military motor vehicles in use in the Italian service, *i.e.* :—

S.P.A. 25-H.P. 10, carrying a load of	1·8	tons.
Ceirano 47-H.P. ,, ,,	3	,,
Ceirano 50-H.P. ,, ,,	5	,,
A trailer, towed by the latter ,,	4	,,

For transport of troops, the Ceirano 47-H.P., which has pneumatic tyres, is best, though there is little to choose between the three.

For transport of material the Ceirano cars are superior to the S.P.A. 25-H.P. 10—the Ceirano 47-H.P. being most suitable for roads with a gradient of less than 3 per cent.

In conclusion, the writer states the requirements for a military motor vehicle. The maximum load that a normal military bridge will carry is 10 tons (10,000 kg.) ; this should, therefore, be the maximum weight for a loaded lorry. The lorry itself might weigh 4,500 kg. ; its load might be 5,500 kg. If semi-pneumatic tyres are used, the speed can be 30 to 35 km. per hour ; with full pneumatic tyres the speed can run up to 45 km./h. To give more space for the load, the driver's seat should be located over the engine. The turning circle should have a radius of 6 m. In other respects, simplicity and strength are essential.

6. *La difesa del Pasubio e del Corno Battisti.* By General Ferrario.

The Pasubio *massif*, standing on the former boundary between Austria and Italy at the southern end of the Trentino, was a very important point for the 1st Italian Army. It commanded the passes of Vallarsa and Borcola, over which roads ran from Rovereto in the Adige valley to the plains of Vicenza. An advance along either of these roads would have threatened the Italian rear, but it did not at first form part of the Austrian plan of campaign. The Italians were consequently able to seize the Pasubio early in the War.

General Ferrario gives a detailed account of the defence of the Pasubio from May, 1916, when the Austrian offensive began, up to the end of the war. The narrative is illustrated with eleven photographs and four plans. The troops who took part in the defence had to undergo the most terrible hardships and discomforts ; mining and countermining went on the whole time ; the cold in the winter was intense and losses were very heavy, but the position was held throughout.

A.S.H.

REVUE DU GENIE MILITAIRE.

(*November–December*, 1934.)—1. *La défense de l'île de la Réunion en* 1810.

The island of Réunion, which had been a French colony since 1638, was attacked by the British fleet in April and September, 1809. On the latter date, General de Brulys, the Governor, was summoned by Commodore Rowley to surrender, and, seeing no hope of a successful resistance, he committed suicide. He was replaced by Colonel Sainte-Suzanne. Another attack was made in force on the 7th July, 1810, and the island was compelled to capitulate on the following day.

In this article certain official documents relating to the defence and capitulation are quoted, as recorded by Major Soleille, of the Engineers, when a prisoner on parole. The island was restored to France in 1815, under the terms of a treaty, by which the neighbouring island of Mauritius, taken about the same time, remained a British possession.

In his report to the Inspector-General of the Imperial Corps of Engineers, Major Soleille points out that Saint-Denis, the capital of the island, was held by one company, 80 strong. The British attacking force numbered 6,000, a superiority of about 70 to 1. The defenders, however, held out for 24 hours, during which, he states, they inflicted 500 casualties on the attack. When they finally surrendered, they were allowed all the honours of war.

2. *Passage de l'Aisne par surprise, le* 6 *nov.* 1914.

Captain Simon, at that time a Sergeant in the 1/3 Company of Engineers in the 1st Corps, describes how his company effected a surprise crossing of the Aisne during the night of the 5/6th November, 1914. The object was to recover a portion of the line that the Germans had captured during October. The Germans were occupying the village of Soupir on the right (north) bank of the river, but it was discovered that they withdrew their patrols from the river-bank at night.

It was decided to launch ten boats with bridging equipment at a point some 8 km. upstream of Soupir, and to float them down, during the night, to the point of crossing. A serious difficulty was the negotiation of the ruins of a demolished masonry bridge that obstructed the waterway. The last 2 km. of the river passed through territory in enemy occupation. The boats reached their destination safely. It was decided not to build a bridge, but to ferry the attacking infantry across.

The operation was carried out in the early morning mist without alarming the enemy, and in the subsequent attack a large portion of the ground was regained that had been lost in October, while a hundred prisoners were captured.

3. *Note sur une nouvelle sondeuse.* By R. Joffet.

In the April–May, 1932, number of this magazine a portable boring plant was described, capable of driving a bore-hole from 165 to 300 mm. in diameter to a depth of 200 metres. For geological surveys, however, the process of boring with a rotary drill and water-jet is unsuitable.

The writer describes a new type of boring plant worked on the "rope and drop-tool" principle, without a water-jet. The drop-tool is fitted at the bottom with a set of chisel cutters, and is used for cutting an annular groove around the bottom of the hole, and raising the core so formed for observing the character of the rock, without pulverizing it.

By using drop-tools of varying diameters, bore-holes can be excavated varying in diameter from 150 mm. to 1 m., to a maximum depth of 60 to 80 m. It is suggested that a boring plant of this kind might be included in the equipment of a corps park.

A photograph shows the drop-tool extracting a lump of rock weighing 57 kg.: a cross-section of the boring tool, showing the mechanism, is given, also small-scale drawings of the whole plant.

4. *Emploi du génie aux opérations du Maroc en* 1933.

General Naquet-Laroque concludes his article on the work carried out by the engineers in the Morocco operations of 1933 by describing the work done by the signallers in the 41st Regiment of Engineers. This regiment was called upon to maintain the existing system of telephones, telegraphs and radio-telegraphy in the pacified portion of the country, and to provide detachments for maintaining signalling communication throughout the active operations.

The permanent telegraph lines are of iron wire (very rarely of copper) carried on posts. In many of the temporary lines the bare wire is merely laid on the ground. In dry weather the insulation is perfect; messages can be got through, with a little difficulty, in damp weather; during heavy thunderstorms communication is completely stopped, but interruptions have never lasted longer than six hours.

Radio-telegraphy gave fairly satisfactory results, a short-wave system being employed. Some "fading" often occurred on all wave-lengths at night and in the early morning. The amount of work done by the staff is exemplified by the fact that some radio stations transmitted 7,000 words a day, and ordinary telegraph stations 20,000 words a day.

(*January–February*, 1935.)—1. *La ventilation par pulsion d'air chauffé.*

Captain Sardi, who has had experience in the installation of several hundreds of ventilating plants, has written a study of some 70 pages in order to assist engineer officers engaged in similar work. In the system that he describes the outer air is passed through a radiator that is heated by a special boiler. During the summer the radiator is by-passed. The warmed air then passes through a centrifugal fan driven by a synchronous three-phase motor, and is then forced through ducts to the various rooms in the building.

The greater part of the article is devoted to calculations, but some of the main points of interest are the following:

In the distribution system the velocity of the air should be kept down to a minimum to avoid noise. Different types of fans are discussed, the angle at which the vanes are set, and the number of the latter. With the type of motor described, direct drive is preferable to belt drive.

A low-pressure boiler is preferable to one working at high pressure. The latter requires the constant attendance of a skilled mechanic. Radiator tubes may be of copper or of steel; the latter resist frost better. Copper tubes with steel fins are to be avoided. Tubes should slope sufficiently to allow the water vapour condensing inside them to run off.

The ducts are usually made of galvanized iron, with collar or soldered joints, and asbestos packing. Three different types of dampers may be used. The mouths should be slightly conical: the cone angle should not exceed 8° or 10°. It is important that the installation should be noiseless. The main causes of noise are here investigated.

2. *Travaux de relevage d'une locomotive déraillée sur le réseau de l'état.* By Captain Beauvais.

On the 24th October, 1933, the Cherbourg-Paris express was derailed between Conches and Evreux, at a spot where the line runs on a viaduct crossing the Rouloir stream. The locomotive, tender and some of the carriages fell into the valley. After the salvage operations had been completed, the State railway removed the tender and carriages, and entrusted the recovery of the engine to a private contractor.

The engine, weighing 110 tons, was resting on its wheels, but was tilted over at a slight angle, the front bogie being buried 30 cm. and the back part 85 cm. in the ground.

The article describes how a coffer-dam of steel sheet piling was driven round the engine. A framework of wooden trestles was erected on top of the piling. These trestles carried three stout I-beam transoms, to which pulley blocks were fixed. The engine was lifted by means of a series of winches and steel cables attached to the longitudinals of the engine chassis.

It was lifted sufficiently high to allow of sleepers and rails being placed under the wheels; the engine was then lowered on to the rails.

Two officers of the 5th Regiment of Engineers were present while the work was in progress.

3. *Enquête sur la radiesthésie.*

(*a*) *Coups de baguette.* Lieut.-Colonel Du Tersent traces the history of water-divining from the time of Moses to the present day. Only in recent years has it been considered a subject for serious study.

The divining-rod has nothing to do with magic or with metaphysics. Like the pendulum, it works by a stimulus that is purely physical and, although the personal equation counts for a good deal, it is certain that anyone, with a little technique and rational instruction, and an elementary knowledge of geology, can become a dowser.

The usual type of divining-rod used is a hazel-twig, but all that is needed is something that will act as a spring to indicate a change of equilibrium in the nervous system. Two strips of whale-bone tied together at one end will answer the purpose.

During the war officers have been able to discover the position of land mines, as well as of submarine mines, by means of a divining-rod.

(*b*) *La radiesthésie appliquée aux besoins militaires.* M. Viré explains, amongst other things, a method of ascertaining to what material a divining-rod re-acts. If a piece of iron is held in the hollow of one's hand, the rod will re-act to iron only, and not to water, for instance.

The writer relates an instance that occurred during the war, when underground cover was required for a field hospital. He was able to show that there were a number of abandoned quarries under the ground where he was standing, forming vast subterranean vaults.

A.S.H.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*February*, 1935.)—1. *Pages d'histoire de l'armée belge au cours de la guerre* 1914–18.

Colonel Delfosse, as a Captain, was in command of a special " demolition " cyclist company belonging to the 6th Division. In this first article he describes the tasks with which his unit had been entrusted in September, 1914, to attempt to delay the German advance by demolishing important points on the railway. Time being limited, and opportunities of doing damage very few, the company confined its efforts to damaging the rails by placing against them charges of tonite, arranged to detonate when a train passed over them.—(*To be continued.*)

2. *Les procédés de combat de l'infanterie allemande.*

Major Wanty begins by describing the organization of a German company and platoon and then goes on to deal with the duties of a company and platoon in an advance guard, the preparations for an attack, and the execution of the attack.—(*To be continued.*)

3. *La manœuvre du Cser* (12–19 *août* 1914).

Lieut.-Colonel Desoil gives an account of the first battle of the war between the Austro-Hungarian and Serbian forces. The Austro-Hungarian force to which the operations against Serbia were entrusted consisted of the 5th and 6th Armies under Marshal Potiorek. The Serbian army was composed of eleven excellent infantry divisions under the Crown Prince Alexander, with General Poutnick as Chief of the Staff.

