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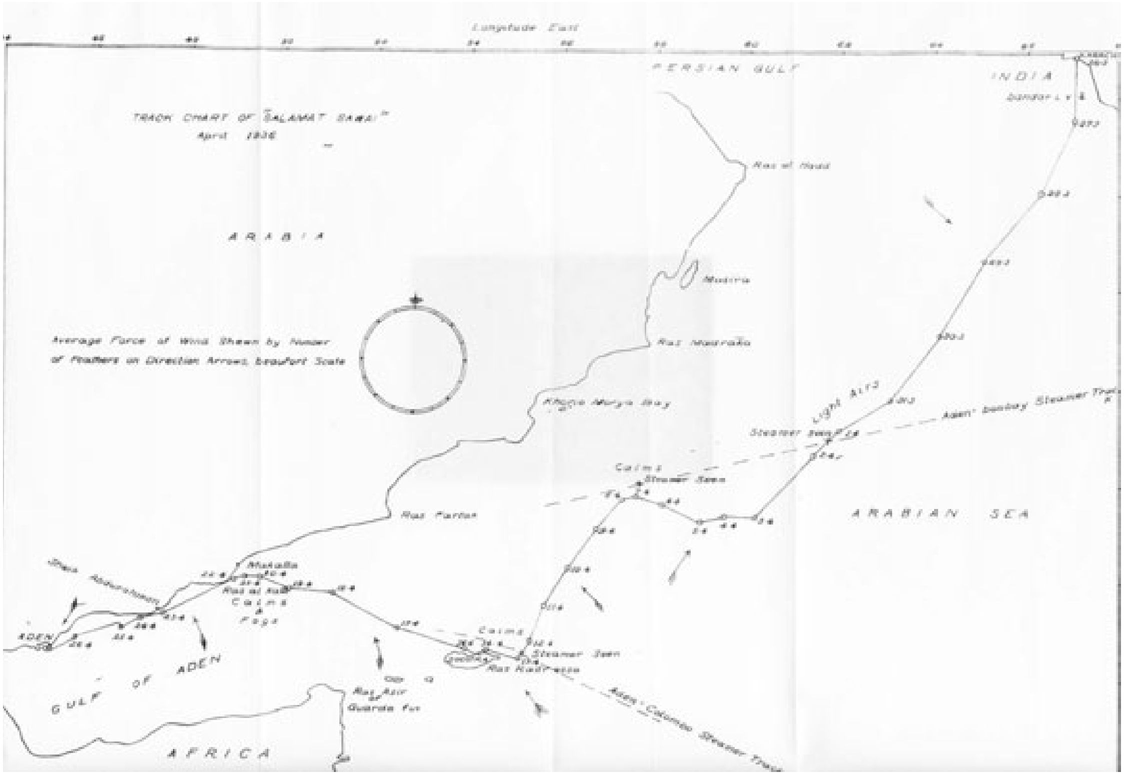

Track chart of 'Salamat Sawai

COAST PROTECTION ON THE NORTH SEA COASTS OF HOLLAND, FRANCE, BELGIUM AND GERMANY.

By J. H. van der Burgt.

Engineer of the Netherlands State Waterways Administration.

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The coast-line of the eastern borders of the North Sea consists mainly of sand, and is protected by works of very dissimilar construction. Little is known of the forces at work along these coasts, in particular regard to the transportation of sand and silt which influences the alterations in the coast-line more than anything else. These phenomena must be thoroughly explored so as to make it possible to apply the necessary measures for the proper maintenance of the foreshore, the tideways and the adjacent shipping fairways. Although the Dutch shore is being quite heavily attacked at certain points, the situation is not unfavourable on the whole.

Historical.

It is believed that during the ice-age that part of the North Sea lying to the south of a line running approximately from the mouth of the Humber to Cape Skagen, was dry land, and that by the melting of a great part of the land-ice on the surface of the earth, the sea-level rose appreciably and the North Sea spread southwards. The submersion of this part of the land is to be attributed to a small extent to the settlement of the sea bed, following the melting of the land-ice in Scandinavia; the surface pressure then decreased, the land rose, and the area along the southern edge of the North Sea therefore sank. Several periods are distinguishable since the retreat of the land-ice, each of which has left its mark on the formation of the Dutch coasts. After the sea-level had risen, sands and clays were first deposited and then, after the Straits of Dover had been broken open, a raised beach stretching almost as far as Alkmaar was formed from detritus from the sundered isthmus. In the partly cut-off stretch of coast behind this ridge, the old marine clay was deposited, and after this area had been completely cut off, peat began to form there. The last and present period, which began, it is thought, about the year 500 A.D., is distinguished by storms and a heavy rainfall, causing a powerful coastal attack which has, to a great extent, destroyed this ridge; on the landward side of it, in sheltered places, is a new landscape—the recently formed dunes. The sea then again obtained access to the previous shore area, the upper layer of peat being now covered with a sandy silt—the recent marine clay.

After the beginning of this unfavourable period, the inhabitants of the low-lying lands near the sea were increasingly troubled by inundations, and their fight against the water had begun when the first dykes were thrown up against it. During a long period, experience in making dykes led to ever more suitable methods of construction; the people began to go farther, and gradually recovered large tracts of lost land; continuing to the present day, this has culminated in the reclamation of a large part of the Zuiderzee. As long as the present period lasts, and is not superseded by a more favourable period, the fight against the water must continue.

Old documents and maps make it almost sure that the coast of Holland has retreated considerably in the course of centuries. To reconstruct the previous coast-lines, old records must be searched with care, for maps before 1800 are frequently inaccurate owing to antiquated survey methods. At some points where the protecting row of dunes threatened to be swept away entirely, and villages and cultivated land lying behind would be inundated, attempts were very early made to build short lengths of dyke, to check the retreat of the coast-line. The first dyke at West-Kapelle was built about 1500; the first villages of Huisduinen and Vlieland had been protected by dykes by the beginning of the eighteenth century, but all these works were later lost to the sea. The sea-dyke at West-Kapelle moved repeatedly landwards, and the two villages were at last swallowed up by the sea.* The retreat of the coast-line near the Helder is illustrated in Fig. 1; in this its position is shown as in 1571, 1702 and 1866; the position to-day is much the same as in 1866.

The present-day sea-dykes at West-Kapelle and near the Helder have been kept up at great expense by building out short groynes in front of the dykes, and by covering the under-water slopes in front

* For the submersion of the village of West-Vlieland *see* Section IV of the *Return of Public Works*, 1865. J. V. D. Vegt, Memorandum on the past and present conditions in Vlieland, etc.

of them with stone, with and without fascine-mattresses underneath. Where threatened, the coast has been protected by dykes. The building of dykes dates back to the Middle Ages. It was natural that these structures, already adopted with great success along the banks of inland seas and large rivers, should have been considered suitable for the shores of the North Sea, but experience taught our forefathers that the dyke, by itself, was not the proper construction against the sea.

At the beginning of the nineteenth century, however, it was realized that groynes erected perpendicularly to the shore at regular distances apart provided a much more efficient protection to the gently sloping sandy shore. This discovery was very fortunate because along our coast there was a northward movement of the sand by water and by wind, and the groynes, provided they are rationally constructed, hold up this sand, and to a great extent prevent further erosion of the coast.

The building of the groynes on the Islands of East Friesland and along the Belgian coast began with the last century, those along the Danish coast much later. The existing coast protection works from the Straits of Dover to Cape Skagen are shown in Fig. 2. Those in Holland in Figs. 3 and 4. It will be seen there that the eastern shores of the North Sea, which consist mainly of sand, are only protected here and there. It is now known that the existing protective works in Belgium, Holland and Germany need not be extended much at present; on several of the Frisian Islands, however, very considerable sums are necessary to improve and renew the existing works, for on several islands the tideways or "swills" run close inshore and very serious erosion is taking place. The protection of the Danish coast to the north of Blaavandshoek, is by no means yet complete; the difficulties of building groynes there are obviously very great owing to the heavy seas which get up during storms in the very deep, broad channel south of Norway.

Need for Investigation and Constant Measurement.

It is important that on each section of coast the reasons why protective works are or have not been necessary should be investigated, not forgetting the problems which will have to be taken account of in the future. It is beyond the scope of this Article to go further into this, and comparatively little is known about it at present.

Existing Organisation and its Results.

The coast of Holland is 422 km. long. It is under the control of 25 different authorities. This is presumably why there exist sometimes entirely independent mileage systems on various sections of the coast. A clear general view is given in Figs. 3 and 4 of what may be considered the mileage system of the North Sea coast of Holland; the mileage measurement count (in kilometres) along the coast is also shown. The chart, Fig. 5, gives the average annual movement in each coastal section :—

(1) of the foot of the dunes, (2) of the high-water mark, (3) of the low-water mark, (4) of the underwater contours at 5, 10, 15 and 20 metres below low water, for the period of about 30 years, during which data have been collected of the annual shore measurements (begun about 1850) and the soundings along the shore.

The coast-line is 1/7 water (56 km.), 1/7 sand flats (40 km.), 3/7 unprotected dunes with beach (195 km.) and 2/7 protected coast (111 km.); this appears from the running lengths classification shown in the Chart.

We see from it also that the protected sections of coast have undergone little change in this comparatively short period; this also applies to the unprotected parts of the so-called "free" coast, that is to say the coast of north and south Holland, which has no sand "bars" fronting it. The protected coasts of Koegras near den Helder, and of Vlieland, which were only groyned in the second half of the period, are more deeply eroded in consequence. On the other hand, considerable alterations in the coast-line have occurred in the estuaries and along the arms of the sea. This is due to the continual changes in the "bars" and in the "swills" adjoining them. The enlargement of the Beer, near the Hook of Holland, due to the improvements to the Nieuwe Waterweg and the retreat of the estuary of Brielle should be noted. There has been considerable accretion at the western and eastern ends of Ameland and the western point of Schiermonnikoog, due to the sand-flats moving from the bar area of the neighbouring estuaries and depositing themselves against the shore. The Engelsmanplaat sand-bank, between Ameland and Schiermonnikoog, has considerably decreased, and as this decrease has frequently been observed it appears to indicate that this bank will eventually disappear. The accretion on the western shore of Terschelling affects the high-water line and the foot of the dunes only, and so far as the high-water mark is concerned, is due to the heightened deposit of sand on the broad stretch of beach called Noordvaarder. The foot of the dunes has moved seawards, owing to the fact that a series of "drift-dykes" has been made on this stretch of beach; see Fig. 4. The foot of the dunes has similarly moved seawards as a result of the drift-dykes on the beach at Hors, at the south end of Texel, and on the western part of the Boschplaat at the east end of Terschelling.

On other parts of the coast, in the estuaries and arms of the sea, on the other hand, coast erosion may be observed; this is very considerable, for example on the Island of Rottumeroog, see chart Fig. 5. This unprotected island is gradually shifting to the east and must in the long run be submerged by the Westereems. One of the main occupations on this island is building drift-dykes to protect the grassland on the Wadzijde and the watchman's house, which has often been swept into the sea eastwards, being then rebuilt. The erosion is considerable too at Goeree, and on Texel to the west of the village of Den Hoorn; and particularly at the northern end of the Eierlandsche coast. Figs. 7 and 8 give a clear picture of these sections of coast. Near Den Hoorn the offshore bank is less gently sloping and the coast erosion there is apparently a result of the very small supply of sand; the retreat of the shore of Eierland, on the other hand, is to be attributed to the presence of a swillway close inshore.

A study, incomplete however, of some of the estuaries leads one to suppose that the alteration in the banks lying within them, and those off the coast-line, is in no way arbitrary; there seems to be a fixed rule, but the rule is not identical at different places. The banks in question, whose extent is proportionate to the size of the estuary, act as sand-collectors, which periodically shed shoals, and these shoals usually unite later with the beach. To decide whether the construction or widening of coastal protective works along or close to the estuaries or arms of the sea is necessary, the sand-banks lying in front of them should be studied. The under-water contours 5, 10, 15 and 20 m. below low-water mark are those studied off the "free" coast in north and south Holland; these contours have not noticeably shifted; this indicates that the alterations occur exclusively inshore. The preliminary results of the investigation of the movement of sand along the coast tend also to stress that, under favourable weather conditions, the movement of sand greatly decreases below 5 m.; that the comparatively weak coastal current has probably little effect while the wind current, and the wave movement in the region of the breakers do all the work. It is not yet possible to draw any very definite conclusions; to do this it will be necessary to make a prolonged study of the whole coast including measurements and soundings.

Annual Costs.

Fig. 5 gives us the average annual cost per kilometre, from 1907 to 1931, for each section of coast. It will be seen, however, that the cost of the sea-wall is the biggest item and, except for the Pettemer sea-wall (about f. 14,000 per km. per annum), have amounted to f. 25,000 to f. 30,000 per km. per annum. At West-Kapelle the sea-dyke suffered considerably from storms for several years; the Hondsbossche sea-wall has been gradually rebuilt from 1922 onwards; the sea-walls at the Helder and at Horntje on Texel have been raised and strengthened, while the under-water protection work there has been much strengthened. The cost of groyne protection varies greatly; south of the Hook of Holland it runs from f. 3,000 to f. 9,000, and north of that point from f. 10,000 to f. 13,000, in each case per km. per annum. This great difference in cost is undoubtedly due to the heavier attack to the north of the Hook of Holland for it is also a less sheltered position. The groynes of Delfland were rebuilt and strengthened between 1920–1931; at Koegras and Vlieland many new groynes were built and many rebuilt at that time.

The most important annual and capital costs from 1907–1931 are given in Fig. 9; in this chart, as in that of Fig. 5, no account has been taken of the rise in prices after 1919. From Fig. 9 it will be seen that the total annual cost of coast protection is considerable, varying from about f. 800,000 to as much as f. 3,000,000; on the average f. 1,360,000. The average annual expenditure by the Government on sea-protection works amounts to f. 687,000 or about 3·5 per cent. of the average total annual disbursements on all works by the State Waterways Department in that period. The last-mentioned figure does not include the cost of dykes along the mouth of the Nieuwe Waterweg and the harbour groynes at Scheveningen and Ymuiden.

CLASSIFICATION OF WORKS.

The coast protection works on the eastern border of the North Sea may be classified as:—

I. Longitudinal works.

(*a*) Sea-walls and sea-dykes. (*b*) Defended outer dunes.

II. Groynes.

The works under I. aim at preventing erosion of the foreshore, *i.e.*, above low water; it is protected in several ways. The sea-walls or sea-dykes generally have a normal dyke cross-section with a flat outer toe, whilst the protected outer dunes have a solid sea-wall or else the foot of the dune is revetted to a certain well-defined cross-section.

The works under II., the groynes, run from the foot of the dune to just below the low-water line; are placed as a rule at regular distances from each other, perpendicularly to the shore, with the object of stabilizing the low-water line and consequently preventing the foreshore from being eroded. With a gently sloping beach as, for example, on "free" coastal sections, groynes are the right form of construction. When, however, deep swills or waterways run close inshore, as in the estuaries and other arms of the sea, groynes cannot be maintained as fixed points, or only at great cost and as a rule serious lowering of the beach still occurs between the groynes. In such cases the fascine mattress work must be carried down under-water on the sand at least as low as the bottom of the swill and the revetment of the foreshore above low water is almost always necessary as well.

ADAPTATION OF TYPES OF CONSTRUCTION TO DIFFERENT SITES.

I (*a*). *Sea-walls or sea-dykes.*

In this part of the North Sea these works only occur in Holland. Cross-sections of the most important Dutch sea-walls are given in Fig. 10.

The sea drops to great depths immediately below the sea-wall at den Helder and at Horntje on Texel; these places can only be protected by providing a continuous revetment on a mattress foundation which, in the shallower parts, may be replaced by groyne defence; see Fig. 4. The Hondsbossche and Pettemer sea-walls, as a result of the erosion of beach and dunes, lie in a gap in the continuous range of dunes on a flat open stretch, and are protected by lines of groynes. The sea-dyke at West-Kapelle lies on a shallow channel and is only partly protected by short groynes, while the deeper under-water parts are mainly protected by random rock filling; mattress foundation is hardly employed here at all. Above low water these sea-walls are as a general rule rather flat, and are heavily protected.

I (*b*). *Protected outer dunes.*

Some representative cross-sections of the construction in use for the protection of the outer dunes between the Straits of Dover and the Jade are given in Fig. 11: Figs. 12, 13 and 14 show some Belgian and German types of these longitudinal works. They are as a rule of quite light construction, and are often built so as to serve as a permanent promenade for the bathing season. They are classified as sea-walls or revetted dune slopes. The sea-walls are stable in themselves, and the top slope has a concave (Scheveningen) or vertical (Juist) cross-section. The protected dune slopes lie below a solid bank (Sandgatte, Middelkerke and Terheiden), and these have an S-shape (Norderney) or hollow (Borkum) cross-section. The existing works, on the whole, do not have to withstand any very heavy attacks, except those on Borkum and Norderney, where the inshore channels are rather deep. The Juist section sea-wall is generally strong enough to stand the shock of the waves; from time to time the Borkum section suffers storm damage; the Norderney section is on the whole satisfactory, as here the waves, by an unobstructed run up the revetment of the sea-wall until quite spent, are entirely controlled.

A disadvantage of the steep or concave face is that the waves shoot upwards and are blown landwards; this is apt to do serious damage to the cultivated dunes or crops lying behind. That is why an inclined or slightly S-shaped face best protects the outer dunes with or without an upper slope on which the wave can run up and expend itself completely. In the past the mistake was often made of not placing the toe low enough down; then if later the foreshore levels fell, extensive and costly extension of the toe became necessary—see Fig. 11, Middelkerke, Scheveningen Juist and Borkum sections; also Fig. 14, in which the cross-section, originally suitable in shape, is seen to be entirely lost.

DESCRIPTION OF GROYNES.

II. *Groynes.*

Fig. 15 gives some representative cross-sections of the different types of groynes in use between the Straits of Dover and Cape Skagen. These do not by any means include all types of groyne construction which have been adopted. No reinforced concrete construction is included. Concrete has not on the whole been satisfactory in withstanding wave action. The French, Belgian and Zealand types all use the open rows of piles as surf-breakers and sand-catchers; the Belgian groyne is much wider than the other two. The older Belgian and Zealand groynes, are revetted with stone pitching set in compartments bounded by wattle walls: but the wave action on the parts of the coast which are protected by the Flemish Banks is not very heavy. In Belgium all this work is as a rule done in winter so as not to interfere with the bathing season; to the north of the Hook of Holland, owing to the frequent rough winter weather, this can hardly ever be done except in summer.

Fig. 16 shows the Zealand new type with the stone revetment seen in the foreground. The groynes of Delfland, North Holland and Vlieland are generally similar; the Delfland and Vlieland groynes have much heavier dumped stone protection, however, and as a rule the mattress work is much more extensive. Whilst these groynes are situated on a gently sloping shore with shallow toe slopes and are intended to maintain the low-water mark in place, the groynes on the German Frisian Islands are usually on a fairly deep waterway, where pronounced lowering of the beach is the rule. The German groynes are frequently very wide, as a result of regular additions to the revetment of their edges—see Figs. 17 and 18. Later, instead of the above revetment, light sheeting was introduced to protect the sides; still later, after serious damage by the sea—see Fig. 19—and a considerable lowering of the beach, an entirely new form of groyne was used, the sides of which were protected by waled sheet-piling—see Figs. 15 and 20.