The Serbs expected an attack down the valley of the Morava, along which the Belgrade–Nish railway runs. Instead of that, the Austrian attack was delivered across the Drina, against the Serb left flank, and the Serbian army was compelled to execute a rapid change of front. Thanks to the splendid marching of the infantry over very difficult country, the Serbs were able, not only to save the situation, but to win a decided victory, between the 12th and 19th August, 1914.

The Austrians made two mistakes; they attacked with the 5th Army only, making no use of the 6th Army, and they attacked over a mountainous section, where their superiority in artillery gave them no advantage.

4. *Les chemins de fer allemands en* 1914. By Captain Bedoret.

This is a study of the organization of the German railways in 1914, showing how all details had been worked out beforehand, so as to make the best use of the railway system on the outbreak of war.

The position on the 1st August, 1914, was as follows:—The western theatre of operations contained thirteen independent lines from the mobilization centres to the zone of deployment, and four excellent transverse lines between Strasbourg and Cologne. The eastern theatre of operations contained three lines, of which two had a double track. There were communications between the two theatres consisting of four double-track lines as far as the Vistula, and two lines east of that river.

The traffic problems were sub-divided as follows:—

(*a*) Transport on mobilization.

(*b*) War transport.

(*c*) Economic transport, *i.e.*, that relating to supply of food and material to towns. These are all described in detail.

5. *Vue d'ensemble de quelques applications possibles de la psychotechnique à l'armée.* Lieut. Mente concludes his article on psychotechnics, begun in the previous number. He shows how mental tests might be applied to recruits and, if successful, how the system might be applied on a larger scale.

Some practical results obtained are given, both in the army and in civil industry. They show how, in all countries in which tests have been made, those men who have given the best reaction to mental tests are less prone to accidents, give a better out-turn of work, and cause fewer breakages and less waste than those in a lower category.

6. *Note relative au valeur des poutres composées d'éléments en bois et à leur utilisation comme ponts de circonstance.* By Prof. Gysen.

A treatise on calculations of compound wooden beams, capsills, brackets, and framed wooden girders of large span.

(*March*, 1935.)—1. *Opérations de la Compagnie Spéciale de Destruction de la 6 D.A.*

Colonel Delfosse concludes the article begun in the February number. On the 29th September, 1914, one of the three groups forming the demolition company succeeded in blowing up a rail and de-railing an enemy troop-train. This led to threats of German reprisals against the civil population.

The company was unable to effect anything useful after that. The enemy had pushed forward so far that retreat was impossible, and Captain Delfosse had no alternative but to cross the border into Holland and surrender.

2. *Au "Boyau de la Mort" le* 6 *Septembre* 1915. By Major Beaupain.

In connection with Lieut.-Colonel Jones' account under the above heading in the number of December, 1933, Major Beaupain gives an account of the gallant conduct of two Sappers in the "Boyau de la Mort."

3. *Les chemins de fer allemands en* 1914.

In the previous article Captain Bedoret describes the railway preparations made for the mobilization and deployment of the German army; he now examines the results of the preparations at the commencement of the Great War.

Preliminary arrangements were made from the 28th to the 31st July. On the 1st August, at 17 hours, a general mobilization was ordered.

On the evening of the 1st August it was hoped that Russia alone might be involved in the war; but it is stated that Moltke overruled the Kaiser's orders to mobilize on the eastern front only, on the ground that it was impossible to alter the pre-arranged plan. On the 2nd August, at 0.45, the order was given to cross the frontier.

On the evening of the 6th August began the great movement of the deployment of the army, and 660 troop trains ran daily on the thirteen lines leading to the western frontier. The 8th Army on the eastern front had a comparatively easy task.

The remarkable success achieved by the German railways was the result of many years' work, and of the close collaboration, both in peace and war, of the military and the railway authorities. It is essential that the army should have the services of railway officers with a knowledge of their special mission, who have all details connected with the railway system at their fingers' ends.

4. *Défensive d'arrêt. Tirs de concentration exécutés par les Mi. dans la zone des avant-postes.*

Lieut.-General Grade mentions the various points that affect the accuracy of machine-gun shooting. At extreme ranges the probability of hitting the target is so slight that it is of little use firing at ranges exceeding 2,000 metres.

5. *Observation d'artillerie. Contribution à l'étude de son organisation.* By Captain Smesman.

6. *Les procédés de combat de l'infanterie allemande.*

In this number Major Wanty concludes his article on the methods of training in the German army. The first subject dealt with is the company in the defence of a position; it is illustrated by means of a practical example. Next, we come to outposts, also illustrated by a practical example, with a platoon as unit. The article ends with the combat group both in attack and defence.

7. *Rapport général sur la manœuvre de défense passive du Grand-Bruxelles.*

Lieut.-General Cattoir, Chief of the Service of National Mobilization, describes an alarm practice carried out in Brussels in February, 1934, during a sham attack by aeroplanes supposed to be dropping incendiary bombs. He acknowledges the collaboration of the big manufacturers and the railways, and the population generally. The practice has been useful in bringing to light many points requiring attention, such as "alarm" and "all clear" signals, the wearing of gas-masks, extinction of fires, etc.

8. *Levée de candidats sous-lieutenants en* 1813. By Major Couvreur.

The circumstances in which the Emperor Napoleon ordered the raising of 10,000 "Gardes d'Honneur" from the better-class families was described in the *Bulletin Belge* for July last. Major Couvreur tells us some of their subsequent history in the campaigns of 1813 and 1814. They received their baptism of fire at Leipzig, when, on the third day of the battle, the Saxons went over to the enemy. During the retreat from Leipzig, on the 30th October, the Gardes d'Honneur took part in a charge at Hanau. Later on they were employed as part of the guard on the Rhine. The cavalry commander of the Imperial Guard reports that they were, on the whole, badly dressed and badly equipped, and that many of their horses were poor. Their discipline and instruction were bad, but they were keen and willing.

A.S.H.

REVUE MILITAIRE FRANÇAISE.

(January, 1935.)—This number opens with an article on *Alexandre 1er, Chef d'Armées*, by Lieut.-Colonel Tournyol du Clos. It describes the great part played by Prince Alexander of Serbia, as he then was, in leading the Serbian armies from defeat to victory in 1914. Prince Alexander was Commander-in-Chief of the Serbian forces throughout the war, and the stubborn opposition of the Serbians to the Austrian invasion, the skilful but terrible retreat to the sea, the reorganization of the army and its junction with the Allied armies on the Salonika front, and finally the triumphant advance from the borders of Greece to the Danube in 1918 were all in a great measure due to his brilliant leadership. He was, like the late King Albert of the Belgians, gifted with far-seeing powers, and displayed gifts of capacity in the field which entitle him to be considered as one of the brilliant leaders of the war.

The Serbians, who suffered throughout from want of all kinds of supplies, found themselves still more deprived of resources when the superior Austrian forces compelled them to retire from the Drina to the Koloubara in November, 1914. But the retirement was conducted with great skill. Counter-attacks were made in spite of the paucity of reserves. When Prince Alexander was driven back from his chosen position on the right bank of the Koloubara, it seemed as if his chances had become hopeless, but he maintained his grip of the situation and, watching his opportunity, he suddenly launched his whole army against the Austrians, who were now strung out and had the flooded Koloubara behind them. There was practically no artillery support, for munitions had run short; but the indomitable spirit of the Serbians had not been crushed, and it now carried them forward with such success that the two Austrian armies of invasion were driven right out of Serbia. In two weeks the Serbians had regained what had taken the Austrians two months to conquer.

The conduct and capacity of Prince Alexander as a commander deserve more notice than they have yet received, and a history in detail of the Serbian campaign of 1914 would form a very instructive study.

Guerre d'hier et de demain, by General Pichon, is a long article of 66 pages, discussing the exercise of the command of a division in a war of movement, and comparing the present-day advantages of wireless communication. Very few of the author's main points are new, but he offers some well selected thoughts and suggestions which will assist the non-specialist who reads the article. He lays particular stress on the organization of intelligence and the communication of orders.

So much space is now given in the *Revue* to articles on the subject of information and interchange of reports that it is clear that the French staff are paying much attention to the growing importance of these matters in view of rapid mechanized warfare.

In an article entitled *L'Achèvement de la Pacification Marocaine*, Lieut.-Colonel Juin describes the final stages of the French operations of the last few years in Morocco. He summarizes the methods and programmes and, in fact, supplies a very useful epitome of the longer articles on this subject which have been appearing in recent numbers of the *Revue*.

The operations, which terminated in 1934, twenty-seven years after the landing of French troops at Casablanca, carried the French occupation of Morocco to the borders of Ifni, the Spanish enclave, and the Rio del Oro. A sketch map accompanies the article and shows the various stages of the occupation from 1907 to date.

The adversaries which proved most difficult to overcome were the tribes or confederations of tribes of the Middle Atlas, and the Central Grand Atlas. Warfare was in the marrow of these Berber tribes, who were continually at strife with their neighbours or the Sultans from the northern territories.

The native tactics were primitive but not to be lightly treated. The tribes held their positions only so long as their line was not pierced or their flanks turned; they would then break away in order to move their property and their families to safety. If, on the other hand, the French did not follow up their success or occupy the conquered district, their adversaries would reassemble and become aggressive, harassing the flanks and rear, and pouncing on any isolated detachments. The story is not new to us, but the French methods of dealing with these problems is of much interest.

The Great War, of course, interrupted the pacification, and gave the tribesmen an unexpected respite; but it also gave the French increased means when it came to a resumption of operations; and mechanical apparatus of all kinds was available in the later stages. The whole operations, since 1931, were under the control of General Huré, who had under him four regional commanders. As many as 36 battalions were at one time employed, all being native regiments.

(*February*, 1935.)—This number opens with the first part of an article by Colonel Menu, *Les Journées des 29 et 30 août 1914*. It gives a very detailed account of the fighting which took place on those dates between units of the French Xth Corps and the German Guard Corps, as part of the Battle of Guise. General Lanrezac had contemplated attacking the German Second Army when it reached the Upper Oise, but had given up the idea on the representation of his Corps commanders that the troops were too exhausted after the fighting on the Sambre and the strenuous marching subsequent to it. General Joffre, however, having seen for himself the strained relations between Sir John French and the Fifth Army commander, insisted on an attack being made. Plans were accordingly prepared for attack in a south-to-north direction, when Joffre learned that the German forces following up the Fifth Army had been reduced by two Corps left to besiege Maubeuge. This news caused a considerable change in Joffre's plan. He now considered that Lanrezac would afford more direct help to the British if he attacked westwards instead of northwards, leaving only one corps to cover the attack on the north. This proposal involved a good deal of re-direction in the marches of the French Corps, and Lanrezac objected but was overruled. The new attack was to be made between Hamégicourt and Bernot with eight divisions (4th Group of Reserve Divisions, XVIII and III Corps). The I Corps was to follow the III Corps in rear, while the X Corps was to cover the right, on a line Audigny–le Sourd. This operation would increase the already large gap between the French Fifth and Fourth Armies, but it was known that there was a corresponding gap opposite between the German Second and Third Armies. The Germans were becoming exhausted with their long and rapid marches, and had already become more cautious as a result of the Sambre fighting.

This instalment of the article treats almost exclusively of the doings of the French X Corps, but a sufficient framework is given to enable the reader to connect the narrative on either side with other formations. The operations are viewed from both sides in a very interesting manner; and the most detailed description of company movements is included. At one moment we are wondering why the French gave way apparently so easily; at another why the Germans were so cautious in coming on. All is explained with full reason. Most of the fighting was done in the mist. The troops on both sides were almost dead beat. They had had a very severe time, with little or no rest for ten days. The French had suffered heavy casualties in officers, and their lack of subaltern leaders was apparent in almost all the fighting described.

The efficiency of the French artillery can be distinguished throughout the article; while on the other side, the German discipline was evident in the behaviour of the troops surprised in the village of le Sourd.

It would be natural to suppose that in such early stages of a campaign, the principles of tactics so carefully taught in peace-time would be followed, if with diminishing care, so long as regular troops were left. But the books and the peace-training can never provide the very different state of affairs which actual war presents; and while we are reading this very detailed account of the operations on the Upper Oise, we must bear in mind the mist, and that other fog of war—uncertainty as to the whereabouts of other troops—the fatigue of the men, the loss of junior leaders, and the shattering effect of machine-guns.

General Inostransev contributes the first instalment of an article *L'Opération de Sarykamich*, of December, 1914. This was the first episode of the fighting between the Russians and the Turks in the Caucasus. The scene of operations was as little attractive as could be wished; the climate severe; snow abundant; winds violent. On the Turkish side, roads scarcely existed; there were only tracks, and these had not been maintained. All the operations of war in such a country became arduous in the extreme.

The Russian Army of the Caucasus had had to part with the best of its troops on the mobilization of the whole army, and when Turkey declared war, the gaps had to be filled up hastily with new units and reinforcements from Turkestan and Siberia. The Army of the Caucasus consisted at the beginning of the operations of the I and IV

Caucasian Corps, and the II Turkestan Corps, and was commanded by Count Vorontzov-Dachkov, an old but popular chief. His Chief-of-Staff was General Yudenitch. The Turks had their Third Army, consisting of the IX, X and XI Corps, concentrated around Erzeroum.

The scattered positions of the Russians and the state of transition in which their troops were involved invited attack, and Enver Pasha himself went up into the Caucasus to take charge of the operations.

The article well describes the manner in which the Turks, whose transport and equipment were not of the best, although perhaps suited to the rugged nature of the country, developed their Schlieffen-like plan, and most successfully advanced their columns with great rapidity, in the effort to capture Sarykamich and cut the Russian line of communication with Kars. The plan was ambitious, the early stages of the execution skilful, and the troops in good order. The Russians fought well, but everything seemed to be going against them. So desperate seemed their situation that their commander, General Mychlaevski, gave them up for lost, handed over the command to Generals Yudenitch and Berchman, and returned to Tiflis to organize a new army! The Turks had nearly succeeded in encircling Sarykamich, when the Russians recovered brilliantly, and ended by completely routing the Turkish Third Army.

The writer truly says that these important operations have been very little studied; he has certainly given us an instructive account of them, and will make his readers wish to know how he draws his conclusions. The article is accompanied by a useful series of sketch maps—not without some obvious errors on them, however—notably Sketch 5 which shows 77th Division instead of 17th, and 29 Divisions for 29th Division.

The next article is entitled *Une figure de Soldat. Von Lettow Vorbeck*, by Colonel Charbonneau. The fame of the German commander in East Africa needs no introduction to English readers, but this short sketch of his career from a French point of view will be of interest to many students. Von Lettow Vorbeck was commander of the military forces in German East Africa when war broke out, and is one of the very few examples in the war of a peace-time commander taking the field and holding his command throughout until the Armistice. The writer quotes very largely from the memoirs of von Lettow Vorbeck. He pays tribute to the chivalrous conduct of the Germans in East Africa, and points out that Germany, so fond of decrying the use of native troops, should remember with gratitude the services of the faithful troops who followed von Lettow Vorbeck to the end. The implicit trust of those coloured soldiers in their leader is only one more indication of the loyalty of such men to their white officers when the latter show themselves worthy of it. The East African campaign was chivalrously conducted on both sides and left behind no burning resentments.

(*March*, 1935.)—Colonel Menu concludes his article *Les Journées des 29 et 30 août 1914*. He describes how the French Xth Corps was driven back by part of the German Xth Corps and a division of the Guard Corps during the 29th August, and how the situation was changed by the intervention of a very weak French force—the 4th Cavalry Division and 51st Reserve Division. Lanrezac sent orders to these two units—which were covering the right flank of the Fifth Army in the gap which separated it from the Fourth—to attack the flank of the Germans as they advanced against the Xth Corps. There was not much striking power in these formations. The Cavalry Division had a brigade of Hussars guarding the crossings over the Thon and the Oise from Origny to Autreppes, and its other two brigades assembled round Vervins, neither of the latter being trained or equipped to fight on foot. The 51st Division was too far distant to be available for a long time. The Cuirassier and Dragoon brigades of the 4th Division were, however, ordered off, supported by the Divisional cyclists and artillery (three horse batteries). Of this force, only one cyclist platoon and one battery (four guns) were immediately available, but these did their work well, and their unexpected appearance on the German flank so startled the 2nd Guard Division that it halted, and formed its brigades to face what it thought was a whole French corps. This check to the Germans gave time to the French Xth Corps to rally, and to the I Corps to bring its leading brigade into action between the Xth and IIIrd Corps. The initiative changed over to the French and when, owing to the general situation, Joffre ordered the Fifth Army to break off the fighting, Lanrezac had so shaken von Bulow that the German commander decided to give his troops a rest on the 31st and refrained from pursuing.

The account of this complicated fighting gives a very good example of the difficulties caused by the fog of war.

The story of the Battle of Sarykamich (December, 1914—January, 1915) in the Caucasus, begun last month, is now concluded. The author, General Inostransev, describes how the victorious Turkish advance was turned into a disastrous rout by the gallantry and good leading of the Russians. All seemed lost for the Russians, when their commander, General Mychlaevski, gave over the command to Generals Yudenitch and Berchman. Their fortunes then changed, for the troops were brilliantly handled. Rapid moves on the battlefield, combined with extreme endurance on the part of the troops, threw the Russians on the Turks when they had shot their bolt. Enver Pasha had done his best, but his " Cannae " had been too ambitious, and the total lack of roads and means of supply had brought his outflanking wing to disaster just when it was on the verge of success. The author gives some interesting examples of the stoutheartedness of the simple Caucasian soldiers, and makes one think by how much the war might have been shortened if only the Russian army had had more leaders like Berchman and had had the backing and organization its soldiers deserved.

General Schweisguth contributes a short article, *La défense de Sélestat en 1814.* Sélestat, a small town in Alsace, was isolated when the French forces under Victor and Milhaud fell back, and its investment by a mixed force of Austro-Bavarians began on January 5th, 1814. The garrison was very weak, composed of National Guards and a few recruits ; none with any military training, and many without arms or uniforms. But the garrison held out for three months, suffering bombardments daily, and losing 400 soldiers and 100 civilians by typhus ; at the end of which time the besiegers raised the siege and left the little town to its glory.

With this introduction, the article gives, for the first time, copies of the correspondence which passed during the siege between the Austrian commander, Count Pappenheim, and the French commandant, Schweisguth. These letters throw an interesting sidelight on the minor affairs of war, and show, as the author says, that even twenty years of revolutionary warfare had not abolished all habits of chivalry and polite conduct.

The last article in this number is a short review of Prof. Kiritzesco's book, *La Roumanie dans la Guerre Mondiale de 1916 à 1918*, by Lieut.-Colonel Delmas. The Rumanian plan of campaign, responding to the national aims and to the representations of the Russian General Staff, was too ambitious for the limited resources available. There was a great lack of heavy artillery, aeroplanes and machine-guns. And although it appeared that Rumania would have a definite superiority in men at the outset, the balance was quickly reversed, for by November, 1916, the Central Powers threw 40 divisions against the Rumanian 27. Germany's ability to engage so large a force in a fresh theatre was another proof of her exceptionally good organization and bold strategy. The failure of the Rumanian intervention was due to the failure of the Russians to carry out their expected offensives in the Dobrudja and the Bukovina, and to the failure of the Allies to make their expected offensive from Salonika. In spite of the strong French Mission sent to Bucharest under General Berthelot, the Allies were unable to co-ordinate their plans, and the Germans seized their chance.

The campaign itself is not described. W.H.K.

MILITAERWISSENSCHAFTLICHE MITTEILUNGEN.

(*January*, 1935.)—*New Year Editorial.* "The more we are occupied with our professional duties, and the more our everyday cares and distractions press upon us, the more profitable will it be for us at the milestones of our career to make a retrospect, in order, like the mountain-climber, to gather fresh strength from a contemplation of the difficulties already overcome." Taking this as his text the editor calls attention to what the Austrian army has gone through in the last fifteen years, in working itself up to its present state of discipline, efficiency and respect on the part of the public, from the days of 1920 when officers were not saluted, and groups of men in uniform took part in demonstrations in the streets. With Austria's demand to the League of Nations for equal rights of armament with other nations, in order in the present unsettled state of Europe to be able to defend its independence, hopeful prospects open up for the development of her forces. Great are the demands which 1935 may make upon the soldier, and only serious training in all ranks upon a scientific basis will enable him to do his duty to his country.

Fort Hensel in the Great War, by Colonel Baron Wolf-Schneider. In all Austria's wars concerning its south-western frontier the space between Tarvis and Villach, difficult of access, difficult to traverse and poor in roads, lying between the Carnic and the Julian Alps, has played an important role. This space lies on the shortest route from upper Italy into the heart of Austria, to Vienna: it is here that the roads up the Tagliamento and the Isonzo meet the military roads, from Tarvis down the Save into Carniola and Croatia, and along the Drave from the Tyrol through Villach to Styria and Hungary.

In 1808, after war had on several occasions suggested the desirability of fortifications being built, work was started on two forts, one at Malborghet, west of Tarvis, and the other guarding the Predil pass, south of that place. They were soon put to the test, and in May, 1809, Fort Malborghet under Engineer-Captain Hensel and Fort Predil under Engineer-Captain von Hermann each held up the advance of a French column for four days, the defenders earning undying fame for their self-sacrifice: in fact, the Austrian Thermopylæ!

After Austria's S.W. frontier had been pushed back in 1866, owing to the loss of the province of Venetia, the former importance of the Tarvis-Villach area revived, and in the 'eighties the barrier-forts were brought up to date. The names of the two engineer officers, the heroes of 1809, were perpetuated in the new works, Fort Malborghet being renamed Fort Hensel. The latter consisted of two works, 140 metres apart, with underground communication, bomb-proof shelters, armoured turrets, masonry escarp, rock counterscarp, a high wall for the gorge, and the whole wired in. Its armament was originally two 10-cm. howitzers, four 9-cm. guns for flanking, and eight 12-cm. guns; but most of the guns were removed in the spring of 1915 to fresh positions outside, since it was realised that an old, at best only adapted, fort would be unable to stand up to modern siege artillery.