The mattress work even in the new groynes is of small extent, and is covered with small stones which, in rough weather, are often carried away from the foundations. The latest type of groyne, built on Borkum, consists of a single line of iron-sheet piling, which may or may not be doubled at the toe, all round which there is mattress work covered with random rock rubble—Fig. 21. The groynes on Wangeroog have wooden surf-breakers. The Danish groynes consist of one or more rows of retaining-wall, protected by heavy piles of dumped stone; these sink into the sand very quickly, which is to be ascribed to the absence of any foundation under the stones—see Fig. 15.

The art of building groynes and the correlated protection of the outer dunes dates from the beginning of the nineteenth century and so is still quite young. Owing to want of experience and very limited knowledge of the foreshore phenomena, works were originally of much too light construction. Gradually other and heavier construction was adopted; wood, stone, concrete and iron were successively tried. Even now the construction is in many cases far from rational, because the earlier methods of construction have been adhered to too closely; because the materials which were at hand, stone revetment in particular, have been used again in rebuilding; and lastly, because the purpose to be served by each component part of the protective works has not been understood.

To the north of the Hook of Holland, where the sea attack is heaviest, several drastic but rational changes in construction have lately been introduced, *i.e.*, by

1. The application of extensive mattress work covered with heavy stones (200 to 1,000 kg.) both in front of and alongside the toes of the Delfland groynes. This mattress covered with stone has been adopted in Vlieland with success; it provides an immovable rampart in the area of the breaking surf, so that the solid part of the groyne is attacked much less heavily. Besides this the mattress work collects a lot of sand and so pushes the low-water line seawards by raising the beach-level.

2. The substitution of a solid groyne of stone pitching surrounded by a long retaining-wall of short wooden piles in a single or a double row joined together. This form of construction was the necessary consequence of the unusually serious lowering of the beach in Borkum in 1927, when the old groynes were entirely destroyed. Even on beaches which are not continuously eroded this construction is quite rational, because the shore in the North Sea periodically changes its level as new sand-bars form in the sea; these bars merge with the shore or may be separated from each other and from the foreshore by deep swills parallel to the shore.

From the daily measurements of the height of the beach, which are still being made on Texel, Vlieland and Terschelling, these sand-banks appear to rise out of the sea in about a month; the difference between the maximum and minimum levels of the foreshore which lies between low water and half-tide is very considerable.

In most cases groynes have had to be rebuilt owing to the enclosing sides giving way; under the periodical lowering of the beach, the groynes broke up and sank; the foundations of the groyne are usually rebuilt at a lower level but built up to the former height and cross-section.

The modern standard groyne would be constructed :—

1. The toe or sea-end is made of a quite considerable mattress work covered with heavy stones (blocks of 200 - 1,000 kg.). The toe must be in the region of breaking surf; sometimes to reduce the osier and brushwood foundations the under-water work is finished off with sandbags. The mattress work can be gradually narrowed as it goes up the beach but must be carried up as far as half-tide level.

2. The head or land-end consists of a single iron wall 3 to 3½ metres deep, stiffened at the top with two U-iron girders, and reaches from just below the half-tide line right up to the foot of the dune.

The toe of the groyne, owing to its construction, collects sand on a large scale, and should maintain the low-water line in position and push it seawards. The head must be set far enough up towards the dune to prevent any washout of the beach between it and the foot of the dune. Fig. 22 illustrates such a groyne.

Although the coast of Holland is, on the whole, not unfavourably situated, several sections of coast are at present a heavy charge for maintenance, whilst little or nothing is known of what may be required in the future. The conditions are more or less the same along the rest of eastern seaboard of the North Sea. A thorough study of all the coastal phenomena of the North Sea coast will include the currents in the shipping channels and minor waterways. By this means alone can the proper timely steps be taken to prevent further coast erosion; to make permanent sand and silt accretions where required; to prevent the silting-up of shipping channels and fairways to the sea; and to design the most suitable works for coast protection.

This inquiry will include the collection, investigation, classification and tabulation in terms of comparable units of existing and periodically appearing data; and compiling reports on all constructed works, on tides, "storm-tides," on the movement of sand and all allied matters. Numbers of old maps exist in various archives, and, although frequently inaccurate, often contain important information which should be extracted. Records of borings are an indispensable part of our knowledge of the geological formations under the coast and must be collated too.

PERIODIC RESURVEYS.

Periodical data include hydrographic surveys of the coast, the estuaries and the arms of the sea; beach surveys, soundings along the coast in front of the beach and on the bars and banks; records of tide and other water-gauges.

The hydrographic survey of the Dutch coast, begun about 1800 to assist shipping, has mapped the navigation channels to the sea, buoyed them and published charts. The constant changes in the sea bed involve regular periodic resurvey, which has led to the issue of a new chart for each successive survey of the same zone. The great accuracy of these charts and their more or less periodical appearance, provide very complete data for studying the changes in the coast. Shore measurement was started by the Highways Department about the year 1850. Measurements are made annually along the whole coast of Holland (at stations 1 km. apart, each marked by a datum pile) of the position of the foot of the dune, the high-water mark and the low-water mark in relation to the station-pile. The land measurements which record the exact alterations in the coast-line, point to a certain periodicity in the changes and give proof of the satisfactory effects of groynes in checking coast erosion.

Soundings on the banks are as a rule only made in those parts where the coast is heavily attacked by currents or much open to storm damage. In the latter case a record of the submarine contours is required at regular intervals. Along the Dutch coast and that of the adjoining countries automatic tide-gauges at certain places keep a continuous record of the tides. From these data, mean high- and low-water levels are calculated, and the highest and lowest water-levels are recorded. The first Dutch automatic gauge dates from 1850; the results are published at regular intervals.

The Dutch study of the coast also includes the collection and digestion of new data, which is especially necessary to add to our existing knowledge, as well as for the initiation of new projects and the subsequent design of the works. The minute examination into the suitability of existing works is necessary to enable one to judge whether technical or economic improvements are not possible. The dams of the Nieuwe Waterweg to sea, the dam of the Hellegat to guide the current and the groynes on Vlieland are now being subjected to further examination for this reason.

This previous examination of all projected improvements is desirable whenever considered necessary, as, for instance, when any particular stretch of coast begins to retreat or when any channel or fairway begins to silt up.

Other Necessary Periodic Observations.

Among the new data to be collected is the charting of the coastal area, with detailed soundings, current measurement, observation of the salt content, specific gravity and temperature of the water, as well as the observations of the movement of sand and silt in the currents. Detailed maps of the coastal area are essential. Aerial photography has already proved its great value for such surveys, but detailed soundings in certain parts of the sea will still be necessary, and as a rule these soundings will have to be taken periodically.

The movement of sand and silt is most important, as this exercises a predominating influence on the changes in shape which the coast undergoes. Along the Dutch coast sand is carried in a northerly direction, but it is by no means certain at present where this sand comes from or how it is distributed along the coast, in the estuaries, the outer harbours and the Waddenzee (Frisian sea). Part of this inquiry will include the taking of samples of sand at various points in order to examine the size of grain and colour. Sand is transported by water and by the wind. In the water this is not directly perceptible and, from investigations which are still quite incomplete, the principal factor is not the coastal current, which is comparatively feeble; but the wind, the current which it induces and the wave movement in the zone of the breakers seem to be the largest factors. The transport of sand along the beach, on the other hand, is visible and obviously not inconsiderable, as large drifts are formed by it in a short time, leaving a small part of the blown sand fixed in position—see Fig. 24. The transport of sand and silt is complicated because it is caused by such very diverse factors; the movement of tides, the waves, the wind, the condition of the sea-bottom and of the beach, and possibly many other more or less correlated factors. Thus the solution of this problem is far from simple.

At the last shipping congress held in 1931 at Venice, several important reports on coast protection in various countries were submitted. From these and other publications it appears that the desirability of a thorough study of coast protection, and particularly of sand-transport and correlated phenomena, is admitted everywhere. As far as Holland is concerned, the study of the whole Dutch coast was taken in hand officially by the Highways Department some years ago. At the present time the mouth of the Nieuwe Waterweg and the estuary of the Vlie, *inter alia*, are under investigation, whilst a study of the erosion of the coast of Eierland, on Texel, and the western shore of Schiermonnikoog has been begun. For the general investigation of the Dutch coast a sea-going survey ship has been commissioned.

This inquiry opens up, in many ways, an entirely new field. The methods and the instruments are more often experimental than not. The possibilities are very great, the results are often very surprising, so the work is very attractive. The co-operation of various services, administrative departments and other people, is necessary for success, also to make it possible to correlate such a mass of heterogeneous data. Great interest is already being taken in these investigations and the co-operation asked for is being given with the greatest goodwill.

This general pressure to get to the bottom of all the problems of the coastal zone by mutual co-operation will undoubtedly lead to solutions from which we shall learn to understand these phenomena at last. We shall then probably thereby learn to see that in the long run the requirements of coast protection, land drainage and shipping must all be looked after together in as practical and economical a manner as possible.

NOTES.

(1) Fascine mattress work (*Bezinking*) which is the combination of several "*Zinkstukken*" is made of fascines of willow or other suitable brushwood, fastened together and is sunk to the bottom in the exact position for the foundation by small stones piled evenly upon this floating raft. When in position on the bottom it is covered with random rubble rock filling (*Bestorting*) of a size suited to the exposure.

Fig. 25 shows wattle-work compartments (*Vlechttuin, Vlechtwerk*) by which the small stone is kept in place while the raft is sinking.

(2) A drift-dyke (*Stuifdyk*) is built up of wind-blown sand from the foreshore arrested by rows of artificial obstructions such as fences of pine branches, osier, or other suitable materials, in conjunction with lines of bent-grass and straw-bundles set in the sand. A low ridge of sand, the drift-dyke, is thus formed: a second fence is then placed on the first drift-dyke and more bent-grass or straw is planted, and so on. If all goes well, the drift-dyke in one summer may grow so broad and high, that it will stand firm against moderate or even strong storm-tides. By the planting of viable bent-grass the natural vegetation is accelerated, and after some years this vegetation takes over the work of the dead materials. The bent-grass grows through the newly drifted sand, and thus holds more and more sand. By this process, almost entirely by natural means, the drift-dyke will finally grow into a broad chain of dunes, see Fig. 26.

(3) Pinned straw-mat work (*Krammat*) is a straw covering pinned down on the clay surface of the upper portions of the long gentle slopes of Dutch sea-walls to prevent or reduce wave scour at times of storm and high tides, see Fig. 25.

LITERATURE.

1. *International Shipping Congress, Venice,* 1931. *Section II. Marine Navigation.*

"Second question: Defence of Coasts against the sea, with or without preponderating coastal shifting of materials."

(*a*). M. Kauffmann. "Memorandum on the defensive works of the French coast." Report No. 78.

(*b*). E. Verschoore. "Defence of shores against the sea." Report No. 74.

(*c*). R. Schmidt and Dr. Eng. Heiser. "Protection of coasts against floods along banks of currents with or without great density of matter in suspension." Report No. 73.

2. T (Dr. Eng. P. Tesch). *The Netherlands and the Estuaries of the North Sea.* (Handelsblad, Nov., 1931—Mar., 1932.)

An article on Coast Protection between Rye and Folkestone is in preparation. It is hoped that anyone who has anything of general interest on this subject to communicate will co-operate with the Editor by sending it to him.

21.—New Groyne, No. 3, Borkum. On the left wrecked Groyne No. 3. June, 1931.

24.—Drift-dyke on the Boschplaat at Terschelling. 1932.

Coast protection 21 & 22

7.—A coast of erosion at Beach Station No, 14, near Den Hoorn on Texel on 6th September, 1933.

8.—Coast of erosion, Eierland on Texel, on 6th September, 1933.

Coast protection 7& 8

12.—Outer dunes protected by groynes. Knocke, Le Zoute, Belgium. 1931.

13.—Protected outer dunes, Borkum. Borkum profile. 1931.

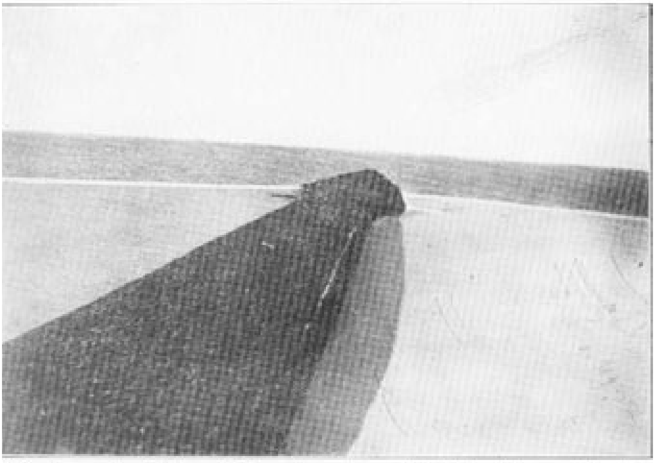
Coast protection 12 & 13

14.—Protected outer dunes, Norderney. Norderney profile with extended toe. 1931

16.—Zealand groyne of new type. Walcheren. 1933.

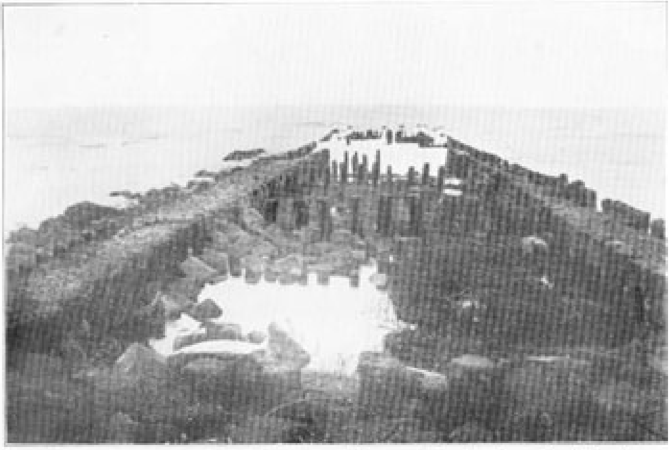
Coast protection 14 & 16

17.—Groyne, D.1. Norderney. Sides supported by iron retaining wall. 1931.

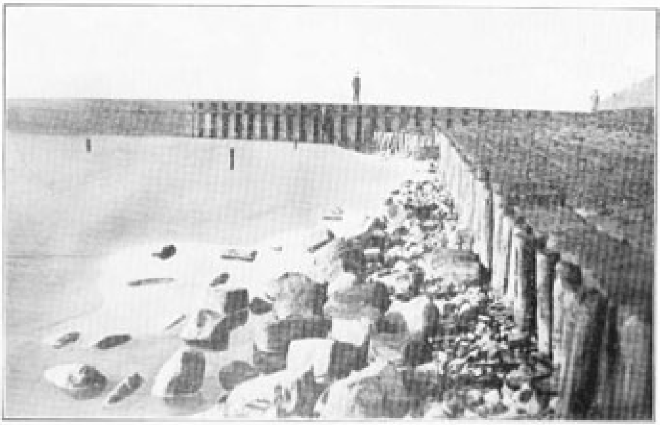


18.—Groyne B. Baltrum. Between low-water and half-tide. Sides revetted with thin corrugated sheet-piling. 1931.

Coast protection 17 & 18



19.—Storm damage, Groyne No. 4, Borkum. This groyne has since been demolished. 1931



20.—Erosion near the junction of Groyne No. 7 and the protected outer dune, Borkum. June, 1931.

Coast protection 19 & 20

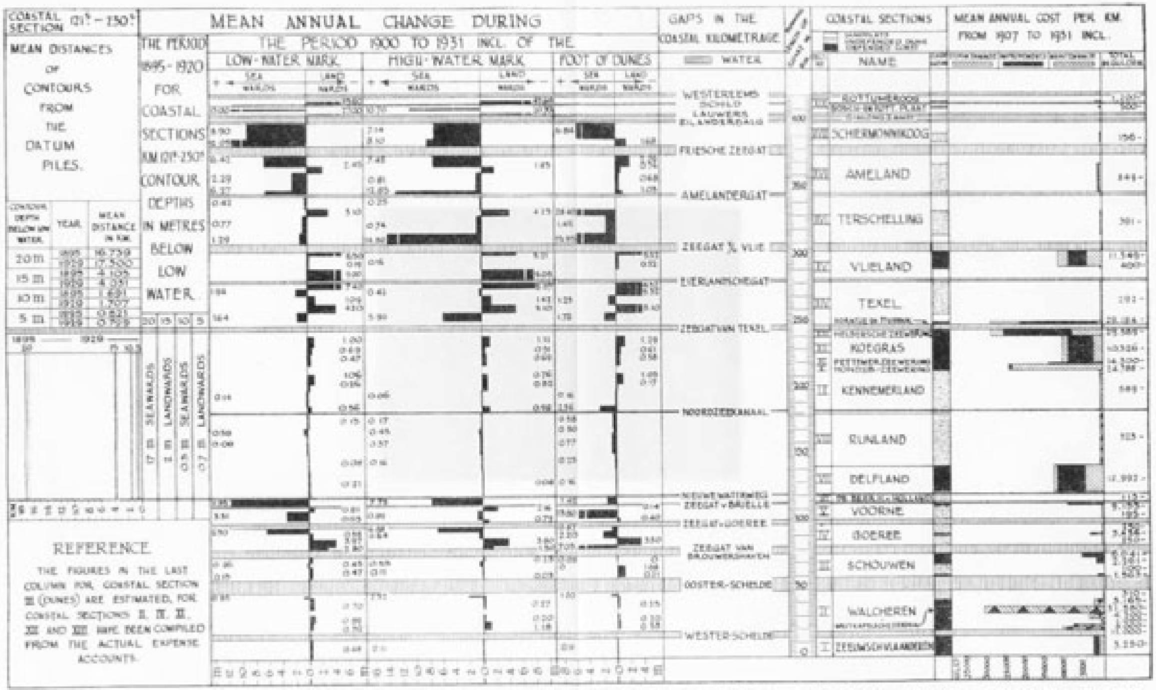
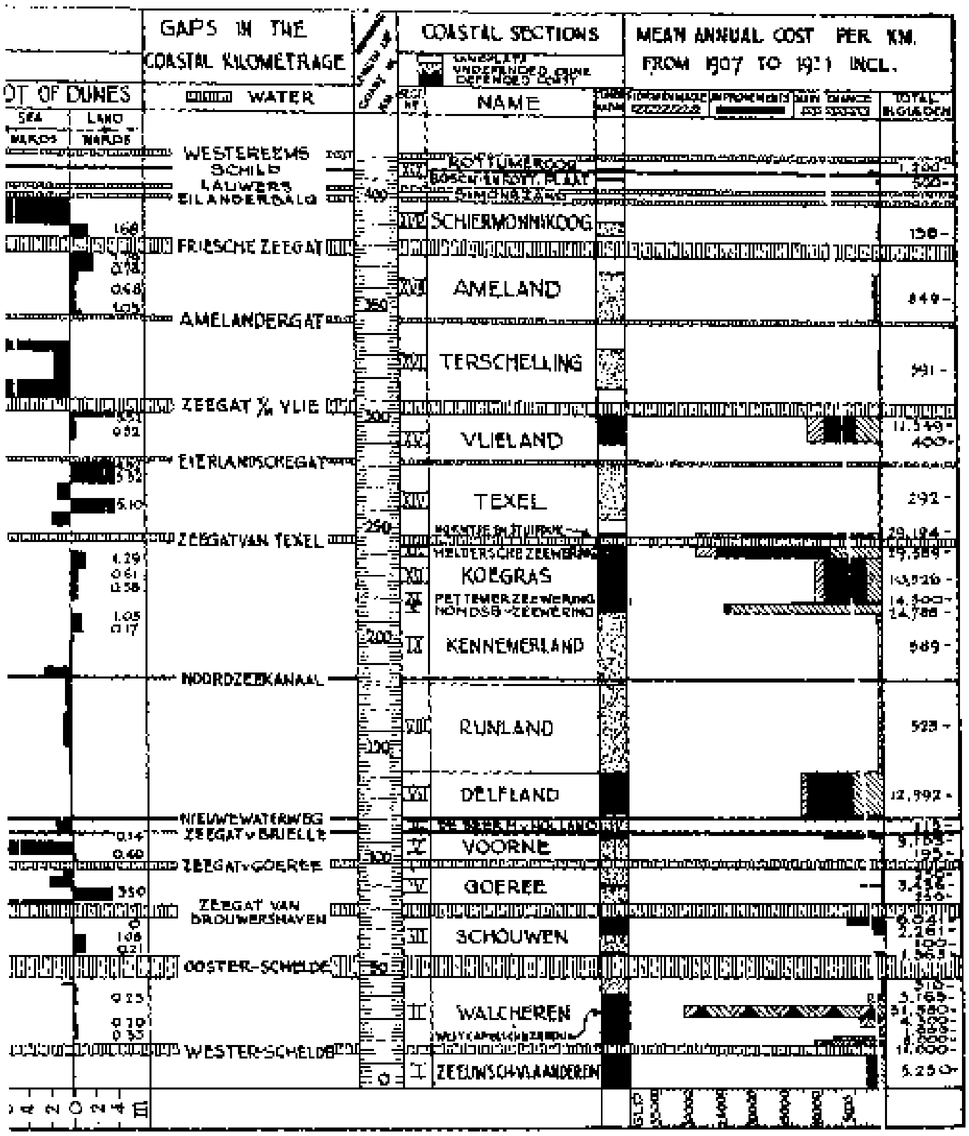