When Italy declared war on May 23rd, 1915, the position of Fort Hensel between three and four kilometres behind the front line must have been a source of anxiety to the Austrians. It could still fulfil its function as a barrier to an advance up the valley, but, in the event of its being seriously attacked from the mountains overlooking it, it would become merely a cockshy. It was part of the original Italian plan for their Carnian Corps to capture Tarvis, so as to cover the left flank of the Second and Third Armies, striking due east, but the Corps Commander preferred to remain on the frontier to butting against the barrier-forts. Instead, the Italians seized the heights required for their O.P's and brought up their heavies. Fort Hensel had thus achieved a purpose. On the 20th June a systematic bombardment of the fort started which lasted 48 days. During that time eight mortars and howitzers of calibres from 15 to 30·5 cm. fired 300 tons of ammunition at the fort, hitting it at least 1,200 times. At the end of that time the fort had still in action two howitzers and one gun, or three-quarters of its total armament. Ten months later, on 19th March, 1916, the fort was abandoned as only a heap of ruins, the commander being one of the last people killed.

It is one of the astonishing stories of war that this fort held out so long, hopelessly outranged and against overwhelming odds, its garrison patching up by night as well as they were able the damage done each day. The Archduke Eugène, who published an A.O. on the subject, said that what had happened was a proof that the strongest defence is not armour-plate and masonry, but the spirit of man.

Questions about the Use of Artillery, by General von Eimannsberger. What the former Inspector of Artillery has to say on this subject is worthy of the closest attention. In lecture form it occupies here 14 magazine pages, and is so concisely put that the shortest possible *résumé* could hardly condense it (*experto crede !*) to less than 2,000 words. This lecture concerns first and foremost the General Staff, and it might have been entitled "The Conduct of the Battle of the Future," but that it was desired to bring out particularly how the warfare of the future will affect the artillery arm. Readers of "Tank Warfare" (*v. The R.E. Journal*, September, 1934, p. 459) will, however, have already gained the impression that its author is a soldier first, and a gunner afterwards. In this article his careful analysis of the events of the Great War, particularly of the *Chemin des Dames* offensive of May, 1918, and his clear thought lead him to conclusions devoid of partiality, as witness :—" Decisive for the future of the artillery as an arm will be whether it succeeds tactically and technically in adapting itself to its new tasks, and the mobility they demand. The task is there : if the artillery cannot, or will not, solve it, other arms will and must fill the breach, the tank itself and the aeroplane."

The Final Manœuvres of the Italian Air Forces, October, 1934. Italy carried out last year short, but instructive, naval manœuvres off Gaeta, army manœuvres on a large scale in the Tuscan Apennines, and finally an air force exercise. The latter was intended to show the capabilities of the Italian airmen, their latest machines, and especially to test the bombers. For the latter purpose near Furbara, on the coast, about 40 km. west of Rome, a "harbour" was laid out in outline on the ground, including the outline of a large ship, while on "shore" were indicated a railway terminus, a factory, and the hangars, etc., of an aerodrome. Attacking or defending, 160 planes took part in the exercise, and the enemy bombers whose base was at Orbetello, about 80 km. away, dropped 1,000 bombs (totalling a weight of 25 tons) in 20 minutes. There followed acrobatics, and a march-past in which three patrols flew one above another at very great speed and closed down to one plane's height apart. Photographic films taken during the bombardment were dropped by parachute, and the prints on view in forty minutes. In the latest pattern bombs, from 44% to 49% of the total weight is explosive.

International Military Politics in 1934. Major-General Paschek makes his annual review of events affecting international relations. In his preliminary remarks he points out that the seriousness of the military situation in the Far East and in Europe can be traced to similar deep-lying causes. In each case a great nation is struggling for the conditions upon which its continuance is possible ; Japan, for room to settle her surplus population and for an economic sphere of influence ; and Germany for the right to arm like other nations. At present Germany can get no allies, as it has nothing to offer them. Germany's right to re-arm, after a restriction lasting more than half a generation, can no longer be denied her. It will in any case lose in value owing to the increase of armaments " knowing no barriers " of the nations around her. Thus we have hard times ahead !

The author then carries out his review under the following headings, a distribution which is in itself instructive, apart from the elucidatory notes under each heading and against each nation mentioned :—

I.—Grouping of the European Powers.

A. The struggle for the New Europe.

1. The French sphere of influence.
   (a) The Western Group :—France, Belgium, Spain, Portugal.
   (b) The Little Entente :—Czecho-Slovakia, Jugo-Slavia, Rumania.
   (c) Russia.
2. Italy, intermediate between 1 and 3.
3. Disarmed Central Europe :—Germany, Austria, Hungary.
4. The Protection of Eastern Europe against Bolshevism :—Poland, the Baltic States.
5. S.E. Europe and the Levant :—The Balkans, the Near East.

B. The Neutrals :—Switzerland, Scandinavia, Denmark, Holland.

Apart from England being mentioned a few times the British Empire is not dealt with under I, being reserved for II, " Outside Europe," an almost complete return to splendid isolation.

A table of armaments of forty different countries gives statistics relating to armaments under thirty separate headings.—(*To be continued.*)

(*February*, 1935.)—*The Russo-Polish War*, 1919–20. Colonel von Wittich continues his considerations, critical and uncritical (*v. The R.E. Journal*, September, 1933, p. 537, and September, 1934, p. 494). He resumes his story in the middle of the second of the three phases of the war, when the Russian drive of the Poles back from the Dnieper to the Bug had been checked by the Polish counter-offensive in the north. On July 4th the second Russian offensive in the north started at dawn with heavy artillery and tanks. At the decisive spot they had 12½ infantry and 2 cavalry divisions against the Polish 5½ divisions, and gained 15 to 20 kilometres the first day. At this juncture Poland appealed to Great Britain, and the British Foreign Minister proposed a line behind which the Poles should retire, with the Russians 50 km. away. Fortunately for Poland, the Soviet, sure of victory, would not agree to the Curzon Line, and declined all foreign intervention. The Russian drive continued ; on July 20th the Polish 4th Army was broken through at Slonim on the Szczara, and by August 6th the Russians were on the Bug and threatening Warsaw. Here Colonel von Wittich stops to weigh the pros and cons of a continuation of the Russian offensive, the factors making for a Polish national revival, French assistance, etc., the mistaken Russian idea that the people of Warsaw were eagerly awaiting the opportunity of going Bolshevik, and the state of demoralization of the Polish 1st Army, which led the C.-in-C. of the Russian Northern Group of Armies into the grave psychological blunder of judging the state of the other four Polish armies by what he himself had seen and heard of the beaten troops in front of him. This short chapter sets the scene for the curtain to rise on the turn of events in Act III.—(*To be continued.*)

The Most Important Manœuvres in 1934. There was in general an increase in scale all round. The article deals first with Austria's neighbours—Italy (most importance attached to the army), Czecho-Slovakia, and Switzerland. Hungary and Jugo-Slavia held manœuvres, but allowed no particulars to be published. Germany held no manœuvres on the grand scale. Further dealt with are France, Great Britain, the U.S.A. (on the largest scale, sea and land) and Russia (very large manœuvres, but with much secrecy, no foreign officers being present except Italians, and not even the foreign attachés from Moscow being invited). Japan is not mentioned.

Cross-country Motor Vehicles in Military Service. For the benefit of his Austrian readers Major Schmilauer relates the development from the tracked to the wheeled c.c. vehicle, and the present-day uses of the latter, with six to eight wheels of which at least four are driven, for moving troops, light, medium and anti-aircraft artillery, for artillery reconnaissance, for the carriage of pontoons and engineer tools, and for cavalry first-line transport. Some of these c.c. wheeled vehicles can be converted to semi-track when necessary. Tracked vehicles in any case remain indispensable, and an example of their use is given from the 1934 manœuvres in the mountains close to the Semmering Pass, where a 10·4 cm. howitzer in three loads was taken up over 2,150 feet in 9½ hours by caterpillar tractors. A 10-cm. gun in four loads, which followed it, only failed to accomplish the same feat by being overtaken by darkness when just short of the top, the officer in charge preferring for safety to wait till daylight.

International Military Politics in 1934. Part II of these admirable notes deals with "Outside Europe" and with general questions, the League of Nations, armament *v.* disarmament, naval limitations, armament industry, capitalism, army organization, economic preparation for war, the advance of weapon technics, world economics and world communication.

General Paschek here puts some questions to his readers to pursue :—(1) In what countries does their distressed economic condition indicate a danger of war ? (2) To what extent does international capitalism gain by war, and influence it ? (3) To what extent can the intervention of the state do away with the canker of unemployment ?

Outside Europe is dealt with under the headings :—The British Empire, the United States, Latin-America, the Far East ; the policy of the first-mentioned in 1934 being summed up in one sentence : "As England, in its narrow sense, burdened with the weaknesses of its home defence, in all questions of European power gives way to France, and especially avoids all military obligations on the Continent, so the British Empire as a whole strives to keep its as yet untried new internal relationship from any disturbance."

The notes end on 15th December, 1934, since when much water has flowed under bridges.

Before the Decision in the East. Under this title Major-General Kerchnawe deals with the Austro-German campaign against Rumania, and the last offensive of the Russian Imperial army, being the contents of Parts 3 and 4, the second double-number, of Vol. V of *Austro-Hungary's Last War.*

Laudon, Wanderer and General. Colonel Baron Wolf-Schneider reviews this book by F. Winterholler, published by Staackman's. It is far more than the novel it professes to be, and is here praised for its historical and biographical accuracy. Loudon (the spelling has been changed to suit German pronunciation) came of a Scottish family which had emigrated to Livonia. At the age of 16, in 1732, he entered the Russian army as a cadet and marched with it through Europe to the Rhine and back almost to the Black Sea. Later he tried his luck in Sweden, and only the fact of being a thoroughly bad sailor kept him from trying to enter English service in the East Indies. He turned to Prussia instead. Frederick was engaged in raising a new army to fight Maria Theresa, and Loudon offered his services, was kept waiting nearly a year in straitened circumstances, and then arrogantly refused. As Eugène had done before him in a similar case, he wandered to Vienna and was welcomed by the Austrians. In 1744 he was once more on the Rhine, fighting as a Captain. During the Seven Years' War he crowned Austria's standards with unfading laurels, beating the great Frederick time and again, notably at Domstadl, Hochkirch, Kunnersdorf and Schweidnitz. As a Field-Marshal and at 72 years of age Loudon was called upon by Austria once more ; and this soldier of fortune put the crown on his military career by capturing in succession the fortresses of Dubica, Novi, Berbir, and, finally, in October, 1789, Belgrade.

Other articles in this number are: *My Experiences as a Musketry Teacher*, by Colonel von Loneck, and *National Service Conscription for Women*, by Lieut.-Field-Marshal von Urbanski, an article called forth by the news that Poland is increasing her war-time army from 2¾ to 4¼ millions by conscripting over 1½ million women, capable of taking over a man's work at home and thus setting one more man free for the front.

(*March*, 1935.).—*The Early Training of Officers in Austria*. An empire like the Austrian, constantly at war, was bound in the course of time to have a large number of military schools of various sorts, and Major-General Kainz has compiled some notes on their history. One of the earliest of these was founded in Vienna in 1666 for the purpose of producing "capable military engineers," and was extended in 1735 to embrace "the fire-worker's art." In 1717, thanks chiefly to the efforts of Prince Eugène, an "Ingenieur-Academia" was founded to teach *Architectura militaris* with the mathematical sciences pertaining thereto, *Arithmetica*, *Geometria tam theorica quam practica*, . . . *Statica*, . . . *Mechanica*. When the Engineer Corps amalgamated with the Sapper and Miner Corps in 1851 this school became the "Genie-Akademie," hence the forerunner of the Engineer Division of the Technical Military Academy.

Many of the old schools for the making of officers took boys from six or seven years of age.

Infantry Field Survey. The introduction of infantry-accompanying artillery has brought with it the necessity for infantry field survey. Its objects are given as (1) Observation for intelligence purposes. (2) Communicating information for the fire-direction of the infantry heavy weapons. Lieut. Fussenegger, after two years' experience with an infantry F.S. section, thinks the veil which surrounds this new institution should be lifted. He says: "Infantry Field Survey is simple, and should not remain the wisdom of specialists." The work of the section, starting with resecting its own groups, is the making of a plan on which the positions of the heavy weapons and of the targets seen are to be marked. It consists of 1 officer, 1 N.C.O., 3 survey groups of 4 men each, and 1 central collating group of 9 men; total, 1 officer, 22 O.R. As it has 700 kilos of equipment, it is best carried in two 1½-tonners, men and all. Lieut. Fussenegger says that its training will take fully 9 months of 25 to 30 half-days per month.

This number also contains:—*Tactical Exercise No.* 1, the first of a series of exercises by Colonel Zellner, dealing generally with a strengthened infantry brigade, with attached artillery, in this instance in defence in mobile warfare. The object is to bring out points in the new Austrian Combat Regulations. *Training of the Artillery Pack-animal*; this refers not to mules, but to the "Haflinger," a mountain pony from the Sarntaler Alps between Bozen and Meran, a bright bay with characteristic tow-coloured mane and tail, hardy, persevering and sure-footed. He is an excellent pack-animal, good in draught, and very good as a rider in the mountains. Thus, for mountain artillery work one "cannot put him wrong." *The American 75-mm. Mountain Howitzer M.*1 (with photographs), taken from an article in *Army Ordnance*, Washington. *The Soldier of the Reich, Prince Eugène*; Colonel Heller reviews the book by Rössler (published by Stalling, Berlin) bearing this title, and as a biography he praises it. He takes exception, however, to the standpoint from which it is written, as the very title discloses. We have already had a case made out by Fascist Italy for claiming Austria's great soldier (*v. The R.E. Journal*, December, 1933, p. 696) as an Italian on the ground of his birth as Prince of Savoy; and this claim cannot be denied. When, however, as in Rössler's book, Eugène is claimed for Hitlerian Germany, this is a pure ramp. Eugène served, not the Reich as it now is in Germany, a centralized German National State, but a Reich impersonated by the Emperor, reigning in Vienna, the head of the Holy Roman Empire of German nationality.

F.A.I.

WEHR UND WAFFEN.

(*From 1st April, 1935, re-named WEHRTECHNISCHE MONATSHEFTE.*)

(*January*, 1935.)—*The Base in Sound-ranging*, by Prof. von Hofe and Dr. Raaber. Hitherto, methods of determining the direction of the source of a sound have rested upon three different theories. The oldest of these methods was based simply upon the greatest intensity of sound. A sound-receiver, generally a conical funnel, is turned so as to bring the sound to its loudest. The system thus works with one ear. Rayleigh's phase theory starts with the use of two ears, and says that the direction of the source of the sound is recognized by the sound reaching both ears in the same oscillation phase. The time difference theory of von Hornbostel and Wertheimer maintains that the direction is correctly determined when the sound reaches both ears simultaneously, and that the time difference determines the sensing of the wrong direction.

Sound-direction finders on the intensity principle are very inaccurate even when arranged for two ears instead of one. The other two theories are hardly to be distinguished one from the other. Both of them lead to the result that the determination of direction is the more accurate, the greater the distance that separates the two receivers.

The firm of Goerz has lately made from the design of Dr. Maurer a sound direction finder, which works on the intensity principle, but must be binotic. It has a right and a left receiver. Each receiver is a combination of paraboloid and ellipsoid, built together so as to have one focus in common, so that sound waves arriving parallel to the axis of the paraboloid are reflected by the paraboloid to the common focus and travel thence to the other focus of the ellipsoid (*v. The R.E. Journal*, December, 1931, p. 753). Each paraboloid receives sound waves and passes them to the receiver when they come from directly in front of it or from its own side. It reflects outwards (*i.e.*, rejects) any sound wave coming from the other side. In other words, the right ear hears to the front and to the right, the left ear hears to the front and to the left. This arrangement makes for extraordinary accuracy.

Since constructively the two receivers of the Goerz listening apparatus have to be a certain distance apart, it has often been asserted that a base is necessary, and that the instrument works either wholly or at any rate partly according to the time difference theory. The authors have now shown theoretically that this new sound-direction finder works neither on the phase theory nor on the time difference theory, and have proved experimentally that it needs no base at all.

Peace Training and War Experience. Lieut.-General Marx continues his war experiences as a battery commander. In this instalment no examples appear of faulty peace training, but an instructive example is given of an artillery brigade taking up position with the batteries in line along the edge of, but within, a wood. This surprising situation was made possible by the work of a half-company of pioneers and an infantry battalion, which felled enough trees to provide a one-way road through the wood on one flank, along the position, and back through the wood from the other flank. The men spoke of this adventure ever after as " The merry-go-round at Nouillon."

There is the usual crop of good stories, for instance, of the French cavalry patrol (shining helmets, red breeches and all) which surprised and was surprised by a German artillery reconnoitring party, how they stared at each other through their field-glasses, while not a sound was heard except the occasional champing of a bit, until both sides decided to melt away, which was done with a cheery wave and to mutual relief.

There is also a picture of the artillery brigade which was not called in the morning, and how the O.C. battery had to crawl out of his *pal* on all-fours at the feet of the orderly officer sent to find out why they were not on the march with the rest of the division; and how in consequence they had to get off without even watering the horses, and go into action without their breakfast coffee.

The analysis of the Serjeant-Major's frown when he is about to report something amiss, and how the O.C. can read its meaning, before the report is made, according to the occasion, place and hour of the day, is a bit of fun appreciable in any army. —(*To be continued.*)

New Constructional Ideas for Improving the Driving Properties of Motor Vehicles. It is a peculiarity of the constructional progress in automobile manufacture that it takes place by means of changes which are repeated with noticeable regularity. On the one hand, constructional ideas of a purely technical nature are adopted: and on the other hand both the constructional principle and its method of execution are retained in their essentials, but new methods of manufacture are adopted for the cheapening of production. The rarer case in which such technical and economic development occur simultaneously is therefore of the greatest significance.

An example of this nature is given here in an article, well illustrated with photographs, dealing with synchronized springing and the stabilizer, both invented for the purpose of reducing the fatigue from which drivers suffer after many hours of jolting, and which is prejudicial to their safe driving. The first difficulty to be surmounted was the reducing of the fore and aft jolting motion, which is caused by the front axle springs necessarily differing from the rear axle springs, the former, because of the steering, being shorter, stiffer, and with small lateral play. A new system had to be devised in which the two functions, lateral stability and large vertical play of the springs, are organically separated and work independently. This has been done in the synchronized springing of the Adam Opel Coy. of Rüsselsheim in the manner here described and illustrated, the steering being done not on the wheels, but on the steel spring boxes.

There remains the question of lateral stability. This is achieved by means of the stabilizer, which consists principally of a torsion spring, the two ends of which are connected with the arms of the two hydraulic shock-absorbers above the rear axle springs. The effect of this torsion spring is that the axle springs no longer come into play independently, but over bumps or round curves they assist each other. The car is thus kept almost on an even keel, and corners can be taken without noticeable centrifugal effect upon the passengers.

Both arrangements, for longitudinal and for lateral stability, are included under the one title of synchronized springing.

The Transport of Wounded, by Dr. Adam. After a series of articles, which started with the various ways of carrying a wounded man on the battle-field, and passed in review many patterns of stretcher, plain and wheeled, the pack-saddle, and the ambulance, horsed and motor, this final instalment deals with hospital trains, hospital ships and barges, and the ambulance aeroplane.

The first transport of wounded by rail is claimed to have taken place in Germany in 1859 when coaches of wounded were added to ordinary trains. Further experience was gained in the wars of 1861–64 and of 1866, and the hospital train *per se* came into existence at the end of the Franco-Prussian War. Now all armies have these independent and self-contained units, with a normal capacity of 300 lying or 500 lying and sitting.

It is stated that British mobilization schemes in 1914 contemplated the provision of one hospital train per division, or roughly 20,000 men. This scale was not attained. Actually there were 41 British hospital trains in 1918 to serve an army of two millions in France and Flanders, and 20 more on the railways of Great Britain. The number of wounded and sick carried by these trains was 3½ millions in France and 2½ millions in England.

The composition of a hospital train is dealt with, and also the organization into flotillas of the hospital barges which rendered invaluable service on the waterways, conveying the cases of head and body wounds, which were not fit to stand the shaking of a train. The barges on the Somme Canal alone carried 13,000 French wounded in the month of July, 1916.

Mention is also made of the motor-launch ambulances used in Mesopotamia.

The aeroplane made its appearance as an ambulance in the Great War, but has been mainly developed by the French since, as a result of their experiences in Algiers, Morocco and Syria. In 1925 two Hanriot '14's were converted to ambulance purposes, later a Bréguet '14, since replaced by a 1929 Potez, taking two wounded and fitted with special shock-absorbers. The Hanriot 431 bomber has also been used, and the Farman 60 which can take up to ten stretcher cases.

A photograph shows, converted for hospital use, a closed railway truck, which turns out on examination to be an old friend of the B.E.F. in France, known as the "*Quarante hommes et huit chevaux.*"

Strategic Demolitions carried out by the British Fifth Army during the Battle of the 21st to 27th March, 1918. Colonel Wabnitz continues his very careful analysis of General Buckland's account. He points out that, after deducting 43 bridges which were handed over to the French to destroy, there remained 273 bridges for the British to destroy and that only 25 of these were failures. This percentage, considering the difficulties already pointed out, must be considered as small. He then selects a number of cases for description as being the most interesting from a technical point of view. Among these are the Omignon bridges at St. Martin les Prés (r.s. joists) and Tertry (semi-circular brick arch); the clean job of the Tortille bridges made by the 178th Tunnelling Coy. at Moislains, Allaines and Feuillacourt; the "100% for contingencies" used by the 260th Railway Construction on the railway bridges south of Péronne; and the treatment of the bridge at Hargicourt, an r.c. roadway carried on steel girders, only 18 in. above the water, and a single brick pier. As typical of the method of destroying wooden pile bridges a report of the C.R.E. 36th Division is quoted.