FIG. 5. THE DUTCH COAST. GRAPHIC CHART OF COASTAL SECTIONS SHEWING THE MEAN ANNUAL CHANGE IN THE SUBMARINE CONTOURS FROM 1895 TO 1919 AND 1900 TO 1931 INCL. AND THE AVERAGE ANNUAL COST PER KILOMETRE FROM 1907 TO 1931 INCL. IN EACH SECTION.

The Dutch coast



. SECTIONS SHEWING THE MEAN ANNUAL CHANGE IN THE
1931 INCL. AND THE AVERAGE ANNUAL COST PER
ON.

7.—A coast of erosion at Beach Station No. 14, near Den Hoorn on Texel on 6th September, 1933.

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Coast protection 7& 8

12.—Outer dunes protected by groynes, Knocke, Le Zoute, Belgium, 1931.

13.—Protected outer dunes, Borkum. Borkum profile. 1931.

Coast protection 12 & 13

WANA.

By LIEUT.-COLONEL R. L. BOND, D.S.O., M.C., R.E.

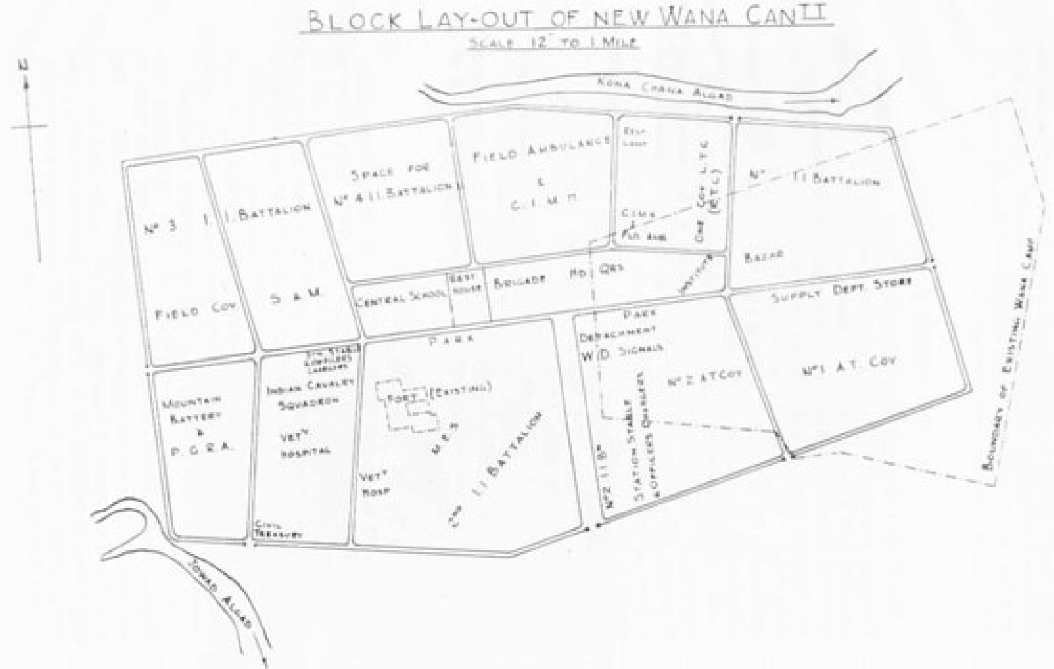
1. WAZIRISTAN.

GENERALLY speaking one's first impressions in Waziristan are a mingling of shame and pride; shame that one should have been so abysmally ignorant of this intensely live and interesting corner of the Empire; pride at the remarkable feats of engineering and administration that those who have gone before us have achieved in a hard and unfriendly country, legitimate pride also that one has been privileged to add somewhat to the structure, of which the most important and difficult parts have been designed and erected in the past.

To the writer, before his arrival, as to most of those visiting Waziristan for the first time, it presented a mental picture of hard-burnt rocky mountains, rough and rocky roads in early stages of development, a country inhabited by people armed to the teeth and waiting to take a fleeting shot whenever opportunity offered. Far from this being the case one finds three fine tarred roads, perfectly graded, with surfaces that could not be bettered in England, fast roads where an average of 30 miles per hour on a 70-miles run is easily attained in spite of rising 6,000 feet in the process; quite a large number of people who carry no guns and are, for those who work amongst them, normally friendly, hospitable and humorous.

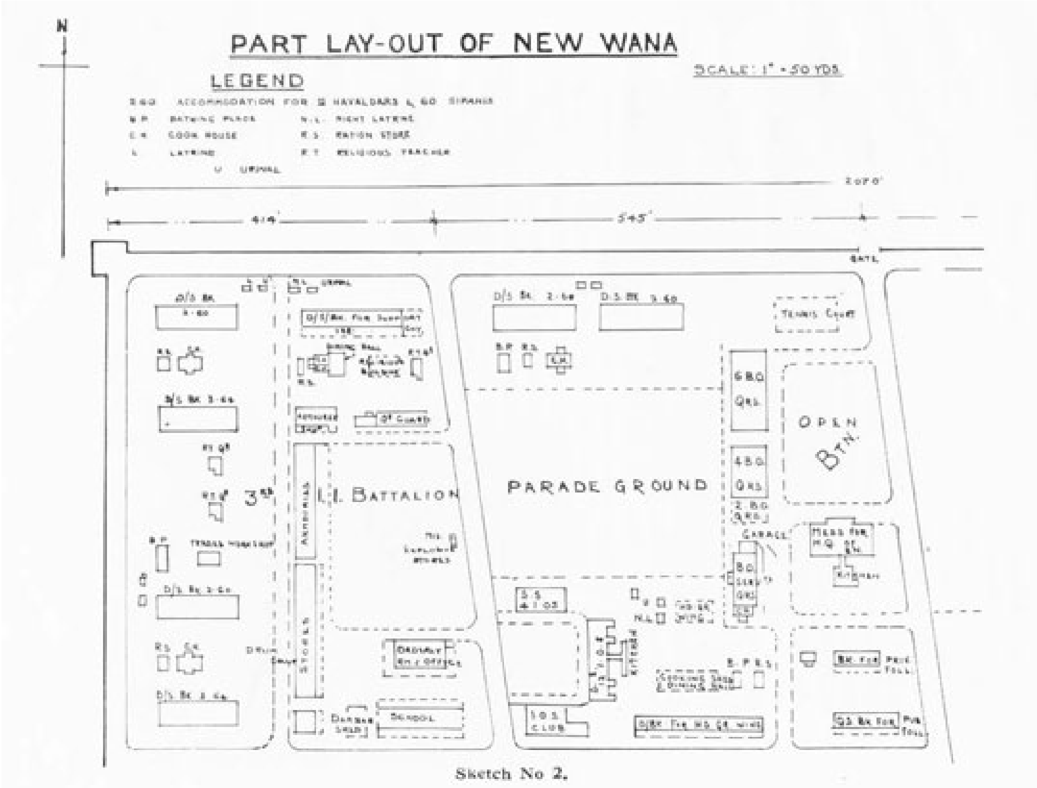
Waziristan then is roughly that block of the N.W. Frontier of India which stretches from the Kurram in the north to the Gomal River, the boundary with Baluchistan, in the south, a distance of 100 miles as the crow flies.

It is bounded on the west by the Durand Line, the boundary with Afghanistan, and on the east by the administrative border, the invisible line running along the foot of the mountains separating tribal territory from the settled districts of British India. This rectangle 100 miles from north to south and 70 miles from east to west is a tumbled mass of mountains rising near Razmak, centrally placed in the western section, to 11,000 feet. From east to west it is traversed by three main practicable routes. In the north the Tochi River winding through a highly cultivated valley



Sketch No. 1.

Layout of New Wana sketch 1



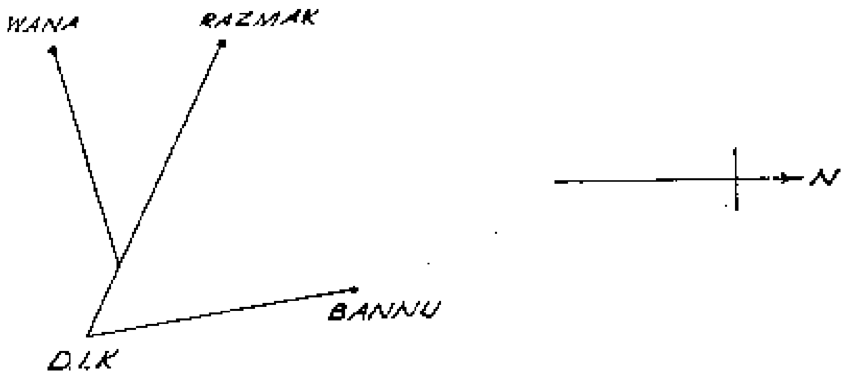
Layout of New Wana sketch 2

from the Afghan border to Bannu; secondly the Takki Zam, a stream taking its rise near the upland plateau 6,000 feet high at Razmak and winding in tortuous curves through deep and narrow gorges till it reaches the plain near Tank; and thirdly the road which, following the Wana Toi ("Toi"—stream) for some miles, climbs over the Madijan and then follows the Danawat and Shahur rivers through the famous Shahur gorge till it joins the Takki Zam at Jandola ten miles from the border. Forming the southern boundary of Waziristan is the River Gomal, another important line of communication from Afghanistan into India.

Joining the Tochi to the Razmak plateau is the main road rising rapidly from Tal in Tochi to the Upper Khaisora valley, climbing in the last few miles up a tremendous hillside, over Razmak Narai (7,300 feet), on to the plateau. This latter road forms a link in a long road running roughly parallel to the Durand Line by Mir Ali, Razmak, Wana and Fort Sandeman, and linking the forward garrisons of the frontier from Thal in Kurram to Quetta.

Waziristan Military District contains also that stretch of the North West Frontier Province between the Indus and the Tribal border; the District as a whole is thus roughly equal in area to that part of England from Dover to Bath and the Channel to the Trent; it contains nearly 400 miles of road, of which half are metalled and tarred and the remainder mostly surfaced with shingle.

From District Headquarters at Dera Ismail Khan on the Indus the main stations of the District lie at the tips, as it were, of three fingers—Bannu Brigade 90 miles, Razmak Brigade 115 miles, Wana Brigade 125 miles away.



2. WANA.

Wana is 4,500 feet high and 17 miles from the Afghan Border. It was first occupied by a British Force in 1894 under Sir William Lockhart, whose A.C.R.E. it is interesting to note was Captain Aylmer Hunter-Weston.

Wana lies at the eastern end of a plain some 15 miles long and 5 miles wide bounded by hills rising to over 10,000 feet. This plain is of considerable strategic importance, as from its western end run well-used routes into Afghanistan and from its eastern end lead the passes, now traversed by roads, to the plains of India and to Razmak and to Baluchistan. Wana has been the scene of much fighting during the 40 years since its first occupation, and in 1929, after being in the hands of the Wazirs for 7 years, it was finally occupied by the Manzai Brigade. Since that date the troops have lived in a confined perimeter camp under canvas. A project to build barracks reached the stage of completion of estimates in 1931, but the financial crisis and elements of uncertainty in regard to future policy led to the project being dropped. The cost of the work, which would have been carried out by contract, was estimated to be roughly 90 *lacs* of rupees (£675,000).

3. KHAJURI PLAIN CONSTRUCTION.

In 1933 an experiment was carried out in Peshawar District, which was to affect profoundly the housing problem at Wana.

After the Khajuri Plain operations of 1930 a cordon of forts was built commanding the exits from Afridi territory into the Peshawar Plain. Each fort is garrisoned by one battalion and in 1933 two Sapper and Miner Field Companies, with the assistance of the battalions in the forts, built barracks for the garrisons on a system of mass production of hollow concrete blocks. The barracks were single-storey of simple design and were erected at high speed in five months.

4. INCEPTION OF WANA PROJECT.

The necessity for provision of permanent accommodation for the Wana garrison now five years under canvas was in the meantime becoming urgent, and the success of the Khajuri Plain experiment indicated a cheap and speedy solution. Early in 1934 an approximate estimate of 40 *lacs* (£305,000) based on the Khajuri Plain results, with the necessary allowances for the much enhanced distance for carriage of stores, was submitted to H.E. the C.-in-C. and subsequently to the Secretary of State. Intimation of these proposals first reached the C.R.E., Waziristan District, about the end of June, 1934, and steps were at once taken to examine the fundamental bases of the problem.

It is proposed in this article to indicate some of the problems which had to be solved in the inception and organization of the work. It is hoped that the technical description of the many sides of this vast and intensely interesting troop labour project will be described by some of those officers who have had the practical handling of the work.

It must be remembered that none of the officers or staffs who dealt with this work had had any previous experience of this type of construction, no type designs of buildings were available and the use of hollow concrete blocks introduced many complications which had to be overcome one by one as they arose. Incidentally the Sapper and Miner tradesmen had not had any experience in handling these blocks. Although the Khajuri Plain experiments provided certain valuable lessons, the whole problem was so different and on so much larger a scale that different methods had necessarily to be employed.

5. Preliminary Investigations.

At the very start it was apparent that no appreciation of the time, labour, plant or transport could be formulated without a complete detail of the work to be done. The first thing therefore was to make a complete list of all buildings required. A book was compiled in which were shown the requirements of each unit. The project had to provide for the following :—

Brigade Headquarters and Signal Section.
One Cavalry Squadron.
One Mountain Battery R.A. and Post Guns.
One Field Company Sappers and Miners.
Three Indian Infantry Battalions.
One Section Armoured Car Company.
Two Troops Animal Transport Company, R.I.A.S.C.
Combined Indian Military Hospital.
Field Ambulance Company.
Veterinary Hospital.
Quarters, Offices and Stores for Military Engineer Services.
Supply Depot.
Garrison Serjeants' Mess.
British Troops Institute.
Quarters and Offices for Military Accounts Department.
Piquet Towers and Defences.
Post Stores and Magazines.
Brigade Schools.
Power Station, new Well and Pumping Plant and Reservoir. Electric Lighting of Barracks; Roads, Drains and Irrigation Channels.
Arboriculture.

In addition, and outside the 40-*lac* estimate, the C.R.E. was responsible for the lay-out, design and construction within the post of Military Dairy and Grass Farm Depots, Civil Treasury, Political rest-house, Post and Telegraph Buildings, Bazaar and other adjuncts to the amenities of the post. Outside the post a Civil Serai is to be built and new ranges constructed.

To cope with the extra work of this project the officers' strength of the Military Engineer Services in Waziristan was increased by one subaltern (A.G.E.). Originally it was proposed that the G.E. Wana Division (a small (!) charge of some 200 miles of mountain road, two cantonments, six Scouts Posts—large forts garrisoned by anything from one to three companies and headquarters—and many other responsibilities) should add the project to his normal work. Needless to say this soon proved impracticable and the Garrison Engineer, Major H. F. Barker, became G.E. New Construction with an A.G.E. to assist him, and the senior A.G.E., Captain Clayton, became G.E. Wana Division.

To hark back to the preliminaries, the book referred to above commenced with the detail of the establishments for every unit, checked by the "A" Staff of District Headquarters. Subsequently pages contained lists of every building authorized by Barrack Synopsis, unauthorized buildings requiring special sanction and all other details of accommodation on which a decision would be necessary. Every officer concerned was consulted—C.R.A. for Artillery accommodation, A.D.M.S. for Medical buildings, A.D.S. & T. for R.I.A.S.C. installations and so on, and their opinions recorded. It was very shortly discovered that with so many interests concerned, (the G. & Q. Staff and the Brigade Commander almost invariably), by far the quickest and most businesslike way of settling the hundred and one points of policy that cropped up was to bring them before a Committee. This led to the setting up of the Wana Committee, with the Brigade Commander as chairman, the G.S.O. I, A.A. & Q.M.G., C.R.E., and A.D.M.S. as members, and every point of general policy, scales of accommodation, lay-out, suggestions for economy, transport and so on, was thrashed out and recommendations made to the District Commander. This organization was of the greatest value and assistance to the C.R.E.; it enabled decisions to be obtained with the greatest possible speed and saved endless correspondence and discussion.