The author then turns to the failures. That nearly 50% of the railway bridges fall in the category of not or incompletely destroyed he attributes to the confusion he has already pointed out in the giving of orders for preparation and execution. In the case of road bridges the fault lay partly with insufficient charges, partly with insufficient attention being paid to the structure of the bridge, or it was due to unforeseen *contretemps*. Particular cases are cited at Chauny, Bretigny, Éclusier, Jussy and Sommette-Eaucourt. At Pithon the firing party was lost; while the, lattice-girder canal bridge on the Ham-Noyon road fell on the lock walls just below and remained easily passable by infantry.

An example is given of how hard it is to give instructions to fresh units arriving in the middle of a battle. The 15th Field Coy. arrived at Nesle from Belgium on March 23rd and wasted a day in waiting for orders. At night they were sent in lorries to Licourt to destroy three bridges, with no maps and hardly any guncotton. Their tasks were impossible under the circumstances, and the results achieved negligible.

Other demolitions mentioned are those of pumping-stations and dumps.

As regards criticism, Colonel Wabnitz agrees with all the more important points made by Lieut.-Colonel Playfair in his "Foreword," with the French regulations as regards the futility of demolitions left purposely incomplete with an eye to a subsequent advance, and with the *Encyclopædia Britannica* as regards the divided responsibility between R.C.E.* and the Corps. He approves, too, of thorough preparation for a withdrawal including the early demolition of all non-essential bridges, as against improvisation at the last moment. As regards aiming at getting an officer at every "last-minute" site he points out that this is neither practicable nor necessary, given the right stamp of N.C.O., as the case of Serjt. Crossley, of the 1st Siege Coy., at Falvy, on the 23rd March, proves.

If we had proceeded on the same lines as regards demolition as the German 6th, 1st, 2nd and 7th Armies did before retiring to the Siegfried position a year earlier,

* Railway Construction Engineer.

what our divisions were able to achieve in the adverse conditions of their retirement shows that the 5th Army would have saved much of its losses.

The Artillery of the Alpine Corps in the Break-through Battle of Tolmein. Lieut.-Colonel Stuhlmann states here very clearly the origin of one of the greatest victories in the history of war. He says that the effect of the Isonzo battles, especially of the eleventh in August, 1917, was to make the Austrians feel that they would lose the whole river front if the Italians attacked again. There was nothing for it but a great counter-offensive, and this would only be possible if the Germans helped. The 14th German Army was sent under von Below, and had allotted to it the main attack west of Tolmein. It carried out the attack on a front of four divisions. To one of these, the so-called Alpine Corps (Bavarians), fell the most difficult task of capturing Height 1114, the key of the Kolovrat position, which ran parallel to the river. As paving the way to this, the work of the artillery of the Alpine Corps (221 guns, of which 83 were Austrian, and 93 trench-mortars) was of the greatest importance, and an account of it is given here under the headings, assembly, organization, sectors, registration, fire orders, and tasks.—(*To be continued.*)

The Air Forces of the Different Nations (continued). France. As in England there is a great tendency towards fusion among firms in the aircraft industry, thereby increasing economic power of production and the nation's air strength. Three large firms have formed a block, Bréguet, Wibault and Penhoët. Most of the article consists of items culled from *Les Ailes* and *l'Aéronautique.* Farman's and others have entered the Air Ministry competition for multiple-seater fighters. Morane-Saulnier has produced a two-seater fighter with two Hispano engines capable of 400 km. an hour, armed with two guns, as well as m.g's. Nieuport's by the autumn of 1934 had produced fifteen different types of single-seater fighter. There is also a long list of new bombers, many of which have Gnome-Rhone engines, by Bernard (2,800 km. range), Couzinet, the S.A. Bordelaise, Bloch, Loiré et Olivier, Potez, and the St. Nazaire works (a hydroplane).

(*February*, 1935.)—*Peace Training and War Experience (continued).* The extraordinary position taken up inside the wood at Nouillon by the half-brigade which included the writer's battery was a complete success. Through a long day's fighting never a round was fired at them, and that although their position was so full of danger that they had already been ragged as *morituri.* The explanation is twofold: (1) that the muzzles were so far back inside the wood that no flash or smoke betrayed them; (2) that when, in accordance with an old artillery rule, the French gunners in retiring over this country, had examined it for possible enemy battery positions, they must have ruled the wood out as impossible. During the fight they saw that there were no German batteries in the bracken clearing, and they located them behind the wood instead of inside it. The mainsprings of this successful manœuvre were the genial idea of a one-way road through the wood, the labour that felled the necessary trees, and skilful concealment. It is good to know that the teams picked their way round and over the stumps without hurting themselves.—(*To be continued.*)

The Artillery of the Alpine Corps in the Break-through Battle of Tolmein. This instalment continues the tasks, records the ammunition provided, and gives a short account of what happened on the 24th October, the day of the attack.

The International Automobile and Motor-cycle Exhibition, Berlin, 1935. This is by way of being a guide to the Exhibition, written before it started. It gives a few tips, such as that the motor-cycles are going to show the greatest variety of types, that cars will be generally more comfortable, therefore heavier, and that the Diesel-driven lorries will have many novelties and improvements. It also discloses that the much-advertised "popular" car will not make its appearance after all, certainly not this year and possibly not in 1936.

The History of the Telephone. With reference to army telephony Lieut.-Colonel von Dufais runs over this early history, necessarily starting with the telegraphy from which telephony grew. Apart from von Sömmering's signalling of letters in

1755 by electrolysis, which needed as many circuits as there are letters, telegraphy starts with the needle instrument which Gausz and Weber used at Göttingen Observatory in 1833, after which Steinheil printed letters at a distance in 1836. A year's priority is thus claimed over Morse. Telephony starts in 1860 with Reis, who first made an instrument capable of reproducing sounds by electrical means. Utilizing Faraday's discovery of electro-magnetic induction, Graham Bell, in 1875, made the first practical telephone, which has held the field till to-day. In 1878 the microphone was invented by Hughes (the author gives the palm to Dr. Lüdtge, a German), who returned to Reis' original idea of a battery to supply the main current upon which variations caused by the voice are superimposed. As regards the call, the electric bell, dating from 1846 (Siemens) was introduced into the public telephone service, necessitating the calling switch. In 1877 the telephone became of use for military field purposes through the introduction of the buzzer, on the self-interrupter principle. In 1896 the latter was built together with a hand-set into the military field telephone. In 1900 the bell call could be introduced into the army by adopting from the post office the magneto-generator.—(*To be continued.*)

The remaining articles in this number are *The New Artillery Regulations* (*Gunnery*), in which Lieut.-Colonel Schlieper points out for officers and N.C.O's the additions and changes. *Russia's War Losses*, 1914–17, a Russian source makes the total over seven millions, over half of whom are shown as "missing and prisoners," a method of reckoning which always reduces the number shown as "dead," in this case only 68,000. *The Air Forces of the Different Nations*, which gives more examples of French aircraft firms carrying out fusion, and a table of data of the latest types of bomber. Belgium's success with the new Fairey Fox distant-reconnaissance two-seater is mentioned, which is claimed as faster than the latest French types of Potez and Bréguet, as well as the distant-reconnaissance Les Mureaux. The performance of the Gloster Gauntlet biplane leads to a prophecy of 480 km. an hour before the end of the year.

(*March*, 1935.)—*The Technical Foundations of France's Armed Strength*, by Professor Völcker. A clear representation of the extraordinary increase, intensive and extensive, of France's war-power technics during the last few years is furnished by the recently developed plan of Lieut.-Colonel de Gaulle (*Militar Wochenblatt*, 1934, No. 16) for a heavily armed and highly mobile professional army of 100,000 men. This proposal, which is quite within the intention of the present War Minister, General Maurin, sees a motorized and mechanized professional army of six-year soldiers immediately behind France's fortress army. The seven divisions of this army, each containing an a.v. brigade and an infantry brigade on cross-country a.v's, with special troops and general reserves of very heavy tanks, would be able on the first day of war to penetrate 100 km. into enemy country. It would have three times the fire-power and ten times the speed of a corresponding force in 1914.

As in all that concerns war this matter has a twofold foundation, material and personal. Prof. Völcker thoroughly examines French conditions, industries and products on the one hand, and on the other hand national character and capacities. He comes to a decision that an army of the nature indicated is in France a technical possibility. The proposal is capable of realization. It is to be taken thoroughly seriously.

The History of the Telephone. Lieut.-Colonel von Dufais continues with the advantages of the generator call for military purposes in the field, then describes the simple switchboard, first adapted for use in the field by Ammon in 1910; the central battery, 1906; the automatic call system; amplification; the introduction of a grid by von Lieben into Edison's glow-lamp in 1910 (*v. The R.E. Journal*, June, 1933, p. 371); the idea of wireless telephony suggested by wireless telegraphy; made possible by continuous wave replacing spark; Duddell's arc; Poulsen; the valve as transmitter, 1913; H.F. telephony, or wired wireless; multiple H.F. telephony; telephony on high-tension lines when owing to thunderstorms the ordinary telephone service is out of action; R/T in the field; the connection of one telephone network with another by means of long-distance wireless telephony, 1927; wired wireless applied to moving trains by Huth in 1925, admitting telephony between the train and the public network.

There remains, the writer says, only that favourite of novels of the future, the wireless telephone carried in the waistcoat pocket! Why not? Our age has got out of the habit of saying that any particular thing is impossible. We say instead, "We have not got so far as that!"

Tasks of the Waterworks Engineer in the Fighting near Nieuport, 1914–18, by Professor Oehler, formerly War Geologist, with 17 photographs taken from Captain Déguent's *Les inondations du front Belge*, 1914–18, and *Nieuport*, 1914–18, by Major Thys. The object of this article is to stimulate interest in questions in which the engineer can effectively support the tactician, and must be called upon to do so. The writer claims that the case of Nieuport proves that on both sides the engineer was missing and that both armies suffered in consequence. This may seem a little hard on the Belgians, who at least stopped the German advance along the coast by means of inundations, and saved the Allied line from being outflanked; but the writer adduces so many instances of the Belgians failing to make the most of their opportunities that one is drawn to the conclusion that this new factor, neglected by the one side, was applied only tentatively, and often without the necessary understanding, by the other.

Prof. Oehler's conclusion is that the German spirit of attack, which found its superior in the inundation, would, with the necessary technical knowledge and ability, have captured Nieuport and brought about a completely new war situation. Hence the moral, wherever local water conditions indicate a possibility of this great aid to field fortification, water engineers and geologists must be called upon at once, and the more they know of local conditions the better.

International Automobile and Motor-Cycle Exhibition, Berlin, 1935. This instalment deals with special shows and with the exhibits of the car section. The latter, starting with Daimler-Benz, who alone showed 26 different types of car, were the products of 13 different firms. Of the cars in general it is stated that there was little this year of real technical novelty or surprise. The chief item of interest among foreign cars was the very successful Fiat-Balilla sports car. The special shows were: (1) Historical, by the State Union of the German Automobile Industry: engines and aggregates, which have been landmarks in automobile development; also cars and motor-cycles which have won great events. (2) The State Postal Department, which is the user of a fleet of 14,500 vehicles. Amongst the exhibits it was noticed that the Diesel engine has now got down as far as the 1½-ton postal delivery wagons. Also shown were an electric-drive parcel-post wagon and wagons driven by propane and butane, to which the name has been given in Germany of "State" gases, referring presumably to their home origin as derivatives of methane. (3) The State Railways, which showed wagons with wood-gas generator drive, and steam-driven. Here the most interesting exhibit was a four-wheel wagon for use either on the road or on rails, hence of great military importance. On the road they are either towed, or self-propelled, and can go straight on to the rails. (4) An exhibition of drawings and plans illustrating the proposed National Scheme for providing at the same time a network embracing the whole country of broad automobile roads, and work for the unemployed. (5) A show by Mercedes entitled "Forty Years' Racing."

There are a number of good photographs and drawings which include the Mercedes-Benz double swinging-axle Type 200, 2-litre, 6-cylinder, and the Hansa Lloyd and Goliath Works front wheel suspension, and rear swinging-axle by the same firm.

The United States Army War College. After the war with Spain this college came into existence at the same time as the General Staff. During the Great War it was suspended, and when it came to be revived in 1919 it took its present title instead of General Staff School. The Army War College then ceased to train for the General

Staff, and became a school for senior officers. The course lasts ten months, and 75 officers are ordered to join. According to *The Military Engineer*, from which this account is compiled, officers must not be over 52 years of age, and half of them should be under 44. The College seems to be not very popular.

F.A.I.

VIERTELJAHRESHEFTE FÜR PIONIERE.

(*February*, 1935.)—The frontispiece is a photograph of General von Mudra, who was head of the Engineer and Pioneer Corps and Inspector-General of Fortifications, 1911–13. He is quoted as having written: "The Pioneers entered the Great War as the troops who had been through the hardest training and preparation. Their performance throughout as fighting and as technical troops accorded with the highest requirements. They were splendid from beginning to end."

175 *Years of Pioneer Training Regulations.* The regulations dealt with are those of Prussia only up to the "War of Union," 1870–71, when the Pioneers of the various German States became one Corps, excepting those of Bavaria, which remained separate up to 1914. Up to 1810 there were in existence: an Engineer Corps, consisting of officers only, first strictly organized in 1729; a Pontonier Corps, started in 1715 as a company of the Artillery, with copper pontoons; and a Miner Corps, started in 1742. Most of the other states, but not Prussia, had also a Corps of Sappers. The attack and defence of fortresses was carried out by Engineer officers mostly with infantry labour. In 1810 the separate Engineer Corps was done away with, its officers joining the Pioneer Corps, which contained Pontonier, Miner and Sapper sections. The first regulations were "Instructions to Field Engineers," dictated by Frederick in winter quarters at Breslau in 1758. The latest are: 1923, Field Fortification; 1926, Blocking and Demolitions; 1927, Pontoon Bridging; 1932, Light Field Fortification; 1932, Ferrying and Bridging with Extemporized Material.

That the collection of material for publication is not unattended with difficulties appears from the record of a Commission which sat for nine years, 1833–42, working out Pontooning Regulations, and was then dissolved without having completed its labours.

Short Training for Pioneers. This article is an example of a coming event casting its shadow before. The writer asks, "When we get our men not for twelve years but for only two, or perhaps for even only one, shall we be able to train them?" His answer is, "Yes, with three provisos." These conditions are: (1) The recruiting must be done by Universal Military Service, as no other system can produce the necessary tradesmen. One of the keys to the success of the pre-war short-service system was the annual quota of specialists among the recruits: boatmen, miners, motor drivers, carpenters, smiths and fitters. (2) Pre-military training, such as "all foreign nations have." What this aims at is not "playing at soldiers," but physical training, and the sort of things a boy scout learns. (3) That the Short Service introduced is for two years, and not for one.

Granted this last proviso the pioneer recruit's first year might be divided up as follows:—Individual training, infantry and technical, 18 weeks; collective training, infantry, 5 weeks; bridging with service equipment, 6 weeks, with other material, 3; preparing blocks, 5 weeks; field fortification, 2½; exercises away from barracks, 3½; manœuvres, 3; training of recruit instructors, 3; holidays (Christmas, Easter, Whitsun), 3; furlough, 0; total, 52.

Battle Training of the Pioneers. There is nothing weak about this interesting and convincing article except its somewhat misleading title. The Pioneers of the German army, corresponding to our own Divisional Engineers, were before the war fully equipped and trained as infantry, and had to be prepared to act as such, when occasion demanded, and the carrying out of their normal engineer duties permitted. This article indicates two fundamental changes which have occurred, resulting in a cleavage between the Pioneers of 1914 and those of to-day. First, the infantry has received, and is trained in, a number of heavy weapons, distinguishing it in armament and training from the pioneers. Second, the pioneers themselves, in order to be equal to the much increased number of their technical tasks, have become increasingly mechanized, and thus distinguished from the infantry. In short, the Pioneers are more indispensable than ever as technical troops, and their thorough training in their own duties will leave them little time for purely infantry tasks, which, moreover, they are now of necessity less well able to perform.

War Experiences of the Training of Pioneer Storm Troops. Storm troops is the name given to small parties of one to two N.C.O's and four to eight men, specially selected and thoroughly trained in hand-to-hand fighting, whose business it was to lead the storming infantry. As they had to be skilled in the use of all close-fighting weapons they were naturally formed from the Pioneers, to whom had entirely been entrusted the trench-mortars and the flame-throwers. The latter were indeed an engineer store from the first, being carried in the siege train to be used as a substitute for fire-hose. For position-warfare they were sent up to the trenches where the Pioneers studied and tried them out for quite new tasks. Later the flame-throwers and personnel were collected into a special Flame-thrower Detachment, which eventually grew into a regiment, the Guards Reserve Pioneer Regiment, known as the "Death's Head Pioneers." This regiment, when storm battalions came to be raised, furnished each of them with a flame-thrower section, on relief. The storm battalion belonged to the Army Troops. It consisted of staff, 2 storm coys., 1 m.g. coy., 1 mine-thrower coy., 1 infantry gun battery, and the flame-thrower section mentioned. It also acted as a School of Close-fighting, to which officers and N.C.O's were sent from their units in the trenches for instruction. It served as a very special reserve when things got beyond the power of the ordinary troops, *e.g.*, when an attack had got hung up at a particularly bad place, or when the enemy had broken in and could not be dislodged. Army H.Q. was then called upon and sent out in lorries at once the number of storm troops judged necessary. Their fundamental principles were reconnaissance, preparation, working forward to jumping-off positions by night, taking days over it if necessary—and finally the undertaking itself, generally at the first signs of daybreak, carried out with the greatest speed and over in a few minutes, with as little loss as possible.

The article gives some account of equipment, training, and a large scale example which occurred at Fort Vaux in June, 1916.

The Training of American Engineer Officers. Taken from an article by Major-General Lytle Brown, Engineer-Inspector of the United States Army, in the *Army and Navy Journal*, 1933, No. 26. It points out the much respected position of the Engineers in the U.S. Army, and gives great credit for it to West Point.

Pioneer Training in France. This is a sketch of the Engineers of the French Army, their composition and organization.

The Employment of Engineers in the Defence. An exercise in blocking, taken from the May–June, 1934, number of the *Revue du Génie Militaire.* The force concerned is one division on an 8-kilometre front. It has, with its two Engineer coys., one Engineer Park coy. and one Labour battalion, four roads to block, and eight bridges to destroy—the description of each of which is given.

L'organisation du terrain (concluded). Extracts from the French regulations called *Instruction sur l'emploi des grandes unités* are given, with drawings of a Standard Type Observation Post and of a concrete dug-out for 16 men, with cots. They appear under the plea that to facilitate manœuvre the commander needs the *terrain* to be organized so as to provide observation, concealment, protection, and communications of three sorts, viz., signals, movement of troops and movement of supplies. The German writer finds the trail of four years of position-warfare too unmistakable, and gives a warning that tactical regulations must not be taken too rigidly, especially from a technical point of view.

The Pioneer School at Münich. There is no letterpress about this, only four photographs showing a worthy façade and main entrance, trophies, and the German Engineer losses in the Great War, battalion by battalion, recorded on memorial boards. They total to 60,000, including 1,729 officers. The palm goes to the 7th Battalion (1st Westphalian), headquarters Cologne, which lost 90 officers against its war establishment of 36, and 200% of its war establishment of other ranks.

The Fortress of Schweidnitz in the Seven Years' War. The position of Schweidnitz, covering Breslau in Silesia and close to the Bohemian frontier, made it the centre of much stout fighting between the Austrians and the Prussians. After having changed hands twice in the First and Second Silesian Wars, it was four times besieged and four times captured between 1757 and 1762. Short accounts of these four sieges are here given, with sketches. The third capture by a brilliant *coup-de-main* of the Austrians under Loudon was described in *The R.E. Journal*, March, 1934, p. 169.

German Pioneers 150 kilometres behind the Enemy. To show how the situation indicated could be in any way possible it is necessary to outline briefly the general position. In the middle of September, 1914, the German armies having retired from the Marne were now engaged again in fighting. On their extreme right their 1st Army, from south-west of Chauny to north of Soissons, was anxiously looking forward to the arrival on its outer flank of the 6th Army, which should bring the whole advance into flux again. North-east of Soissons there were no more than isolated weak detachments of Landwehr troops guarding the main points on the German lines of communication. Whether the country north-west of the German right wing was free of the enemy the Germans had no certain knowledge, only reports that fresh British troops were about to be landed in France to attack their right and rear. On the 12th September the Germans in their retirement destroyed four railway bridges round Amiens. The next evening at 8.30 p.m. the 18th Pioneer Regt. was ordered by the 1st Army H.Q. " to destroy all railways leading inland from the English Channel " ! " A devilish difficult task," the writer calls it, but that is clearly a euphemism. As the task would have entailed the destruction of 14 railway bridges, spread over 150 kilometres of country which the Germans were not occupying, it was impossible. The demolition parties could count upon finding everywhere bridge guards and *gendarmerie*, and a population ready to take advantage of them, now that they were retiring. There were also in the area, although they did not know it at the time, Bridoux's Cavalry Corps and four French territorial divisions, who greatly increased the thrills of their adventure, which were already sufficiently great. Being fired at heavily by their own patrols, moving by night in cars without lights and hiding in the woods in the daytime, overpowering small parties of *gendarmes*, and escaping by representing themselves to be English, were all in the day's work and gave plenty of scope for presence of mind. One party actually got as far as Rouen before it was scuppered, while the party whose adventures are given here in detail blew up a bridge of eight 16-in. girders at Arras, and got back safely.

In future such undertakings will be easier of execution and the autogiro with firing party and explosives will constitute a real menace. Failing that, the aeroplane and parachute will provide a means of distinction for those willing to run the necessary risk of capture.