6. Appreciation of Time, Labour and Transport.

The compilation of scales of accommodation was complete by the middle of August and it was then possible to proceed with a preliminary appreciation of the problem. This very soon reduced itself to the basic factor of the rate of laying concrete blocks. It was calculated approximately that the number of blocks to be laid was 1,250,000, and, taking the skilled masons and bricklayers of a Field Company Sappers and Miners as 9 in number averaging 100 blocks each a working day, it was possible to show that the project would be completed in seven years, or with two Field Companies available in $3\frac{1}{2}$ years. Also, from the Khajuri Plain figures it was possible to work out the organization required to keep these masons fully employed. Actually these figures had eventually to be substantially modified, as many changes were made later in scales and specifications and the final detailed figures of blocks proved to be about 1,800,000. On the other hand it was found that, except under the easiest conditions, the Sapper mason could not lay as much as 100 blocks a day, and work on fireplaces, concrete floors, pointing, etc., necessarily lowered the average output; against this it was found that lower rate tradesmen could do their share of laying, so that the average per Company engaged worked out over a year at about 14,000 blocks a month for an 18-day month. In addition to barrack building it was evident that there would be a large demand for skilled labour for electric light and water supply work, and it was therefore proposed that an Army Troops Company Sappers and Miners should be added to the troops to be made available. It was further calculated that to keep two Field Companies Sappers and Miners working at full pressure 380 infantry would be required. This proved to be somewhat of an under-estimate, but was the figure actually obtainable from one battalion. Hence by March, 1935, the working strength on the project consisted of two Field Companies (No. 9 Field Company Q.V.O. Madras Sappers and Miners and No. 20 Field Company Royal Bombay Sappers and Miners) and one A.T. Company (No. 8 Company K.G.O. Bengal Sappers and Miners), a combination of all three Corps in one station believed to be hitherto unique, but to be followed some three months later by the concentration of Sapper and Miner units at Quetta after the earthquake.

It was furthermore estimated that a normal monthly lift of 250 tons from railhead at Manzai with an occasional double lift would have to be met.

The sanction of the Secretary of State to the project at a cost of 40 *lacs* was received in September, 1934, and a sum of 2 *lacs* (£15,000) allotted for expenditure during the year. It was now possible to get down to the project in earnest. Experiments had already been carried out to determine the best size of block; it was thought that, with the more complicated double-storey buildings at Wana, the Khajuri block 9 in. by 9 in. by 18 in. was likely to be heavy and difficult to handle, its weight being about 75 lb. Eventually 8 in. by 8 in. by 16 in. was selected as being the largest size that could be easily handled. A steel mould was designed, holding 10 blocks, capable of hard and prolonged wear, and sufficient material ordered to make 250 moulds or an output of 2,500 blocks a day allowing for blocks remaining 24 hours in a mould. At a later date this was raised to 3,000 to cope with increased output. The steel was ordered in October, but was not all received until February, 1935, so that manufacture of blocks was not practicable before March, 1935.

7. Policy as to Scales and Specifications.

In the meantime much preliminary work in connection with scales and specifications had to be undertaken.

An approximate estimate based on the preliminary survey of building requirements showed that the figure of 40 *lacs* was likely to be a very tight one and, when one by one all kinds of additions such as mosquito proofing for all Indian Troops barracks, cement floors, double sized dining-rooms and so on, which had not formed part of the original simple estimate were ordered, it was necessary to point out to higher authority that the figure of 40 *lacs* must necessarily be far exceeded. The ruling was then given that 40 *lacs* was the limit. The Wana Committee was then faced with the task of forming the proposals in order to ensure that all essential requirements were met. The first obvious economy was to build only for the numbers normally in the station instead of for 100 per cent. establishment. When this was first suggested to higher authority a reply was received that two project estimates should be prepared, one on 75 per cent. basis, one on 100 per cent.!! This was received with mulish obstruction by the C.R.E. and died a natural death. The Wana Committee then produced scales of requirements based on actual needs for every type of building, and these scales were in due course approved. Other economies were verandahs on one side of the buildings only (this affected the lay-out plan as all buildings had to face south), leaving out dining-halls altogether and so on. It was not until February that decisions were given by the Government of India on all these matters of scales and specifications and it was possible to get down to design and estimating. The importance to the engineer executive of an early and firm policy cannot be over-emphasized.

8. Lay-Out Plans.

The lay-out plan of the cantonment had been under consideration for a long while. Wana being a perimeter camp, in which an important factor is economy in the garrison left behind when the column is out, it was necessary very carefully to balance the length of the perimeter against the desire to give adequate breathing space in the camp.

Razmak, the biggest camp in Waziristan, had suffered severely from irregular growth and lack of town planning.

Built mainly in 1923 and subsequent years, Razmak consists of single-storey barracks closely packed, with small parade grounds, few open spaces and living quarters, servants' quarters, stables and all the numerous subsidiary buildings in almost slum-like propinquity. It was considered desirable as far as possible to avoid all these unfortunate features in planning Wana.

It was considered that, by constructing six concrete piquet towers at a maximum of 700 yards apart round the perimeter, and providing adequate wire and lighting, an economical garrison could be ensured. The lie of the ground dictated the general shape of the camp, a six-sided lozenge. In the preliminary block lay-out a number of factors had to be considered. Among these were :—

(*a*) *Malaria.*—A powerful and energetic anopheles had his chief habitation to the south-east of the camp. It was therefore laid down that the bulk of the animals were to be along the southern perimeter to form a barrage against the mosquito.

(*b*) For purposes of defence it was important to have the three infantry battalions more or less equally spaced round the perimeter.

(*c*) Cavalry, Artillery and Sappers had to be reasonably near to one another, as the officers shared one Mess.

(*d*) The Supply Depot, M.T. convoy rest camp and Light Tank unit were better sited at the east end, where the main road from railhead entered the camp.

(*e*) Officers' Messes were to be near the perimeter so as to have the benefit of wide-open views. This is psychologically of importance, for it is frequently the case that the atmosphere of a perimeter camp after a long sojourn has a somewhat depressing effect and an open outlook to the distant hills goes far to counteracting this.

(*f*) To provide the camp with its lungs a large central space capable of being turned into a park was important. It may be mentioned that given adequate water, of which in this case there is no shortage, trees and flowers and grass grow to perfection in Waziristan. The small parks and gardens which do exist in Razmak are a joy to behold during the summer, every English annual and herbaceous plant flowering in profusion, and the same applies to Wana.

(*g*) A road running completely round the camp inside the perimeter was considered essential.

After much thought and one or two abortive efforts, the final lay-out of the camp was approved by the Government of India in the form shown at Sketch No. 1. The Fort shown in the sketch was a relic of a former fortified camp, and houses the existing well, power house and M.E.S. offices and storeyard.

9. The Detailed Lay-Out.

The general lay-out having been approved, the next step was the detailed lay-out of buildings. In an expansive moment the C.R.E. suggested that unit commanders might like to submit their own ideas for their respective lines. Regrettable as it may seem, the results had to be tactfully relegated to the w.p.b.; not the least interesting feature of these town-planning schemes was the fact that in most cases the unit would have had to mount about four guards, adequately to protect its rifles and stores.

The whole of the detailed planning was then undertaken in the C.R.E.'s Office, where we were fortunate in having an Indian Technical S.D.O. of remarkable ability, ingenuity and originality, whose work in this connection was invaluable.

The principles which dictated the lay-out of each set of lines were as follows :—

(*a*) The men's barracks, for tactical reasons to be, as far as possible, near the perimeter.
(*b*) All offices and administrative buildings, stores, armouries, and so on, to be together and grouped round a square and all within view of the sentry on the quarter guard.
(*c*) Traffic circuits for ration carts to be reduced to a minimum, following the lines dividing the administrative block area from the barrack area.
(*d*) Parade grounds to be provided.
(*e*) Officers' Messes to face the perimeter with adequate space for garden and tennis court for each Mess.

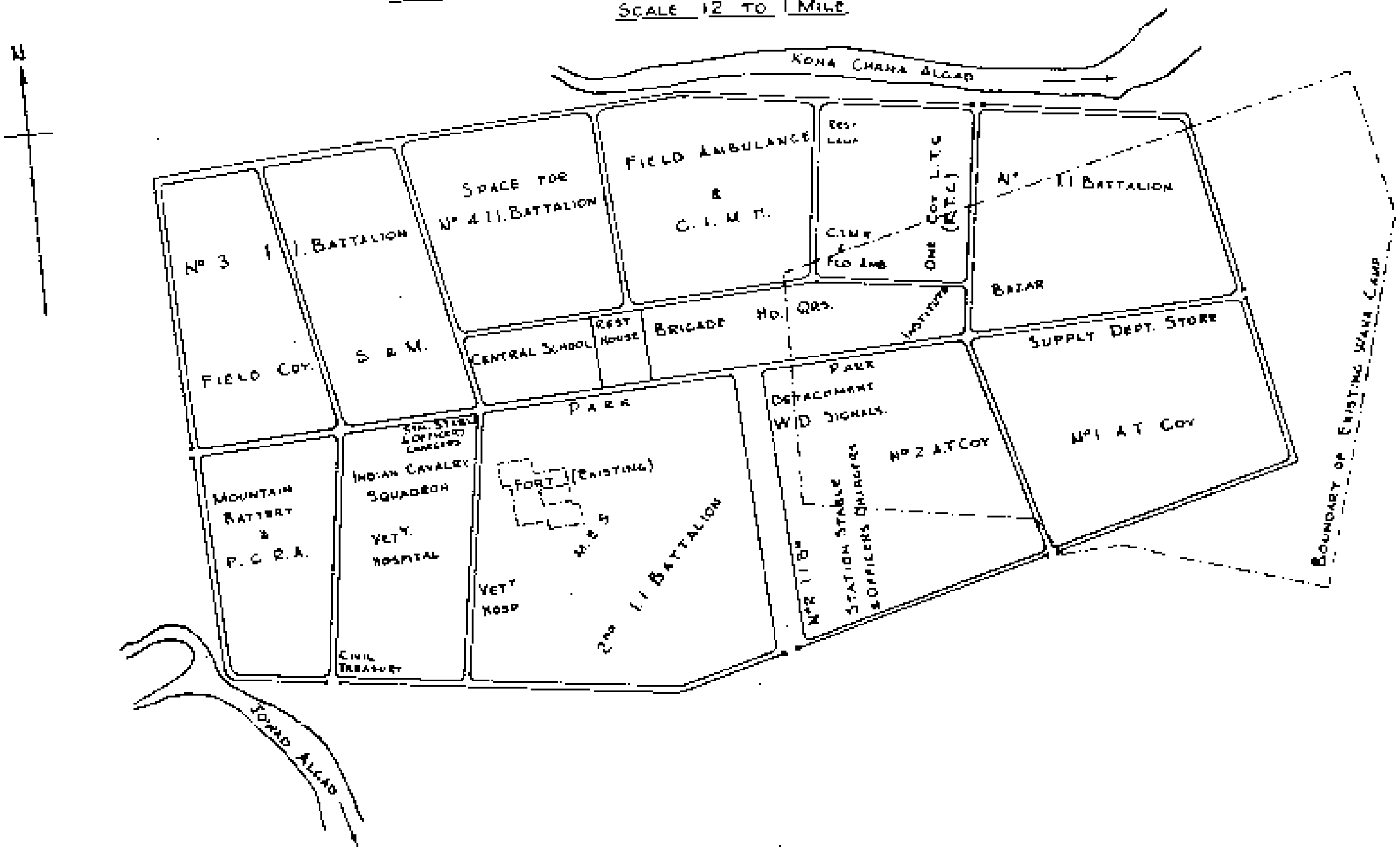
A typical battalion lay-out is shown at Sketch No. 2. The battalion areas varied from 58,000 to 64,000 square yards, and with double storey barracks, this gave ample room and breathing space for every unit.

10. Plans.

All the preliminaries having been settled, it was possible to get ahead with design and estimate. The use of the 8 in. by 8 in. by 16 in. block produced many complications in design, and, with so many different types and sizes of building, a standard design was out of the question. It was therefore extremely difficult to keep

BLOCK LAY-OUT OF NEW WANA CANTT

SCALE 12" TO 1 MILE



Sketch No. 1.

the issue of designs in step with the pace of the work, whilst the problem of obtaining adequate draftsmen in this out-of-the-way spot was by no means easy. It is computed that the project will require in all about 3,000 drawings.

11. The Project Estimate.

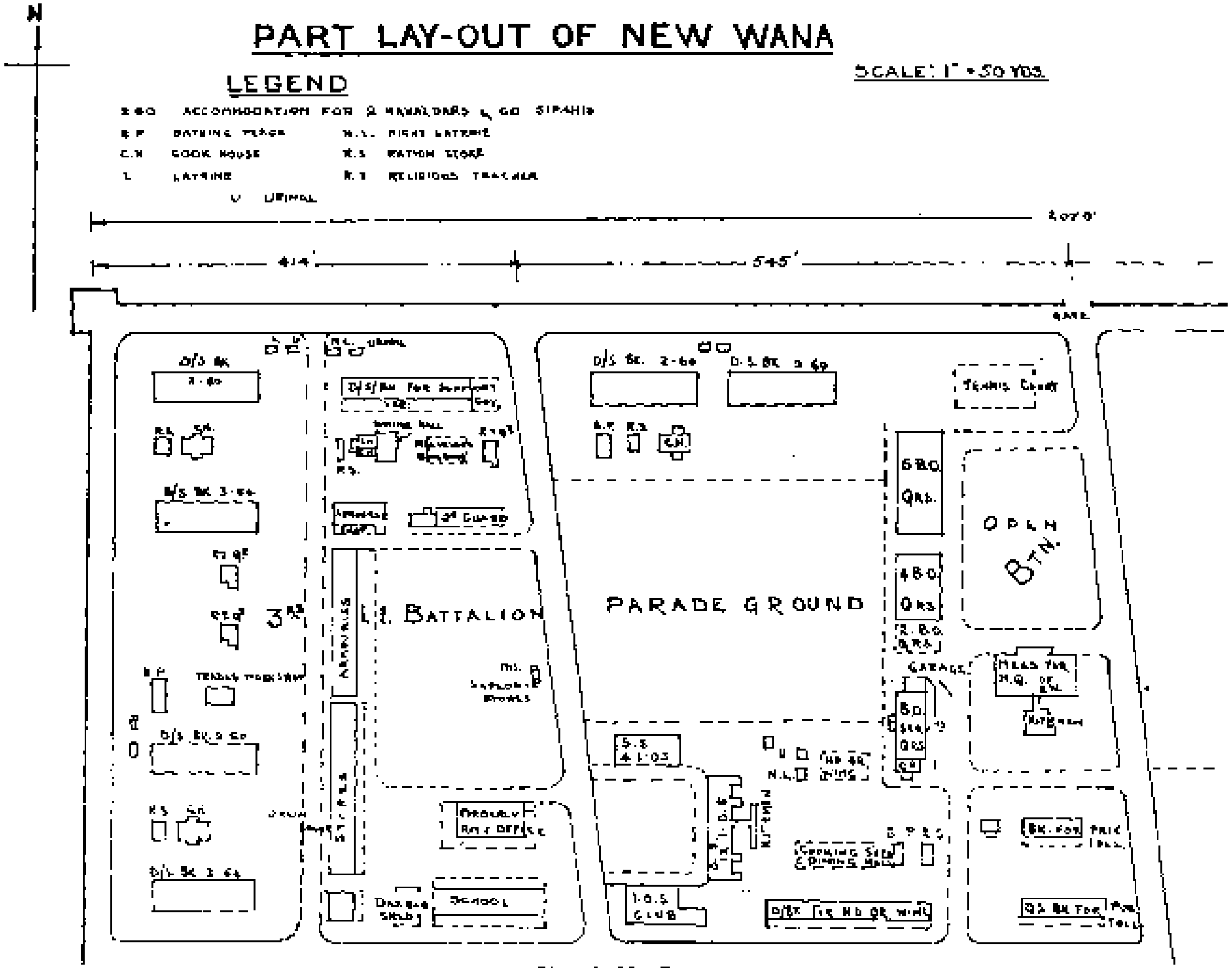
The Project Estimate was a formidable task. No comparative buildings existed and it was therefore necessary first of all to compile from first principles a special schedule of rates for all types of work and materials, on which to work out first the detailed estimates for different types of buildings and hence p.a. rates applicable to each type. The task was tackled with unbounded energy and enthusiasm by the C.R.E.'s Technical S.D.O. and Section and completed in the phenomenally short space of time of three months, middle of February to middle of May; the typing taking a further two weeks. The estimate consisted of 39 parts, the abstract alone forming a pile some 3 feet high whilst the detailed workings formed a tower of foolscap over ten feet in height. Through the personal efforts of the C.E., who with the C.R.E. went up with the estimate to Army Headquarters, sanction was obtained in a remarkably short space of time. The way was now clear to go ahead wholeheartedly with the work.

The various details of this project will be described in later articles by officers who have been most closely connected with the work, but before concluding this introduction a short description of the organization and the progress of the work will not be out of place.

12. Organization.

The Garrison Engineer is responsible for the general organization and direction of the work, the Sapper and Miner units acting as contractors. The G.E. has to assist him an S.D.O. B & R. and an S.D.O. Furniture and Stores. The supply and issue of stores is a very formidable task; the value of the materials-at-site account is 4 *lacs* and the stores comprise hosts of different items. The monthly *lift* of stores by M.T. from narrow-gauge railhead at Manzai, 65 miles from Wana, has been found to vary from 250 to 400 tons, many stores such as electric light poles being of awkward dimensions.

One Field Company is responsible for the organization and running of the block manufacturing platform and has built in addition the lines of the Sapper and Miner Field Company. The other Field Company is employed solely on building and has been responsible for erection of the lines of an Infantry battalion; the Army Troops Company is charged with all water supply and external electric lighting work; it has dug a new well 62 feet deep and


PART LAY-OUT OF NEW WANA
SCALE: 1" = 50 YDS.
LEGEND
N
414'
545'
GATE
PARADE GROUND
OPEN BTN.
3RD I.I. BATTALION
TENNIS COURT
ARMOURIES
STORES
SCHOOL
ORDERLY RM & OFFICE
KITCHEN
I.O.S. CLUB
COOKING SHED & DINING HALL
GARAGE
QRS.

Sketch No 2.

erected the steel reservoir of 50,000 gallons capacity and has built certain buildings not part of unit lines, such as piquet towers and the Power House.

The progress of the project is most easily gauged by the rate at which blocks can be laid, for although there is necessarily some lag in finishing, such as plastering, fittings and roofing, the rate of block laying is a real standard of progress. Commencing in May, 1935, the first eight months were characterized by somewhat slow progress; very many problems in detailed design had to be overcome, difficulties arose over supply of *bajri*, our conceptions of plant were originally inadequate, and the organization as a whole was being built up bit by bit. The rate of manufacture was not for some time up to the practicable speed of laying, and the actual issue of designs could hardly keep pace with the work. Nevertheless the tally constantly rose and by November, 1935, had reached 32,000 blocks laid in the month. During the winter the organization was perfected and plant installed to give a manufacturing output of 3,000 blocks a day. In the spring of this year, 1936, the whole work went off again with a bang, and in May the output of manufacture rose to 64,000 blocks and laying to the remarkable total of 73,000 blocks in the month, equivalent to the construction of six double-storey barracks, more than had been achieved in five months in the previous year. It was anticipated that one battalion lines and the Field Company Lines would be ready for occupation early in October, the Battery Lines are well advanced and the work as a whole a quarter complete, in spite of the unavoidable delays during the first few months. The strength of the parties employed in all parts of the work are Sappers 400, Infantry 380, Civilian tradesmen and coolies about 100.

A satisfactory feature of the work is the enthusiasm of all concerned, particularly of the infantry who ram concrete in moulds, carry blocks and push trucks as if they enjoyed it. Excellent work they put out too; blocks are now first class in appearance and the wastage in manufacture is negligible; in one case 30,000 blocks were made in ten days without one case of failure. The value of this achievement may be gauged by the fact that a loss of 1 per cent. represents a cost to the project of Rs. 5000/-. In all, the project will require some 1,800,000 blocks, of which 420,000 have now been laid.

SEALING OF HANNA LAKE.

By Captain H. I. Pocock, R.E.

Hanna.

Hanna Lake lies about eight miles outside Quetta, and constitutes one of the main reservoirs for irrigation water in that part of Baluchistan. The lake fills up during the rainy season and then, normally, holds enough water for irrigation during the rest of the year. Some years ago it was discovered that the water was disappearing in some mysterious way. Investigation was carried out by the Irrigation Authorities. Evaporation could not account for the entire loss, and in due course they decided that leaks had occurred on one of the sides of the lake. It was alleged that water percolated through the surface soil and seeped away through fissures in the underlying rock.

Photograph No. 1 shows the area which was suspected of leaks. The size of it was approximately 100,000 sq. ft. It was decided to "seal" this area, and advice on the method to be adopted was sought from the M.E.S. (This occurred in 1934.)

Decision to Use Gunite.

A considerable amount of work with Gunite had been done by the cement gun contractor under M.E.S. supervision in Manora (Karachi) in the previous year. (For brief details see Appendix II.) The results had been so successful that a trial in Baluchistan was decided on. Further, it was decided to use Gunite by direct labour. Consequently a plant was purchased, and the M.E.S. undertook the sealing of the area specified by the Irrigation Authorities. As far as the writer knows, this was the first time that Gunite was carried out by direct labour by the M.E.S. Some account of the work may be of interest.

Gunite.

"Gunite" is not a new invention. It has been known in America for many years. There is a reference to it in *Notes on Cement and Concrete. Part I* published by the S.M.E. in 1923, and an article describing its use in the repair of the barge pier at Shoebury.

ness appeared in *The R.E. Journal* of December, 1931. For those who have not met it before, a brief description is necessary before describing the work at Hanna.

Gunite is a process of cement plastering with cement and sand, under a pressure of 30 to 40 lb./sq. in. The plant required consists of :—

Cement gun.
Gunite placing nozzle.
Compressor and air bottle.
Prime mover.
Special rubber-lined hose for connecting air bottle to the gun, and for connecting the gun to the nozzle.
Water hose, ½-in. diameter.
Two water cisterns to withstand pressure of 100 lb./sq. in.

The action of the plant is, briefly, as follows :—

Dry cement and sand of the required mixture are fed by hand into the top of the "cement gun"; from thence it drops into the working chamber, which contains a "Feeding wheel." The working chamber is supplied with compressed air from the compressor, and the "feeding wheel" is caused to rotate by an air-motor (similarly supplied with compressed air). The dry cement and sand is fed by the "feeding wheel" under the pressure of the air (30-40 lb./sq. in.) into a "material pipe" connected to the cement gun. The other end of the material pipe is connected to the nozzle. Dry cement and sand is therefore forced from the cement gun to the nozzle, under a pressure of 30-40 lb./sq. in. Hydration of the cement and sand takes place at the nozzle. Water under pressure is blown from the water cisterns down the water hose to the nozzle. The amount of water issuing at the nozzle is controlled by a valve incorporated in it. The correct adjustment of this valve by the man operating the nozzle ensures the required degree of hydration of the cement and sand. A correct mixture of cement, sand and water is thus blown from the nozzle at a pressure of 30-40 lb./sq. in. on to the surface, and a layer of cement plaster to the required thickness is built up.

The characteristics of Gunite are due to the way in which this layer is formed. Many advantages accrue to Gunite on account of its special characteristics, and render it particularly valuable in repair work. (A note on its application to various types of repair and its advantages over other methods is given in Appendixes II and III.) The chief characteristics are :—

1. High crushing strength. With perfectly clean sand, free from all impurities such as marl, a crushing strength of 6,000 lb./sq. in. is claimed. All sand at Hanna was washed twice before being used.

2. It is practically impervious to water.

3. It does not crack, and hence expansion joints are not required.

4. A very high standard of work can be achieved once the operating gang have been properly trained. This follows from a consideration of the action at the nozzle.

When the mixture is applied to the surface from the nozzle the first thing that happens is the formation of a layer of pure cement on the surface. The sand in the mixture rebounds from the surface. As soon as this first layer of cement is formed, the sand in the mixture following adheres to the cement. A further cement layer is formed simultaneously, and the process becomes cumulative. Any surplus sand that does not become coated with cement, merely rebounds from the wall. An examination of the rebound sand shows that it is entirely free of cement, and it can be re-mixed in the gun.

If too little water is used at the nozzle, the mixture, being insufficiently wet, does not allow the formation of an adequate layer of cement, with the result that the rebound of sand is considerable.

If too much water is used the mixture becomes too soft, and runs down the surface.

In either case no real plastering effect occurs, and the fact is obvious to the supervisor.

If the mixture itself is too weak when fed into the gun, the rebound of sand will be considerable. In this case it cannot be corrected by adjusting the water. Faulty workmanship again makes itself apparent at once. It may, therefore, fairly be assumed that if the Gunite sticks to the surface the mixture is *theoretically* correct.

WORK AT HANNA.

We will now pass on to the actual work at Hanna. Photograph No. 1 shows a panoramic view of the whole area to be treated. This also shows the work in progress. Photograph No. 2 shows the larger part of this area, before Guniting began, but after the loose stones had been removed from the surface.

The area may be divided into three categories, each of which required slightly different treatment :—

1. On each side of the dam the surface was entirely of rock.

2. To the left of this there was a thin covering of earth over the rock, with occasional rocks projecting through.

3. On the extreme left the surface consisted entirely of earth. (See Photographs Nos. 1 and 2.) The earth in its virgin state was covered with loose stones. The bottom of the lake was clay.

The sealing of this area was to be carried out by covering the whole with a continuous slab of Gunite of about 1½ in. thick (mixture 3 sand 1 cement), with no joints of any sort. The slab was reinforced with a steel mesh of 4 in. square, and of $\frac{3}{16}$ section. The reinforcement was pegged securely to the earth at frequent intervals, with 3 ft. long 2 in. angle irons. The object of this was, primarily, to ensure that there should be no subsequent movement between the earth and the Gunite. No reinforcement was used on those areas composed entirely of rock; owing to the pressure under which the Gunite was applied sufficient penetration occurred to produce a good bond. The surface was merely "roughened up," prior to application. In places where rocks projected through the earth, the reinforcement was carried over the rock, and the interstices were packed out with small pieces. See Photograph No. 5, which shows a rock partially completed with Gunite. Photographs Nos. 3, 4, 5, and 6 also show the general treatment of the surface.

To prevent any possibility of water percolating between the layer of Gunite and the clay at the bottom of the lake, a ditch was dug all round the edge and the Gunite was carried down about six feet below the level of the clay. The ditch was subsequently re-filled with clay to the normal level.

A Few Details of the Work.

The work was divided into the following phases:—

1. Preliminary work at the site.
2. Manufacture of "specials" and assembly of plant at site.
3. Training of the gang.
4. Work of Guniting.

1. The preliminary work consisted of:—clearing loose stones and debris from the area; pegging down the reinforcement, and adjusting it so that a clear space of not less than ¾-in. was left for the Gunite to surround it completely; treatment of the projecting rocks; erection of scaffolding near the main rocks, and roughing-up of all smooth surfaces; digging the ditch for the toe of the Gunite layer; and the erection of a store hut and office for the overseer in charge.

2. The plant used was the following:—

Two compressors, each with its own 35 h.p. petrol engine.
One inter-chamber for air supply.
Two inter-connected cisterns for water.
Cement gun, hose and nozzle.
One portable water tank with semi-rotary pump.

Piping, water tanks, etc., for distribution of water along the area to be worked.

Under normal conditions, one compressor, driven by approximately 40 h.p. engine, and capable of giving 200 cubic feet of free air per minute at a pressure of 80 lb./sq. in., is sufficient to maintain the required pressure of 35-40 lb. at the outlet from the cement gun.

Owing to the loss of volumetric efficiency due to altitude in Quetta, it was found that two compressors were required. Each was capable of giving about 200 cubic feet free air at 75 lb./sq. in. at sea level. These were connected to an "inter-chamber" from which connections to the gun and water cisterns were taken. See diagram Appendix V, also Photograph No. 7, showing the order in which the connections were made. The inter-chamber was made of ¼-in. mild steel plate in the M.E.S. workshop. All joints were welded, and tested to 150 lb./sq. in. (*i.e.* double working pressure). Pressure gauge and safety valve were fitted.

The inter-connected water cisterns were made in the same way in the M.E.S. workshops. These cisterns are only necessary where a piped water supply giving a pressure of not less than 40 lb./sq. in. is not available. Two cisterns are inter-connected, so that one can be filled while the other is in operation. Connections are shown in Appendix V.

The cement gun is made in three sizes, graded according to the size of the delivery hose used:—

1. Largest size taking a 2 in. delivery hose, used for large areas where the plant can be kept more or less stationary.
2. Medium size, taking 1½ in. hose, used for normal work.
3. Small size, taking 1 in. hose.

No. 2 size was used at Hanna.

The nozzle was supplied in sizes from ½-in. to 1 in. The ¾-in. size was generally used.

No water was available on the site. A reservoir was made out of a portable tank, in M.E.S. shops. This was towed to the site and anchored, and kept filled by a water lorry which carried water from a stream about two miles away.

A convenient footpath—just wide enough to take the compressors (but not the portable water tank)—ran along the edge of the lake, above the area to be Gunited. The plant was assembled on this path for work on the area below, and a piped water supply was delivered along it from the reservoir, by means of a semi-rotary pump. Local storage was provided at various points along the path.

3. Success in working the plant depends entirely on:—

1. Training the men operating the gun and nozzle.
2. Organizing the gang so that they all work as a team, and keep the nozzle man supplied continuously with the correct mixture of cement and sand at the required uniform rate.

When the gang is trained, subsequent check on their work is essential, to see that the team is continuing to function as such. This will be dealt with more fully later. The importance of this will be realized from the fact that cement is being used at the rate of 500 to 1,000 lb. per hour, depending on the rate of the work. An inefficient team may lead to this amount of material being entirely wasted.

The strength of the team will vary according to local conditions. The following may be taken as an average :—

1 overseer in charge.
1 nozzle man.
1 *cooli* to help nozzle man.
1 gun operator.
1 engine driver.
2 *coolis* for mixing cement and sand.
1 *cooli* for filling the gun.
1 *cooli* for filling the water cisterns.

(At Hanna a greater number of *coolis* was employed owing to the necessity of carrying the cement and sand, etc., and for washing sand, etc.)

It is not proposed to enter into the details of handling the plant, as this will not be of general interest. The salient points only will be mentioned. For anyone who is faced with the problem of working Gunite by direct labour, complete details of operating the plant and training the team, etc., may be had from the office of the C.E. Western Command, India. The chief points in training the team are :—

1. Careful selection of "key men," *i.e.*, overseer, nozzle man and gun man.
2. Careful training in their respective jobs, (which, with Indians, cannot be hurried).
3. As much preliminary practice as possible, with careful examination of the resulting work and reasons for any defects that appear.

The duties, in brief, of the various members of the team are :—

Overseer. Must thoroughly understand all the plant and be capable of working any of it himself. He must also be able to keep the "stores ledgers," "work record," etc.

Nozzle man. He is the most important member of the team, in that he is responsible for hydrating the mixture and working it on to the surface. He does this by controlling the amount of water issuing at the nozzle. The chief point about his work is that he should get the mixture just sufficiently wet to make it stick to the surface, without any apparent running, and with the minimum of

4. In this section we will deal briefly with the organization of the work at Hanna, and with some of the difficulties that cropped up owing to local conditions.

One of the first difficulties was that of providing adequate supervision to ensure :—

1. Proper use of all material and labour supplied.
2. Consistent high quality work.

The whole of the executive work was done by Indians, who had been previously trained by the writer in Quetta. Supervision was carried out by the writer and one British S.D.O. (both of whom had many other duties in Quetta, and consequently could afford only a limited time for inspection at Hanna, eight miles away). Consequently we endeavoured to evolve a system which would reduce the time taken for inspection to the minimum, and still maintain the required standard of work, with no leakages of material, etc. The following was evolved.

What we required was :—

1. Daily check of receipt of stores at site.
2. Daily check of issue of stores at site for work.
3. Daily check that these stores had been incorporated in the work.
4. Daily check of labour employed on the work.
5. Daily check of quantity of work done.
6. Daily check of quality of work done.
7. Daily check of cost of work done.

To get this the following records were kept at the site. The overseer was responsible for their preparation.

1. *Stores Ledger.* This was the normal ledger that everyone knows, and had the usual three columns for " Receipts," " Issues," and " Balance."

2. *Work Record Book.* In this we recorded the following :—

(*a*) List of machines in use with checked figures for the consumption of fuel, oil, etc.

(*b*) Details of labour permitted, with jobs of each, in accordance with the " Office Order " issued by the writer.

(*c*) Test figures of the quantity of cement and sand used per hour, together with the time taken per unit of work. These figures were verified by the writer and his S.D.O.

(*d*) Daily analysis of cost.

3. *Plant Record Book.* This showed hours worked per day, issues of material, etc., and technical data.

4. *Copies of Indents.*

5. *Order Book.*

rebound sand. To do this he must control the water valve very accurately, and should apply the stream of mixture at right angles to the surface, holding the nozzle about 2½ feet away. As the nozzle and length of material pipe is fairly heavy, a *cooli* is required to help him, by taking the weight of the material pipe, while he plays with the nozzle. See Photograph No. 6.

Gun operator. He is responsible for keeping the mixture flowing at a uniform rate to the nozzle man. This entails setting the air motor which works the "feeding wheel" to the correct speed, and in seeing that the gun is kept full of mixture, also that the pressure at the gun is correct. If this drops to 20 lb. he must immediately notify the engine driver. If it drops below 20 lb., he should shut down, as no real plastering effect can be had with a pressure of under 20 lb./sq. in. The operator is responsible also for cleaning out the gun after work.

There is a definite sequence of operations, which must be learned as a drill, and strictly adhered to. Failure to do this may result in serious damage to the plant, and consequent stoppage of work for an indefinite period. (This sequence of operations is given in the information already referred to, which is recorded in the C.E.'s office.)

The duties of the remainder of the team are obvious. But they must work at such a rate that the gun is kept continuously supplied, and the actual numbers required must be arranged according to local conditions, so that the whole process of "washing," carrying, mixing, and feeding the gun, becomes a continuous progressive operation. The same applies to a steady supply of water for hydration, and, incidentally, of petrol and oil, etc., for the compressor units.

Any interruption in the continuity of operations results in complete stoppage of work, entire plant being idle, entire team being unproductive, and, probably, waste of all material in the gun. Only a few of these interruptions are required to make the running costs of the work soar to an incredible height, and reduce the engineer's estimate for the work to a mere farce. The question of organization is dealt with in the next paragraph, but, in passing, it may be said that economical work with Gunite can only be achieved by :—

1. Efficient training of the team.

2. Constant supervision.

3. Arranging the order of work in such a way that the minimum of time is spent in moving the plant, and

4. Guarding against mechanical breakdown by regular periods of inspection, cleaning, etc. (One day a week was allowed at Hanna.)

B

6. *Muster Roll.*
7. *Daily Measurement Book.*
8. *Plans.*
9. *Approved sample of sand.*
10. *Samples taken from the work during progress.*

Specimens of the information given in "Work Record Book" are given in Appendix IV.

The following daily checks were carried out :—

1. Receipts of stores were checked against indents made by Overseer.

2. Issues must agree with the figures given in the daily analysis in "Work Record Book." Balances were counted.

3. To check that the stores had been duly incorporated in the work, the issue of material must tally with the "test figure per unit," and area of work done as shown in the "Work Record Book."

The issue of P.O.L. was checked by the test figure for consumption per hour multiplied by the number of hours worked as recorded in the "Work Record Book."

The number of hours worked was checked by the test figure for "Rate of work," as recorded in the "Work Record" and the area measured in the "Daily Measurement Book."

4. The labour employed was checked from the muster roll, and the number compared with the entry in the "Work Record Book," and with the Office order authorizing this amount of labour.

5. The quantity of work was checked from the "Daily Measurement Book." The actual area done was marked and dated with red paint to facilitate check.

6. The quality of the work was checked, firstly by comparing the sand used with the approved sample. (Unfortunately no apparatus existed for testing cement, but as this was obtained through the I.S.D. provision of an apparatus was considered unnecessary.) Secondly, the work was tested by taking, at random, a sample from the nozzle. A slab of about 6 in. by 4 in. by 1 in. was made. Again no proper testing machine was available, but an indication in any variations of quality were obtained by observing the weight of different samples, and by testing their absorption of water. In addition to the above, test holes were made in the actual work, to see that the correct thickness was being applied.

7. The daily cost of the work was obtained direct from the "Work Record Book."

The above may sound an unnecessarily cumbersome affair. In actual fact, the checks took a surprisingly short time to carry out.

And the fact that discrepancies would be shown up instantly acted as a considerable deterrent to the Indian team, and gave a sense of security to those responsible for the work.

5. From the point of view of the work the only real difficulty that arose, was that of ascertaining and removing the cause of small cracks that appeared occasionally in the layer of Gunite. Gunite when laid properly should develop no cracks. The writer has seen areas of many thousands of square feet laid without any crack. The Gunite that was applied to the rock showed no tendency to crack, and a perfect result was obtained on this portion of the job. Difficulty was encountered where Gunite was applied to an earth surface. It has already been mentioned that the nozzle man gauges the correct mixture of water, by watching the rebound sand and the wetness of the work, which should be such that the Gunite is just plastic. On a vertical rock face this is easy enough. But on a sloping earth face the rebound sand hardly shows up at all, and the gauging of the required degree of wetness is also difficult. Furthermore, the rebound sand does not all fall away from the work, as it would on a vertical surface. Hence there is a liability for particles, uncovered with cement, to be left in the work, thus causing a source of weakness. This was remedied by having a slightly stronger mixture, and by running it a trifle wetter than on vertical work.

It is also difficult to gauge the exact thickness when applying to rough earth. The maximum thickness to which Gunite can be laid in one layer is $1\frac{1}{2}$ in. Cracks appear if the thickness exceeds $1\frac{1}{2}$ in. Cracks also appeared where the reinforcement was not properly embedded in the Gunite. This was due to the mesh having been disturbed by *coolis* walking on it. The matter was set right by arranging for a *cooli* immediately preceding the nozzle man, to re-adjust the mesh.

Whenever cracks appeared the faulty area was cut out and examined, and a remedy applied. (A note was made in the "Work Record Book" of all such cases.) In a short time we had eliminated cracks.