The Effect of External Explosions on Buildings. Comparatively small explosions in the vicinity of buildings have their greatest effects on windows and roofs. Generally roofs are built only to withstand pressure from without, *i.e.*, the weight of snow, workmen, their own weight and wind pressure ; and not to resist suction from without, such as is caused on the lee side of buildings by tornados. Similar experience has been made with explosions outside buildings, which often do a surprising amount of damage to a roof on the side remote from the explosion. The pressure-wave of a near explosion passes over the house and produces on the farther side of it considerable underpressure causing rafters to lift, sheeting and roof-covering to fly outwards, an effect as if the roof itself had burst. Generally the more air-tight a roof is, the worse the effect. The remedy is to have a roof, *e.g.*, of tiles, which is not air-tight and to clamp down trusses and rafters to the wall plates, well anchored by bolts to the masonry. The smaller the air space under the roof the better. Large attics extending over a whole house are bad. They should be broken up by cross-walls.

As regards the masonry, the usual practice of building walls both as weight-carriers and as partitions is thoroughly unfavourable. The separation of these two functions, as in factory building, is far better. For instance, in the one case, walls two- to three-brick thick have been simply blown down, while in the other case the main walls have stood while only the partition walls suffered. Nogging walls are recommended, because when they blow out they are quickly repaired again. R.C. concrete walls have stood well, and best of all iron sheeting, Heroklit, or any resilient material. Buttresses have proved surprisingly effective in breaking up explosion-waves which strike them obliquely.

As regards the position of buildings, long rows of parallel buildings should be avoided, and if such exist other buildings which close or stand opposite to the ends of the space between them are very badly placed. As an instance of the effect of guided explosion-waves the case of a powder magazine is cited, which was surrounded on three sides by high earth banks, and on the fourth side was open to the fields. When it exploded it did damage to a village over five miles away but lying directly in its line of fire, since the earth banks caused it to act like a fougasse.

Seventeen Years Later—a Trip to Verdun. The area north of Verdun appears to have become converted into a sort of National Park and National War Museum. It is pleasantly described here in an account of the old battle spots revisited by an ex-Pomeranian Pioneer who " has the nature in him."

Other articles in this number are *River-Crossings with Service Equipment, Exercises for Section Training ;* an account of the opening ceremony of a new stone bridge over the Elbe at Magdeburg to be called " The Bridge of the Magdeburg Pioneers," in honour of the Pioneer battalion of the IVth Corps, connected with that city ; *The German Army Ski Championships*, 1915 ; and notes on the value of Eternit as a roof-covering ; on an electrical riveter by Defries of Düsseldorf ; and on the Demag pneumatic rock-breaker for use under water, successfully used at three fathoms in deepening Heligoland harbour.

F.A.I.

MILITÄR WOCHENBLATT.

(*4th March*, 1935.)—1. *Lessons to be Learnt from the Employment of Pioneers in the First Year of the War.* By General Königsdorfer.

(i) *Organization.* At the outbreak of the war Germany possessed 35 pioneer battalions, of which 25 were field pioneers and 10 fortress pioneers. Field pioneers were allotted to divisions—at the rate of two companies per regular division and one per reserve division. Fortress companies were allotted to armies. There were other units, such as corps and divisional bridging trains, etc.

(ii) *Experience.*

(*a*) *Numbers.* The number of pioneer companies was found to be insufficient, both for mobile and for trench warfare. Three companies were the minimum number required by a division. The corps and divisional bridging equipment was insufficient even for rivers of medium width ; it should have been supplemented by motorized army bridging trains.

(*b*) *Employment.* Construction work occupied the attention of pioneers too fully ; more men should have been available for employment in storm battalions.

(*c*) *Training.* All pioneers should be trained in infantry duties, obstacles, and field fortification. Field pioneers should specialize in water-supply, bridging, explosives, roadmaking and hutting; storm troops should specialize in storm-battalion work.

(*d*) *Mobility.* A pioneer company on foot is an anachronism. Men should, at the very least, be mounted on bicycles, and the equipment carried on motor vehicles.

(*e*) *Peace and War Training.* During the war pioneers were completely controlled by divisions. This should not be an invariable rule: the Inspector-General should be empowered to divert pioneers and their equipment as circumstances may dictate.

(*f*) *Weapons and Equipment.* Carbines are preferable to rifles; storm troops should have hand-grenades and mine-throwers. The pontoons were too heavy, a lighter type is required. Outboard motors and motor-boats are useful.

2. *Problems of Our Study of the History of War.*

Lieut.-General Marx compares the study of war in his young days with that of the new generation of young officers. Formerly, literature on warfare was mainly a narrative of events; nowadays, it is more a criticism of what should have been done. The modern young officer shows a distaste for "dry" books, and asks for something more interesting.

3. *The Chaco War in the Second Half of 1934.*

The Paraguayans made a certain amount of progress during the last six months of 1934, and at the end of the year they occupied a line running roughly north and south, east of Carandaiti and Capirenda as far as the Pilcomayo River, and then along that river as far as the Argentina boundary, but they were unable to make any further headway.

Bolivia accepted the proposal of the League of Nations to conclude peace, but Paraguay declined. Paraguay wishes to make up for her heavy losses in blood and treasure by continuing the war until she has reached the Cordilleras and has acquired some of the Bolivian oilfields.

4. *Tanks in Infantry Warfare.*

In an attack by tanks on an entrenched position everything depends upon the last 300 metres, hence the necessity for complete concealment before the attack is launched, and for covering the ground with the maximum speed.

The Germans consider the British theory that the tank is the best weapon for countering a tank attack as completely out of date. Heavy machine-guns and anti-tank guns form the backbone of the defence against a tank attack.

5. *The Object of Instruction.* By Colonel von Arnim.

Instruction in war games or tactical schemes should be carried out in such a way that the pupil is either left to make his own decisions and is free to carry them out, or else he should be instructed in a definite method and not be allowed to decide for himself.

6. *The Conduct of War and Horse Breeding.* By Major Buhle.

No one has yet had experience of motorized warfare on a large scale, and the writer considers that the horse will still play an important part in future warfare. Riding and pack-horses are likely to be employed more in future than draught horses.

The World War almost exhausted the supply of horses in Germany. But horse-breeding has been taken up since, and the years 1919–1930 saw a steady improvement in troop horses. The tendency has been to breed a heavier type of horse.

A.S.H.

THE INDIAN FORESTER.

The January, 1935, number begins Volume LXI of the magazine, and is adorned with a pleasing new cover.

An article on the preservation of Naini Tal from landslips, by means of the reclamation of denuded hill slopes, is of special interest to ourselves, who frequently have to solve the same problem on newly-built mountain roads. Naini Tal in the past has suffered severely from landslides, which have sometimes involved serious loss of life. The particular case referred to is that of the slope of Upper China, whence rocks used frequently to roll down on to the habitations below, damaging them not a little. Remedial measures were begun in 1905, and were carried to a successful conclusion at what must be regarded as the very low cost of Rs. 6,800. Generally speaking, the treatment consisted in the erection of barriers of posts and fascines, while suitable vegetation was planted all over the area. What were dangerous slopes of loose shale are now covered with young and healthy forest. Sappers with similar problems to tackle might well apply to the nearest forest officer for advice as to the particular shrubs and trees to plant for, of course, quick-growing and deep-rooted varieties are essential.

A note on a timber tennis court, claimed to be the only one in Scotland, states that play on it is very fast and enjoyable and that maintenance costs are low.

The Indian Forester always has a good selection of extracts from other papers. In this number, one from the *Timber Trades Journal* on the problem of overhead charges, and another on " Water-supplies and Emergency Legislation," are worth studying.

In the February number there is a long article on *Bombax Malabaricum*, the tree which produces kapok. It is asserted that Indian-grown kapok is as good as, if not better than, Javanese. The former is, however, almost always adulterated, with the result that the foreign article gets the market.

Here is an excellent big-game story which, did it not come from a perfectly reliable source, would be difficult to believe. " The Reverend Brother Romulus, a Franciscan clergyman . . . is responsible for shooting two rogues. In shooting the first of these brutes, he almost lost his life and that he is alive to-day is due to the elephant's shooting itself when it snatched the rifle from his hands. It was a case of the hunter being hunted when the elephant charged him from a distance of fifteen yards."

While on the subject of natural history, an extract from *Forest and Outdoors* may be noted. According to the author, birds sing neither to please themselves, nor their mates, nor mankind, but solely to warn off trespassers from the small area of tree or ground which they have annexed.

An extract from the *Scientific American* gives an account of the felling of trees by a combination of tractor and dynamite. We may also notice that Tata Sons are exhibiting an autogiro in many large towns in Northern India during the current spring. The number closes with a valuable extract from the *Indian and Eastern Engineer* on the subject of dry rot in buildings.

The March number has a sad tale to tell in the denudation of the Chhota Nagpur plateau. The cutting of timber by peasants to bring more land under cultivation, and by builders to obtain wood for building, has led to the transformation of thousands of square miles of woodland into barren desert. It is heartening to read of the remedial measures proposed—the taking over by Government of most of the forest area left, and a campaign of propaganda among landlords and *raiyats*.

In a review of the administration report of the forests in Madras, it is mentioned that the prickly pear has been almost exterminated in that presidency by means of the cochineal insect. Lantana, another pest, is however reported as still on the increase—an item of news which will appear of less moment than the other to those who have had the misfortune to fall into a prickly pear.

" Tree Rings and History "—an excerpt from *Sylva*, 1935—is a brief *résumé* of the results of the examination of annual rings, whence can be deduced the climatic changes of the region in which a tree grew; an examination which is not confined to trees recently felled, but includes wood and even charcoal from ancient remains. Among other results, the sunspot cycle of 11·2 years has been traced back for centuries.

F.C.M.

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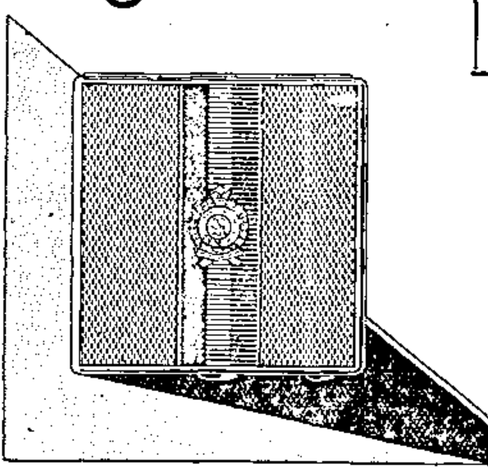

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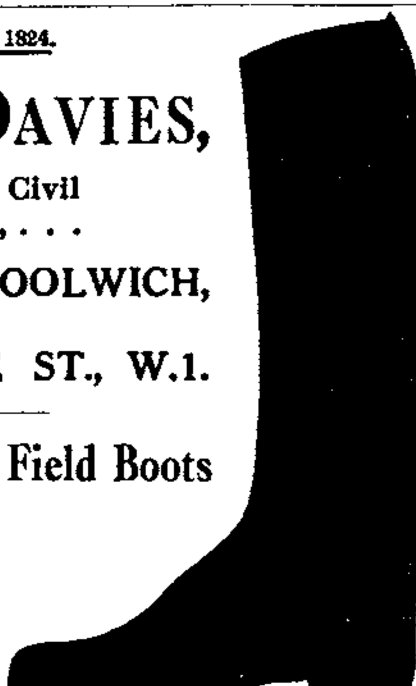

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