Then we tried, in a few places, the experiment of placing a second layer of Gunite on the sloping surface. Occasional cracks appeared. These were cut out and examined. In every case the crack was due to an imperfect bond with the lower layer, owing to some foreign material (generally dirt or rebound sand) lying between the layers. This was cured by arranging for the surface to be cleaned immediately prior to application of Gunite, and thereby reducing the possibility of dirt being blown on to the job. (Hanna is a very windy, dusty place!) And the nozzle man was instructed how to manipulate the nozzle so that the rebound sand fell *away* from the work, and not *into* it. (Detailed information on this point was recorded at the time in the " Work Record Book.")

EFFECTS OF THE EARTHQUAKE.

Work had started early in the financial year 1935-36. On 31st May, 1935, the earthquake occurred. The work was completely disorganized. As the question of storage of water for irrigation was considered urgent, we had to re-start operations as soon as possible. Only one key man of the original team was left. However, within a week or so a new team had been collected, and training started. As was to be expected, much work had to be cut out and re-done to begin with. Eventually the new team worked as satisfactorily as the previous team.

The work, however, was not perfect Gunite. The quality of the slab was up to standard, but small cracks appeared in many places. Great trouble was taken in trying to cure these. All sand was doubly washed. Variations of mixture were tried. " Curing " was tried (this is not normally necessary with Gunite). Different sized nozzles and variations in application of the mixture were tried, all under personal supervision. Cracks still persisted.

The cause was due to the continual shocks that occurred after the main earthquake. The writer happened to be at Hanna during one of these. Even though the shock was slight it was sufficient to start small hair cracks, which, in a few days, opened up to about ⅛-in. It is worth recording that the earthquake had no effect on the Gunite that was applied to rock surface, that the effect on earth where rocks were close to the surface was very slight, and that the effect was greatest where the earth was farthest from any rock formation, and, up to the time the writer last saw the job, the effect produced was limited to the production of small cracks, not exceeding ⅛-in. However, it was considered that the cracks were not large enough nor numerous enough to affect the sealing value of the layer that had been laid. And it is quite certain that no other form of cement plastering would have resisted the action of the continual shocks in the way that Gunite had.

APPENDIX I.

OTHER APPLICATIONS OF GUNITE AND ADVANTAGES OF ITS USE.

The more general uses are for the repair of concrete and masonry structures. It is claimed that it can also be used for the following, although the writer has had no personal experience of these :—

Re-lining coal bunkers.
Renewing furnace boiler linings.
Providing a heat-resisting layer on high-pressure boiler drums.
Re-lining chimneys, both steel and masonry.
Casing-in corroded steel girders.

It is seldom used in new construction, except where a particular type of surfacing is required. Although the Gunite process is a good deal more expensive than hand trowelling of cement and sand, the advantages gained, especially in the repair of cement and masonry, far outweighs the added cost.

Deterioration of reinforced concrete starts by moisture getting in through fine cracks, and corroding the steel. The expansion of the steel due to corrosion bursts the surrounding concrete, and spreads along the steel in all directions, finally weakening the core. The condition may be due to :—

Insufficient cover.
Bad mixing.
Excess of water.
Insufficient tamping.
Careless placing of the steel.

Some action must be taken to prevent the entire disintegration of the concrete. Repair by trowelling on cement and sand is quite unsatisfactory for the following reasons :—

It is impossible to clean the old surface properly.

It is impossible to exclude all air pockets. (Air pockets allow even more serious deterioration than before to go on under the apparently sound covering of cement and sand.)

It is impossible to prevent cracks.

It is impossible to make the surface impervious to water.

It is impossible to guarantee adhesion to the old work.

It is impossible to ensure accuracy of workmanship. Imperfections of mixing, however carefully supervised, are liable to occur. The quantity of water added, which is a material factor in the ultimate strength, is seldom gauged with sufficient accuracy.

Repair by Gunite possesses the following advantages :—

The necessity of cleaning the old surface is not so great, owing to the penetration of the mixture, at the same time the process is easier, owing to the possibility of using compressed air to blow out all dirt.

Any possibility of air pockets is definitely eliminated owing to the pressure of application. If a sample of concrete which has been repaired by Gunite, be fractured, the specimen shows a complete union of the Gunite and the old concrete. Thus deterioration cannot continue underneath the Gunite layer.

Cracks do not occur on the surface of Gunite. A direct comparison of repair by Gunite and repair by the old method of hand trowelling, is available at Manora (Karachi), and bears out the above statement.

Gunite is practically waterproof. A block of 3 in. by 2 in. by 1 in. of Gunite, soaked in water for seven days, showed no appreciable increase in weight.

Accuracy of workmanship is assured, once the gang is properly trained.

APPENDIX II.

PREVIOUS GUNITE WORK DONE IN WESTERN COMMAND.

A considerable amount of work was carried out in 1933 and 1934 in Manora, Karachi, with Gunite.

One of the barrack blocks, constructed of reinforced concrete, showed signs of very serious disintegration, owing to the peculiarly severe action of the Manora atmosphere on the steel reinforcement, the air and moisture having got in through the numerous cracks that existed in the previous attempts at repair. Repair by Gunite was carried out in a very similar way to that used for the Shoeburyness pier, which was described in *The R.E. Journal* of December, 1931. Gunite was also used in Manora to repair portions of the sea wall, and many masonry retaining walls round the fort. In this case 1½ in. un-reinforced Gunite was used. The results were entirely satisfactory.

APPENDIX III.

Further information may be obtained as follows :—

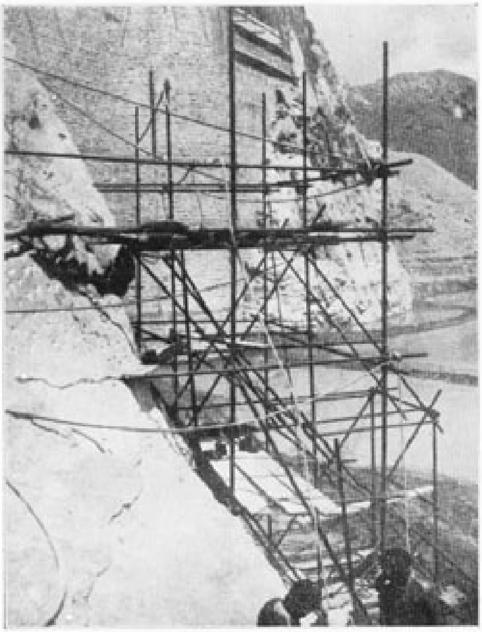
1. From the office of the Chief Engineer, Western Command, Karachi. A technical paper by the writer, giving full details of :—

   Plant required.
   Method of operating the plant.
   Method of applying Gunite to reinforced concrete work.

2. From the office of the G.E., E. and M., and F. and S., H.Q. Division, Baluchistan District, Quetta. Details required for estimating purposes, and for carrying out a job with direct labour, including the following :—

   Checked figures for the rate of work.
   Checked figures for the consumption of material per unit of work.
   Detailed analysis of cost per unit of work.
   Particulars of difficulties encountered, and methods used to solve them.

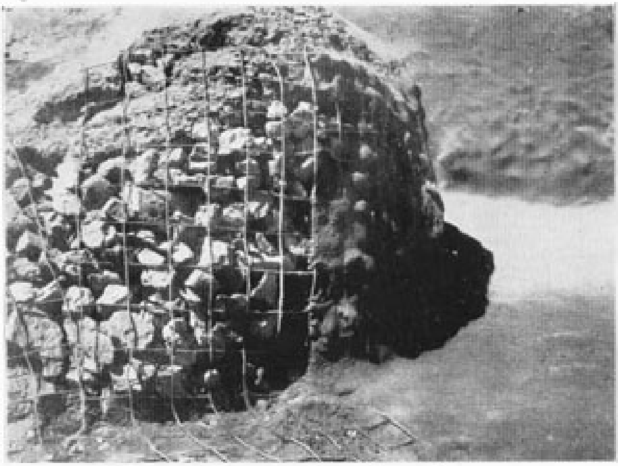
2.—Left section. Surface prepared.



3.—Roughing up surface of rock.

Sealing of Hanna lake 2& 3

4.—Mesh pegged to the ground.



5.—Treatment of protruding rock.

Sealing of Hanna lake 4 & 5

6.—Nozzle-man at work.

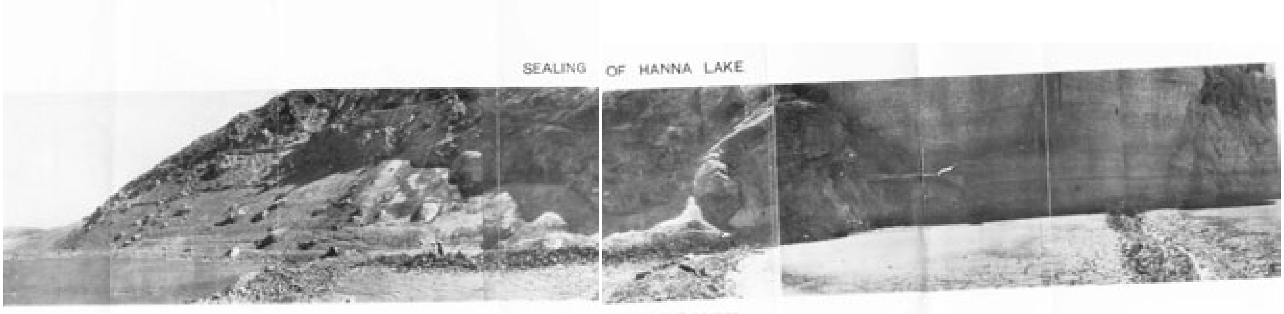
7.—Bird's-eye view of plant and area under treatment.

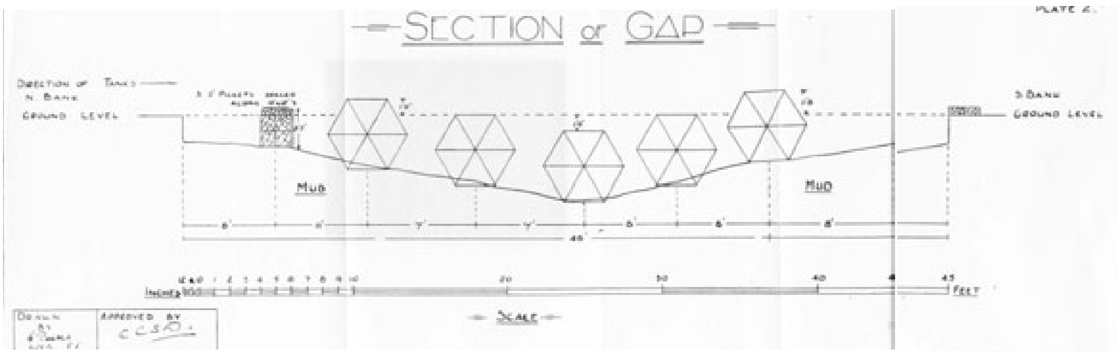
Sealing of Hanna lake 6 & 7

8.—One of the rocks completed

9.—Area completed.

Sealing of Hanna lake 8 & 9





Sealing of Lake Hanna & Section of gap

SPECIMEN PAGE OF ANALYSIS OF COST

FROM WORK RECORD.

DATE.	HIRE CHARGES OF T. & P.	WAGES.	PETROL.	OIL.	MISC. CHARGES.	CEMENT.	SAND.	HOURS WORKED.	AREA COVERED.	TOTAL COST.	COST PER 100 S.FT.	REMARKS.

NOTE :—In view of the fact that the cost of work by direct labour was very considerably below the contract rate, it is thought to be inadvisable to publish the actual cost figures in the above table. The figures are available as stated in Appendix III.

APPENDIX IV

From the daily analysis of cost the following weekly abstract was worked out. It was of use in comparing the individual items of expense, to find the reason for any fluctuations in price per unit of work. As stated before, actual figures cannot be published, but the percentage of the total cost per unit has been given against each item.

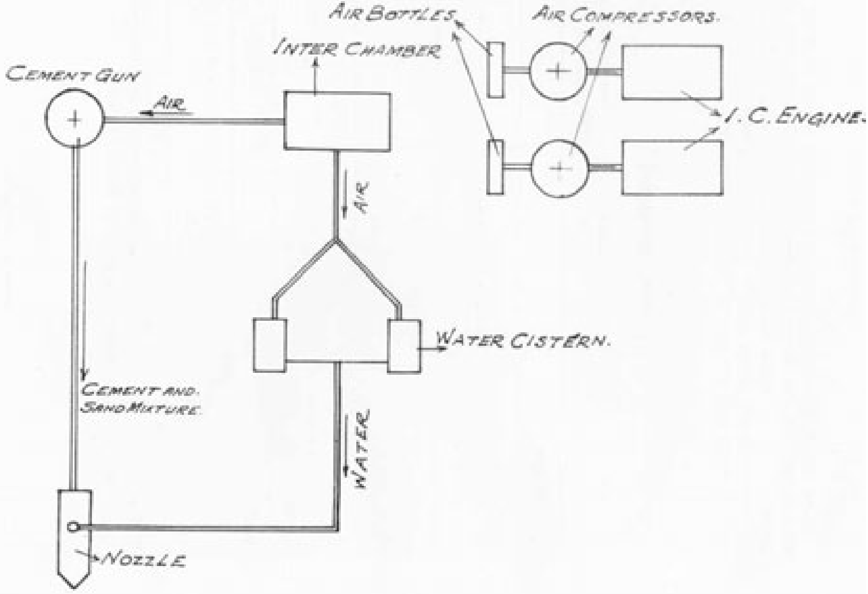
WEEKLY ABSTRACT.

ITEM.	COST.	AREA COVERED.	COST PER SQ. FT. (Percentage of Total).
Hire charges			4%
Wages			17%
Petrol			11%
Oil		6764 sq. ft.	1%
Miscellaneous			1%
Cement			51%
Sand			15%
TOTAL		6764 sq. ft.	100%

NOTE.—Petrol charges could have been reduced if it had been possible to do the work with one compressor only, instead of two.

APPENDIX V.

DIAGRAM OF CONNECTION OF PLANT



MOUNTED SAPPERS IN THE NEAR EAST, 1916-19.

By Lieut.-Colonel F. E. Fowle, M.C., R.E.

PART II

The following evening found us camped east of the Canal at Ismailia, faced with a strenuous month's work re-equipping from cold. The first shock was the discovery that there were only enough riders in the whole of Egypt to mount the sabre squadrons of the Sherwoods; we and the Field Ambulance had to be content with riding mules, while the Yeomanry cooks, batmen, and those kind of people, were given white Egyptian donkeys. Let it be said at once that, despite the continuous blasphemy which they caused for the first month, we were almost equally annoyed when we were given horses again after Christmas, so wonderfully did our little mules stand up to the heavy work of the November offensive.

The situation had its difficulties, though; for one thing, one could not send a mounted orderly anywhere, one had to send two, for the mule is a gregarious beast; for another, there were some mules which no one could ride at all; one never had a saddle on it except when it was held down in the sand. Here, however, we were helped by a sportsman in the South Notts who had been a cowboy with Buffalo Bill, and was prepared, for a liquid consideration, to swap any animal provided it was sufficiently unrideable. He usually turned up the following evening riding our late property in a snaffle.

At the end of a month, we started on a leisurely but exceedingly hot march of 140 miles through the sand-dunes up to the front. In spite of a thoughtful Ordnance issuing us with brand-new breast-collars the day before we started, we came through our first experience of desert marching without any casualties. We were particularly keen on impressing our new Brigadier, and took advantage one evening of a friendly hint that he was going to look at us when we moved out next morning, to get all our steelwork really bright. Unfortunately, we were camped at the time on an alkali flat; the steelwork next morning looked more like the bottom of a kettle than anything else, and the Brigadier was not impressed.

Arrived in the forward area, the Brigade was attached to the Australians. The calm and universal attitude that we should now be shown what real war meant was a little irritating to those who had been in France or Gallipoli, but it must be confessed that we picked up some useful tips ; among the most useful was an ability to produce hot tea at every halt of more than five minutes' duration.

Warfare at the moment was at a standstill, but active reconnaissances of the area south of Beersheba were carried out every week. The procedure was for one of the cavalry divisions to move out to the wells at Bir el Esani, about 15 miles out, overnight, and at dawn next day to put out a screen right across the country to cover the reconnoitring parties. The latter, who left their own units only on the actual day of the reconnaissance, had anything up to 60 miles to ride apart from the actual work ; the plight of some of the normally dismounted officers towards the end of the day was sometimes more than sad.

Our own officers, who were out every time, usually went on the previous evening, and spent the night with the Squadron of the covering Division. On one occasion we made our way beyond the Asluj railway, and had an exciting three-mile gallop across-country on our way back to avoid a party of Turkish cavalry riding to cut us off ; as they succeeded in doing so, it was lucky that they turned out to be a Troop of Australians of the covering force who were apparently bored with the whole affair and taking a little exercise.

One acquired a memorable thirst on these occasions, as there was nothing beyond a bottle of super-chlorinated brackish water to drink, and the desert was exceedingly hot. On one party we came across a miraculous patch of wild water-melons ; the next time, when we were even thirstier, we found another, and it was not till we had had a good bite that we discovered they were desert apples ; for the benefit of those who have never tasted one, a desert apple is about twenty-seven times as bitter as quinine.

The great offensive started off on the 1st November After the first three days when, having assisted at the capture of Beersheba, we spent a sticky two days in the hills to the north fighting for some wells which we never got, memory of the offensive is chiefly of endless marches with no sleep and half-rations, and nightmare periods of trying to water 2,500 horses from a 150-foot well with hand-power equipment.

It must be remembered that, at that time, there was no water-supply gear available for issue other than the lift-and-force pump, and none of the wells in the area of the advance was less than a hundred feet deep. Every Troop and Company had improvised gear of a sort, usually some form of big bucket with a valve in the bottom, to be hauled up by a mule, with a quick-release gear to drop it back when empty, so that a second mule could be hitched on with the minimum of delay. In demonstrations, these contrivances invariably worked well, but after a few bitter experiences in the stress of operations, when the release of the quick-release released the entire outfit to the bottom of the well, we soon reverted to the safer plan of attaching the end of the rope rigidly to the mule and leading him backwards and forwards.

A simple mathematical calculation would seem to show that, if a horse drinks ten gallons at a time,* and if your supply at a water point is 600 gallons an hour, you can water 60 horses an hour and no more. No amount of experience seemed to teach our Brigade this simple fact, and whole regiments would parade for water at the same time, and wait in cursing crowds for hours and hours; even at their very best, we could never persuade less than a squadron to come down at one time.

The problem of protecting canvas troughs against really thirst-maddened horses, or even thirst-maddened men, is no easy one. When we came back to Beersheba after two days and a night in a dust storm with no water, a tactless A.P.M. stood between the leading regiment and the troughs which had been established in our absence and asserted that we were not in his watering time-table at all; he was picked up later, but was not really seriously hurt. On another occasion we had six troughs beautifully laid out and filled with water all ready for the Brigade when a big column of Turkish prisoners, heavily guarded by Australians, hove in sight. A few moments later they had smelt the water and rushed the troughs, and our beautiful layout was a complete wreck, with one Turk dead of excitement in the midst; the Australians' bayonets were red up to the guards, but they were powerless to stop thirsty men; still less could one man riding bareback in a snaffle stop his own and three led horses.

Generally speaking, animals had a poor time. Our mules, having eaten all the limber tail-boards and most of the spokes, their own blankets, and each other's tails, ate up the vet. chest one night, with all its contents that were not metal. Perhaps to this can be attributed the fact that we finished the show without losing an animal, and with nearly every one looking as fit as when he started; perhaps, but mention it with bated breath, to the fact that they were never groomed.

But the endurance of horses *and* mules in the face of short rations and lack of water astonished everyone, even the most learned. It must be remembered that they probably averaged 16 to 18 hours a day under the saddle for five weeks, and that they carried nine stone seven without counting the weight of the rider. At the end of our first 48 hours without water everybody walked about saying, "Stone-

* The Editor has objected that a horse can't drink 10 gallons at a time, so that the mathematics are all wrong. I only said 10 gallons because I thought no one would believe me if I said any more; there appears to be no fixed limit to the capacity of a dry horse.

cold, can't move for a month," but we soon came to regard ourselves as lucky if we watered twice in three days. The record was held by the Lincoln Yeomanry with 84 hours without water, while the 20th Bde. R.H.A. marched 85 miles in 56 hours with no water, and other units had similar performances to talk about. One rather doubts if we could have got through but for the fact that whenever our zig-zag advance brought us to the coast, we could be certain of finding drinkable water by digging down for three feet just out of reach of the waves, an amazing provision of Nature common to the whole coast from El Arish to Jaffa.

Two incidents of the campaign stand out. One was the headlong dash to Junction Station, when we trotted for ten miles with boxes of guncotton hung round the mules' necks to blow up the bridge, only (very luckily for us) to be beaten by three minutes by the Australian Squadron. The Australians, being senior to us, bagged the bridge, while we had to be content with cutting rails. The preparations were completed under a pretty innocuous long-range rifle-fire, and having completed them we persuaded the Brigade to wire the situation back to Corps, as there seemed no likelihood of our being driven back, and we should certainly be in sore need of the bridge directly we advanced any farther. Back came the answer, "Destroy bridge at once," so up went the bridge, including an Indian soldier who had unfortunately gone to sleep underneath it, and about half a mile of rails; by the same evening, the repair of the bridge had been commenced. The *Official History* lays the blame on the Australian Squadron, but if anyone doubts our version, the actual telegram can be seen at Aldershot, in a neat frame on the wall of that Squadron Commander's study.

The other incident was the Turkish counter-attack in the hills on November 28th. We had just been moved back from around Jaffa to what we fondly hoped would be a spot of rest, but the same evening were ordered out in haste to reinforce the extreme right of the line up in the hills. Marching all night along mountain tracks, we halted just at dawn in a valley behind the bit of line we were to relieve, and commenced handing over horses to Nos. 3, as the horses were to go back to the plain to water. At this moment the enemy appeared on the ridge overlooking the valley, and opened rapid fire on the Brigade down below; an immediate dismounted charge by two squadrons of the Sherwoods drove back the nearer Turks, but between 250 and 300 horses were shot before they could be extricated. Actually, we were luckier than we knew, for we had marched up the valley for five miles in the dark with the enemy just the other side of the crest; not only was the line we were to relieve non-existent, but there was a five-mile gap to the left of it as well.

For the next 48 hours the Brigade was hanging on by its eyelids against the Turkish counter-attack, with no artillery support; every man of the Troop was in the line, and casualties all through the Brigade were pretty heavy. Ashcroft, who had joined the Troop in the early spring, was killed, as was the Brigade Major (Bell-Irving of the 11th), while the Brigadier and the senior Colonel, who took over from him, were both wounded. Ashcroft had been our equitation expert, and it was chiefly due to him that the standard of horsemastership was so exceedingly high; the results of his hard work came out when, at the end of the show, we counted our animals and found them all present and correct and fit for service, less ten which had been killed in action.

Relieved finally by the infantry, we were withdrawn into Corps' reserve in the Plain, and had two or three days' peace; our camp was alongside an advanced landing-ground of the R.A.F., quite a good landing-ground, except when it rained, which it did every day, the result being that every aeroplane which landed stuck in the mud and sat on its nose with its tail in the air; there were four there together one morning.

By now, however, the cavalry's part was coming to an end; the infantry were all up, the rains had set in in earnest, and the railway, laid at incredible speed while the dry weather lasted with no formation at all, skidded all ways into the most incredible zig-zags, round which astonished but willing London and South-Western engines groaned heavily along. To feed ten cavalry brigades, however was an impossibility, and seven of them, including ours, were withdrawn, at first to the Nahr Sukhereir, where we were supplied perilously by boats landing on the open beach, and later to Deir el Belah, south of the Wadi Ghuzze, whence we had started five weeks before.

Christmas we spent on the Sukhereir, but the railway had inopportunely been completely cut for three days before, and by Christmas Eve we had nothing but bully and biscuits; a convoy of limbers was sent off 25 miles down the line, and returned just in time with a cargo of turkeys and bottles; the bottles, at any rate, enabled us to forget that it was still raining, that we had no tents, and that nearly all of us were suffering from dysentery in one form or another. Boils, too, were always with us, and by this time few of us sported less than a dozen; to hold a pulling horse with boils on your fingers is a poor form of amusement. Fortunately, a visit to the fleshpots of Cairo was an unfailing cure, and, being well down the L.-of-C., leave for both officers and men was fairly easy to come by; as a matter of fact, it was a necessity, for the only other cure for boils was sea-bathing, and that, besides being excessively painful, was out of the question during the winter.

We spent the rest of the winter in more or less discomfort in a camp in the sand-dunes; we only ran to one bell tent for the three of us and the mess, and life in a bivouac when it rains for five days at a time leaves a good deal to be desired. Our now well-beloved mules were gradually replaced by horses, and pretty poor horses too.

The early spring was really pleasant, and inevitably gave rise to a great recrudescence of training activity, which had perforce been rather at a discount during the winter. There was a good deal of realism about our training, and the first Brigade day against a skeleton enemy nearly ended in disaster, one regimental commander putting in a mounted attack on the skeleton enemy and omitting to stop it; luckily, the skeleton enemy were well mounted, and won a good race. The afternoon of that very day occurred one of the most futile tragedies that could happen, Lieut. Kidd and two men of the Troop, one of them that same Driver Armstrong who swam the Struma, being drowned bathing; three other men went after them and were only rescued themselves with the greatest difficulty.

At the end of March we were on the eve of starting up to the line again when the news of the March retreat came through, with an order for nine of the fourteen Yeomanry regiments in the Corps to proceed at once to France as machine-gun battalions. Each Brigade was left with only one regiment, and impressive funeral services over broken spurs were held among the sand-hills. Corps' orders to the effect that no exchanging of horses was to take place were tactfully held up in the Brigade office, where we were acting Staff Captain, and the Troop became mounted almost throughout on pre-war hunters of the South Notts Hussars.

Consequent on the departure of so many regiments, and the arrival in their place of Indian cavalry regiments from France, the Desert Mounted Corps was reorganized, and the 7th Brigade, from being Corps Troops, became the 14th, and part of the 5th Cavalry Division. The logical and joyful consequence was the expansion of the Troop into a Squadron, at first called the 7th, and later the 5th, taking in also the Camel Troop from the old Imperial Camel Brigade. The balance, of roughly one-third of the Sappers and two-thirds of the drivers, was provided partly by dismounted Sappers from the Base, and partly by transfers of tradesmen from the Yeomanry; as it was irreverently put at the time, half the Squadron were Sappers who couldn't ride, and the rest were riders who couldn't sap.

It took a very strenuous three months to get the Squadron into real shape (the Palestine standard was pretty high), but with everyone confident that all the hard work was only a prelude to the final smashing of the Turk, progress was astonishingly rapid; the large number of promotions consequent on the expansion was a great encouragement, too. Our new Squadron Serjeant-Major came from the dismounted branch, and very good he was, too, but at his first parade he carelessly said, "Form fours," and it was currently reported that every mule on the line turned round and brayed.

A very important part of the Squadron's training was pontooning, which we carried out a Troop at a time on the Auja, just north of Jaffa, with strict instructions to be good at it. Allenby's plan, which he already knew all about though no one else did as yet, involved putting two cavalry divisions 30 miles behind the enemy's line by the end of the first day, and to do that those two divisions had to be got across the unfordable Nahr el Falik, five miles behind the enemy's front, with no delay at all.

But we had compensations not often to be met with on active service, thanks to the fact that Maharajah Sir Pertab Singh refused to stay long away from his Jodhpore Lancers. He came up and camped alongside the regiment, but it was quite impossible for Sir Pertab to stay long in any one place without starting polo. He found quite a reasonable ground, albeit a bit soft, and for some reason, not entirely unconnected with the making of the ground, he invited the Squadron officers to play whenever there was a game, which was about three times a week. His personal staff alone could turn out a 24-handicap side, and with teachers like that, and the personal supervision of Shah Mirza Beg himself, even such complete beginners as the three of us who went there could not help becoming quite useful.

In the middle of August, the Divisional Commander, Sir Henry McAndrew, desired the Squadron to parade for his first inspection, a proposal which did not conduce to peace of mind on anyone's part; he made a habit of demanding the best, and saying just exactly what he thought if he didn't get it. The evening before the great day, the C.O. got a message to cut the parade and go and interview the G.1 instead. This somewhat mysterious order became still more mysterious when we were directed to remove the divisional sign from our coat and accompany the G.1, similarly disguised, in a "plain van" to do a reconnaissance. Going along in the car, however, we were let into the whole secret of the Corps' plan for the break-through, dates, times, objectives and everything, the immediate objective of the day being to devise a plan for hiding the Division in the orange groves around Jaffa, and arranging to water them under cover when we had got them there. This was over a month before the party was to begin, and the plan was known to no one for another three weeks except the Divisional Commander and the G.1, a good example of "taking your Sapper into your confidence." That the secret was well kept is a matter of history; actually, on the 17th September, the C.O. of one of our regiments told me, in the strictest confidence, that we were moving over to the Jordan Valley the next day, and that we were to break through there two days later. The inspection was a complete success; one of our previous Brigadiers had had a brain-wave that horses got sunstroke, and had ordered us to put folded rubbers under the brow-band of the head-collar; this order had never been cancelled as far as we knew, so we had had all the rubbers nicely washed and folded, and paraded complete with sunbonnets, which so electrified the General that he found nothing else to criticize at all.

On 16th September, one Brigade moved off by day 20 miles to the south, coming all the way back again the next night to join the rest of the Division concentrating in the orange groves north of Jaffa. All through the 18th we remained hidden in the orange groves, with the most stringent orders against showing so much as a nose outside, watering the horses in small packets from the irrigation channels among the trees, which we had specially prepared for the purpose during the preceding days; although there were two other Cavalry Divisions, the 4th and the Australian, concentrated in the same area, the Turk never discovered them.

On the evening of the 18th, a stray Gunner limber drove over our saddle, which we had been carefully breaking in for weeks, smashing the tree; the new and strange saddle produced the most dreadful results (on us, not on our horse) by the evening of the next day.

Soon after dark, we moved up to our assembly area close behind the line, with time to turn in for a short sleep before zero at 4.30. Our own zero was not till 6.30, so that it was the noise of the opening bombardment which woke most of us. We were due to water at 5.30, just about sunrise; at about 5.15, a lucky reconnaissance of our principal water-point discovered that some earnest sportsman had thoughtfully removed all the troughs during the night, but not the most modern mechanization could have got fresh troughs up quicker than the resourceful Crawford, who arrived with a detachment and a limber-load of troughs at full gallop just as the first watering party hove in sight.

We were supposed to follow through after the infantry at 7.30, but General McAndrew decided to slip his leading Brigade up the seashore, under cover of the cliffs, a good half-hour before this; our first stroke of luck on a lucky day was that there were no stray Turkish machine-guns covering the beach, for there was no way up the cliffs except every half-mile or so. What was not so lucky was that we struck soft sand (for the last 50 miles the beach had been as hard as a rock) and for nearly five miles we trotted hard in column of sections with the horses sinking up to their knees and more at every step. That first five miles killed more than a score of horses, but at the end of it we found ourselves at the mouth of the Nahr el Falik, well behind the enemy's flank, and, the luckiest find of all that day, found a perfectly good sand bar across the mouth of the river, which obviated the need for bridging of any kind.

The leading Brigade (13th) pushed straight ahead with the Divisional Commander, but we thought it as well to stay back for a bit and see how the first lot of wheels negotiated the sand bar. After watching the disappointment of the Corps' "bridging train" at finding that, after all, they were not wanted for the first crossing of the river (they had performed miracles in getting their pontoon wagons over the trench lines, as had our own 14th and 15th Troops, who were clearing the way for the divisional wheels, and it was really rather bad luck after all their efforts), we had the rather weird experience of riding for 15 miles through enemy country with no British troops in sight at all, in a party not more than a dozen strong all told. Several small bodies of Turks, still fully armed, were trekking obediently southwards in accordance with instructions previously received, some escorted by a solitary dismounted sowar, the majority with no escort at all. A small German intelligence section which we triumphantly rounded up were furious at being made prisoners for the third time in one morning.

Thanks to the extreme rapidity of the 13th Brigade's advance (they scarcely broke from a trot for 30 miles), the bridge over the second obstacle, the Nahr Iskanderuneh, fell into our hands undamaged—it was perhaps lucky that the Turks were demoralized, as the 13th Brigade omitted to leave any guard on it.

During the afternoon, the Division concentrated at our first objective, Liktera, much cheered and refreshed by the innocent arrival of a Turkish M.T. supply column, and moved on again shortly before dark.

That night's march was a bit of a nightmare, at one time involving leading in single file as the track wound through the Abu Shushe pass, and we were beginning to get a bit tired. However, about 3 a.m. we were cheered by heavy dull thuds away to the north, which was Mathews with the 13th Troop blowing up the Haifa railway to stop any interference from the Haifa Garrison, and the sight as dawn broke was worth many months of war. Enemy supply columns asleep on the road just in front, enemy aeroplanes going up and flying off south to look for the war (the last one saw us and made himself most offensive with a machine-gun), and sleepy Turks appearing from bivouacs all over the place.

The failure of the 13th Brigade to catch Liman von Sanders, and the other events of that memorable 20th September, are too well known to merit further description.

Our own horizon was, as usual, bounded by the problem of watering our ten thousand animals, to say nothing of men.

Enough to water the horses twice in the day was found in an adjacent village, and a water-point fixed up with the troughs and pumps we had carried on pack, but drinking water was more difficult, the only source being the locomotive supply for Afule Station; this, an aged steam pump, broke down with distressing frequency, and when it did not, its rising main refused to submit to the conquerors, and burst all over the place. We mobilized some railway trollies to help in the work of transport, and it was somewhat trying, returning for more stores, to find that a passing field troop from one of the other divisions had blown up the line at half a dozen points; however, we found that if we ran the trollies fast enough they jumped the gaps, so no great harm was done.

From 7 a.m. on the 19th to 5.30 a.m. on the 20th the Division had covered 65 miles: on top of that my own little mare (she was only 15·1, and had carried 19 stone 7 lb.) did another ten under the saddle on reconnaissances, and subsequently, having been stung in seven places by hornets, several more miles on her own. The transport came in on the evening of the 20th, no mean feat.

Prisoners in a waterless country do not have a happy time. We had about 1,800 in a cage at headquarters, and the order of distribution for water was: men, animals, prisoners. Gold watches and 500-piastre notes could be had in quantities in exchange for a water-bottle if one had had one to spare.

Two days later the Division took Acre and Haifa, the latter memorable for the charge of the 15th Brigade and the 15th Field Troop, but as the story of this has already appeared in the *Journal* it will not be described again.

From Haifa to Damascus the Division was in reserve behind the Australians, and until we bumped the flank of the Turkish 4th Cavalry Division just south of Damascus, nothing much happened beyond the usual endless marches and difficulties in watering. The Turks had blown up the bridge over the Jordan at Benat Yakub, but it was most efficiently and rapidly repaired by the Australian Squadron. Naturally, however, they were only concerned with repairing it for divisional loads, or what nowadays would be called "light" loads. The leading Light Horse Regiment had purloined a Turkish 3-ton lorry and installed their officers' mess in it: no military policeman was powerful enough to separate a Light Horse Regiment from its mess, with the result that the lorry promptly fell through the decking and held up the whole advance for a matter of three hours. For once we were able to listen in unmoved.

The three days at Damascus, thanks to Abana and Pharpar, rivers of Damascus, were comparatively peaceful, and though rations were short, grapes could be collected by the limber-load. The chief event was a request from the O.C. 13th Troop to kindly move the prisoners' cage, as the Turks were dying at the rate of a hundred or so a day, which he didn't so much mind, but they would insist on doing it in the stream just above his drinking water-point.

From Damascus the Division went on alone, striking through the mountains to drop on to the railway junction at Rayak. Our entry into the town was the most dangerous event of the whole war, as the population were lining the road for nearly a mile, and every male of five years old and upwards was armed with a Mauser and several hundred rounds from the looted Ordnance depot at Rayak. The grown men were not so bad, but the smaller children, who could not lift the rifles much above the horizontal, were not at all safe. Our M.G. Commander had one of his guns out of the clips and swore he would turn it loose at the first casualty, but by some miracle there was none; the Brigade behind thought we had run into the whole Turkish army and were preparing to sell their lives dearly.

Rayak was the terminus of the narrow-gauge railway, and consequently all the locos, which had been retiring up the Hedjaz railway and the Palestine railway as we advanced, could get no farther.

The enemy had very cleverly destroyed all the connecting rods and valve gear on the offside of every loco, but in one case they had made an error and done in the nearside by mistake; Crawford discovered this, and had very soon got one loco into running order, and, after removing a box of gelignite from the fire-box and sundry dynamite sticks from the boiler tubes, managed to raise steam. With this loco we fixed up a sort of armoured train, and, taking an assortment of rails and fish-plates and such things, endeavoured to run back along the railway to Damascus, as this would have shortened our line of supply by over 40 miles.

However, after replacing sundry damaged rails, we were pulled up by a most complete smash-up. The Turks had started off five locos and three trucks down a steep grade and taken out a rail on the outside of a curve in a cutting.

We stayed two days in Rayak; rations were still short, and there were no grapes, but there were almost as many green figs as there had been grapes at Damascus, fraught with the most dire results.

For the next 100 miles, as far as Homs, we had an uneventful march. Water along this stretch was plentiful, sometimes in irrigation channels led down from the mountains, sometimes, as at Baalbek, in a full-sized river bursting out of the side of a cliff.

At Homs (it was here that the incident of the General's thumb in the automatic occurred) we had an interesting job making the 80 miles of road to Tripoli "passable" to lorries. There was not much in it, the work consisting chiefly in bridging over holes in the arch rings of bridges, and with three lorry-loads of Sappers and three lorry-loads of assorted timber "purchased locally," leap-frogging each other, we got through in two days; presumably we had some sort of escort as well.

On our return to Homs, we found that a further advance had been ordered, and were at once confronted with the problem of repairing the bridge over the Orontes, 10 miles north of Homs; a 60-ft. gap in the old stone viaduct (built by the Crusaders so it was said), the roadway 14 ft. above the river-bed, which had to take 3-ton lorries. Fortunately we found a dump of 12-in. telegraph poles in Homs, and by mobilizing all the iron-workers' bazaar to make dogs and spikes, managed to get the thing through in two nights and a day, one hour before the time fixed for the division to cross.

Unluckily, owing to lorry failures, we had only enough decking to single chess, whereas double chessing was required: however, as the Division itself had only horse transport, that did not greatly matter, as there would be plenty of time to lay down the second lot of chesses before the lorries had to cross. It was therefore a little upsetting to see, just behind the leading Squadron, the Divisional Commander in a 5-ton armoured car. A rapid appreciation decided us that we could not be blasted into smaller bits if he fell through the decking than we should be if we told him to stop, so we let him go; the bridge held, or we should not be writing this—but decorations have been won for less difficult decisions.

From here on to Aleppo (the story of how the advance from Hama came to be ordered does not appear in the *Official History*, and cannot, unluckily, be told here; it is much on a par with Nelson at the battle of Copenhagen), our old friend the water problem came to the fore again. The only water was from shallow wells with very poor supply and, though getting the water out presented no difficulties, it was only possible to move by Brigade Groups at a day's interval.

Consequently, when the leading Brigade bumped into a Turkish position at Haritan, just outside Aleppo, held by about 2,500 Turks (with another 10,000 disorganized Turks in Aleppo itself), the Divisional Commander had no supports nearer than a day's march away. But General McA. was not the man to give his enemy any encouragement by hesitation or indecision, and directed the Brigade (Jodhpore and Mysore; Hyderabad were behind on L.-of-C. duty of some kind) to make a mounted attack.

Covered by their Machine-Gun Squadron and some Light Car Patrol Fords, the two regiments, only 350 sabres all told, rode clean through the enemy, and, though suffering heavily, as they rallied, from the fire of the Turks, who had thrown down their arms as the charge reached them, had the satisfaction of gaining a strategic victory, as the Turks went back 20 miles that night and the 15th Imperial Service Brigade had fought the last action of the war.

Five hundred and twenty-five miles in five weeks on short rations —not much in the way of fighting, but pretty tough conditions, and only a third of the men who had started from Jaffa rode into Aleppo. I forget how many horses we lost, but we were rather better than the Divisional average of 20 per cent.: we couldn't hold a candle, though, to the Sherwood Rangers, of our old Salonika Brigade, who did not lose a single draught horse or mule.

Our chief trouble in the early days in Aleppo was these same horses. With enough work for three field companies, we were also blessed with rather worse than four horses per man to look after. Of course, the result was they were not looked after at all; we groomed them on Sundays, and brushed some of the mud off the more important bits before we went out; they grew coats like bears, and flourished exceedingly. Harness, except for keeping some of it soft, was quite impossible, but we came through an inspection by the Divisional Commander with flying colours; he had inspected the Horse Gunners the day before, and they very kindly lent us all their harness for the occasion.

Of the rest of our time in Aleppo there is not much to tell—a good deal of roadmaking to do to supply one Brigade 80 miles to the north, demolished bridges to repair, hutting, water-supply, all the usual stuff. While on a "mission" we met the Turkish captain of engineers who had blown up the Orontes bridge and heard one of the heartiest laughs on record when we told him we had had to mend it.

Gradually the old faces disappeared, demobilized, to be replaced by new drafts of "conscripts" (very good they were, too, except that it had not been thought necessary to send us men who could ride), and gradually they, too, began to go, until finally, on the 25th of July, 1919, having handed over to an S. and M. Squadron, we went down the line with the last train-load of the 5th Field Squadron.

(Concluded.)

A COLD STORAGE PLANT AT PORT SAID.

By CAPTAIN K. H. TUSON, R.E.

A FEW years ago the War Office issued a thesis in which the following sentence occurred :

> " It is unlikely that military engineers will have to deal with cold stores of a capacity exceeding 5,000 cubic feet."

The following is an account of an installation of 80,000 cubic feet capacity with which some engineer officers have recently had to deal. It is perforce somewhat technical, because it is intended to be of use to officers who have to deal with similar installations in the future ; if it consisted of vague generalities or a list of the items of machinery installed, it might be easier to read but would be of little practical value to anyone.

Meat, cheese, margarine and bacon for the British Forces in Egypt are received in large consignments from Australia and the United Kingdom, two months' reserve being always kept. From 1917 to 1935 a store, erected during the war in a very short space of time to deal with the advance into Palestine, was used. An engineer who had been on the staff of Messrs. Hall's, of Dartford, was brought from Iraq, where he was then serving, to erect it, and Messrs. Hall's sent out a complete marine type plant, the only sort that was available at the moment. Two Lancashire boilers supplied steam to two horizontal engines driving carbon dioxide compressors, the steam and gas cylinders in tandem being mounted on a common base containing both steam and gas condensers. The chambers are brine cooled ; there are twelve of them, each 20 feet high and 35,000 cubic feet capacity. Meat is hoisted by steam cranes to a loft over the stores and then run on Decauville track to hatches, then being lowered by petrol-driven winches into the rooms. Insulation is of granulated cork and charcoal.

Subsequently the boilers were converted to oil firing and an ice plant installed to produce one ton of ice in 12 hours. The ice is chiefly used to pack in the railway refrigerator vans, which take the meat three times a week to Alexandria, Cairo, Ismailia and Palestine, and manufacture on the premises has proved to be much cheaper than the previous system of local purchase.

After the war the strength of the British Forces was, of course, greatly reduced, and the store was too large. With steam engines working only eight hours a day and carbon dioxide compressors using for condensation sea water sometimes at a temperature of 90°F.* it can be imagined that the efficiency of the installation was very poor. The running cost for 1934–35 was £4,333, or 2s. 1d. per 100 lb. of produce issued, and 480 tons of fuel oil a year was used. Also the land belonged to the Suez Canal Company, was some way from Navy House where the troops were quartered, and its rent was £500 a year. The lease expired in 1933 and its renewal was doubtful. The provision of a guard was, too, an extra burden on the one infantry company at Port Said.

For all these reasons many proposals for improving matters were considered. One was to let space to civilian firms. To enable an economic rent to be charged, an efficient ammonia plant would have been required to replace the carbon dioxide machines, and also more rapid methods of meat handling, but the scheme was abandoned as the War Office did not wish to compete with civilian cold storage firms in the town. Another proposal was to build a new store with new plant, using the shell of the old building. Fortunately for all concerned this scheme was also given up owing to insecurity of tenure of the site. The difficulty of keeping the old plant running while installing the new would have been very great.

Finally, in 1934, it was decided to build an entirely new store on a piece of ground behind Navy House, which stands at the end of a quay projecting between two basins in the harbour. The ground on which Navy House stands is the only piece in Egypt which is British territory. It was ceded by the Suez Canal Company to the Admiralty in 1870, and is now loaned by them to the War Department. The War Office laid down that the new store should have a net capacity of 800 tons, and in conjunction with Messrs. Hall's started its design.

Design.

(a) Storage Chambers.

Drawings of the store are given in Fig. 1. The sizes of the chambers were based on the assumption that one ton of either frozen meat, cases of bacon, margarine or cheese, requires 100 cubic feet of entirely clear, unobstructed space. This assumption, however, should be used with caution as the room required obviously varies with the skill of the stackers. Seven rooms, each of about 10,000 cubic feet, and one smaller room, are provided for frozen meat, and

* Note.—The efficiency of an installation falls off rapidly as the cooling water approaches the critical temperature of the gas, and the critical temperature of carbon dioxide is 92°F.

three other rooms for bacon, cheese and margarine, and ice The principal rooms are 7 ft. 4 in. and 7 ft. 10½ in. high in the clear.

(*b*) *Construction.*

The main store consists of a double-storey, steel-framed building, with reinforced concrete floors and ceilings. Stanchions are encased in concrete and walls built of local grey sand bricks. The roof is constructed of grey asbestos-cement slates laid on boarding; the trusses are of steel and connected to the main framing. Walls and ceilings of cold rooms are finished with cement render on wire netting, floors with granolithic concrete.

The engine-room, ice plant, and ice- and butter-rooms are housed in a single-storey annexe, seen on the left of Fig. 2 and in Fig. 8. The roof is flat, of reinforced concrete, and insulated with a double layer of Ruberoid roofing felt, covered with Everseal plastic compound, and finished with cement mortar and local cement tiling.

The meat lifts, seen in Fig. 2, form a light, steel-framed structure, covered with Robertson's protected metal sheeting. Offices for the engineer and master butcher, workshops, stores, etc., are grouped in an outbuilding.

(*c*) *Plant.*

Fig. 3 shows the layout of the engine-room and some of the ammonia and brine circuits. Two two-stage 400 r.p.m. three-cylinder vertical compressors are directly coupled to oil engines, and one set is adequate to cool the whole store in the hottest weather, running nine or ten hours a day. Electric drive by synchronous induction or other motors was not possible owing to the high price of electricity and the necessity for complete independence of outside sources of supply. Each compressor has two low-pressure cylinders and one high-pressure, and is driven by a three-cylinder Allen vertical engine, giving 79 b.h.p. at 400 r.p.m.

As far as possible the whole plant is in duplicate; there is one tube condenser, intercooler and liquid receiver to each compressor, and either compressor can be used with either condenser, the change-over taking an hour or two to carry out. The liquid ammonia flows from the receiver underneath the condenser to a spherical vessel on the other side of the room, the pipes to the regulating valves being taken from this in order to get an even distribution to all circuits. The regulating valves, hot gas valves, and suction valves are arranged in three rows as shown in Fig. 4—snapped before the insulation covered everything. This arrangement is not one to be copied, as in the event of one valve leaking the whole store must be shut down and gas pumped out of all circuits before it can be put right. One circuit cools a brine tank in a corner of the engine-room. The gas goes from the suction manifold into a liquid separator, and as sufficient height for gravity flow is not available duplicate liquid pumps are provided.

Brine cooling is necessary for the bacon- and cheese-rooms, the ice-making plant and the ice store. The bacon- and cheese-rooms are thermostatically controlled at a steady temperature, the brine pumps and air fans being switched on at 30°F. and off at 28°F. for bacon. These temperatures are too low for cheese which gets brittle below freezing-point, and the figures worked to are 36° and 34°. Owing to the high cost of fresh water, sea water is used for all cooling except the generating set.

(*d*) *Auxiliaries.*

All pumps, brine heaters, etc., are electrically driven from the town supply, a 29·5 kVA alternator being provided as a standby and for use between 5 p.m. and 11 p.m., when energy has to be paid for at the lighting rate. Supply is 3-phase 3-wire 190 volts 40-cycle for power, and 200/100 volts single-phase 3-wire for lighting. The supply company insists on entirely separate circuits from their transformers, and to arrange for the change-over from these two to one alternator makes the switchboard complicated. The alternator is driven by an 800 r.p.m. Ruston 4-cylinder engine.

All engines are fitted with by-pass streamline oil filters and electric pyrometers. Long-distance resistance thermometers enable the temperature of any store to be read in the engine-room, but care must be taken to test these on site.

(*e*) *Ice Plant.*

The ice plant from the old store had to be dismantled and transferred, a gap being left in one wall when building to permit the entry of the ice tank at the last possible moment. As the same brine tank had to supply both this and the cold-rooms, awkward problems of brine temperature had to be overcome.

(*f*) *Electric Lighting.*

Stores are lit to a designed intensity of two-foot candles. Conduit wiring was not suitable as it would have been difficult to prevent condensation when the rooms were defrosted. T.R.S. wiring was used instead, its ends being sealed with compound wherever possible.

(*g*) *Insulation.*

All rooms are insulated with cork slabs, 10 in. thick on external walls and first-floor ceiling, 8 in. on ground floor, and 4 in. on internal partitions. It was the insulation of piping and valves that presented most difficulty; the inclination of most erectors is to make valve and pipe insulation in one piece to the confusion of the staff when, years later, they may want to get at a leaking valve quickly. Separate valve boxes may be brought from cork suppliers but are expensive, and a skilled man can be taught to make them on the spot from cork slab at far less expense. If carelessly made, air spaces will be left between the cork and the valve body and ice will form. Fig. 6 shows a good type of valve insulation as made by the Cairo Water Company.

(h) Meat Handling Arrangements.

All meat cargoes have to be off-loaded at night to reduce defrosting of the meat in its passage from ship to shore, and an input to one chamber of 20 tons an hour was aimed at in the design. Natives load the crops and hinds from the lighter into trucks of the type used at railway stations, with two pneumatic-tyred wheels and one small iron wheel at each end with 2-in. ground clearance. These trucks are run over platform weighing machines straight into a chamber or into one of two lifts serving the first floor. The weighing machines are of Messrs. Avery's manufacture and are excellent. Their initial adjustment takes several hours, but once done the tare weight can be read directly off a dial to the nearest 2 lb. in 15 cwt.

(i) Testing.

A refrigerating plant can only be satisfactorily tested in its entirety; works tests are usually carried out with unlagged pipes, makeshift condensers and brine evaporators; the result is a figure for the B.Th.U. extracted by the compressor, which is little guide to the performance of the complete plant.

The specified and guaranteed performance of the plant for this cold store was as follows :—

> "The plant is designed to keep all rooms at the required temperature and to make one ton of ice in 12 hours from the existing plant when operating in the hot season about 9½ hours daily and in the cold season about 7½ to 8½ hours, with condensing water at 90°F. and evaporation 0 to minus 5°F."

The makers were to be responsible that both plant and insulation stood up to this test, and it was therefore necessary to devise a test for the complete plant to determine whether the guarantee was complied with. A satisfactory test of a cold store, in contrast to that of an ice-making plant or a generating set, is difficult to make for the following reasons :—

(i) The output is indeterminable as the works method of cooling a known quantity of brine is not applicable.

(ii) The air and water temperatures and the humidity at the time of the test will be different from those in the guarantee.

(iii) The rise of temperature in the rooms during non-working hours will be much greater when the rooms are empty than when they are full, as a result of the low specific heat of air compared with frozen meat.

The method finally adopted is given in Appendix A, with a table of the results obtained on one day. It is very desirable to obtain a complete heat balance, but engine and compressors are seldom fitted with indicator cocks nowadays.

There are several flaws in the method of test described, and suggestions for its improvement would be valuable.

Erection.

The long time required by the W.D. to carry out a work of this magnitude is not always realized. The time-table given here illustrates the point :—

A.—Building.

Foundations complete	November, 1933.
Steelwork erection	Dec., 1933–Feb., 1934.
Preparation of structural drawings ..	June–August, 1934.
Preparation of B's of Q's and Contract documents	July–October, 1934.
Building contract placed	November, 1934.
Main building finished	June, 1935.
Outbuildings completed	October, 1935.

B.—Plant.

Specification sent out	November, 1933.
Messrs. Hall's tender accepted	April, 1934.
Machinery delivered on site	January, 1935.
Insulation erection	March–June, 1935.
Plant erection	March–August, 1935.
Plant adjustment and test	July–August, 1935.

It was essential to guarantee a date by which the store could receive meat, and it was very desirable to finish as quickly as possible in order to save the difference in running costs between the two stores —about £300 a month. A programme had to be prepared at the very beginning and worked to by all concerned; but it will be seen from the dates given above that divided responsibility, among other reasons, resulted in construction taking many months longer than it could have done. The home authorities were responsible for most of the mechanical design and the shipment of all stores, while local authorities dealt with most of the building design, all electrical design, and plant erection and testing.

In other similar jobs the machinery contract should be let before that for the steel framework; in this case the naked steel girders adorned the canal bank for many months and had to be painted several times to prevent corrosion.

OPERATING RESULTS.

On test, the ice store refused to maintain a temperature below freezing, and further brine drums had to be installed. The plant is much more complicated than the old carbon dioxide machines, and the native staff took some time to adapt themselves. When starting up in the morning, or when cooling only one or two chambers, gas conditions alter very rapidly, and control on the suction gauge readings is not quick enough to prevent liquid coming over. The gauge on the liquid separator was useless as the level was frequently above the top of the gauge.

An interesting and so far unexplained feature of the plant is the temperature difference between the two ends of the suction pipe. At the separator end the temperature is 2°F., while at the machine it is 16°, and this amount of superheat necessitates some half an hour's extra running a day. The pipe is only 8 ft. long, and lagged with 2 in. of cork.

An automatic air purger is connected to the top of the liquid receiver at its lower end. The adjustment of the purger is tricky and it would be better to connect it to the top end of the receiver and to put a level gauge on the latter.

The total cost of the store was £25,000, and this should be recouped in reduced running cost in eight years. The engineer staff consists of a military mechanist, an assistant engineer, two engine drivers, a cleaner, two fitters and a carpenter, who also do general work in the station, and two labourers for harvesting ice.

MEAT HANDLING.

The system of trolleys and lifts has not proved satisfactory. To avoid demurrage charges on ships, work has to be carried out at top speed at night with very low-grade labour. Meat is flung on the

Fig. 2.—New cold store.

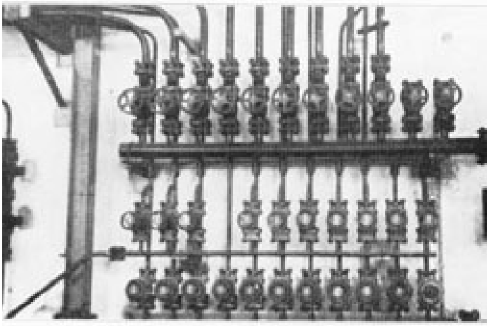


Fig. 4.—Regulating, etc., valves before insulation.

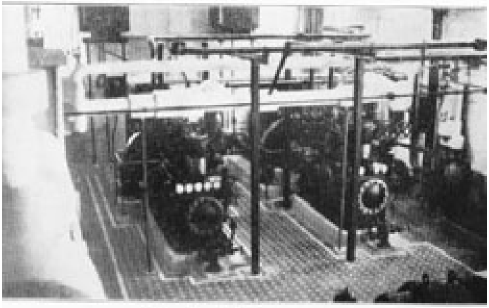


Fig. 5.—Engine room.

Cold storage plant at Port Said 2, 4 & 5

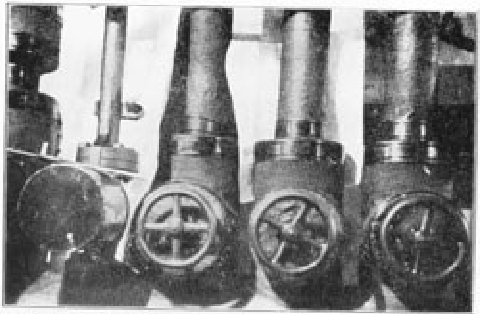


Fig. 6.—Valve insulation, as made and fitted by Cairo Water Co.

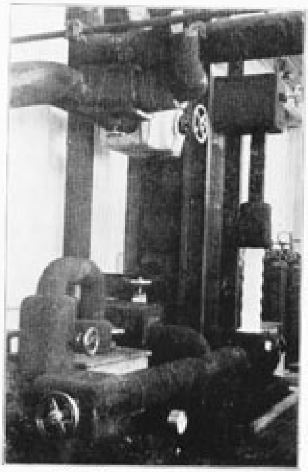
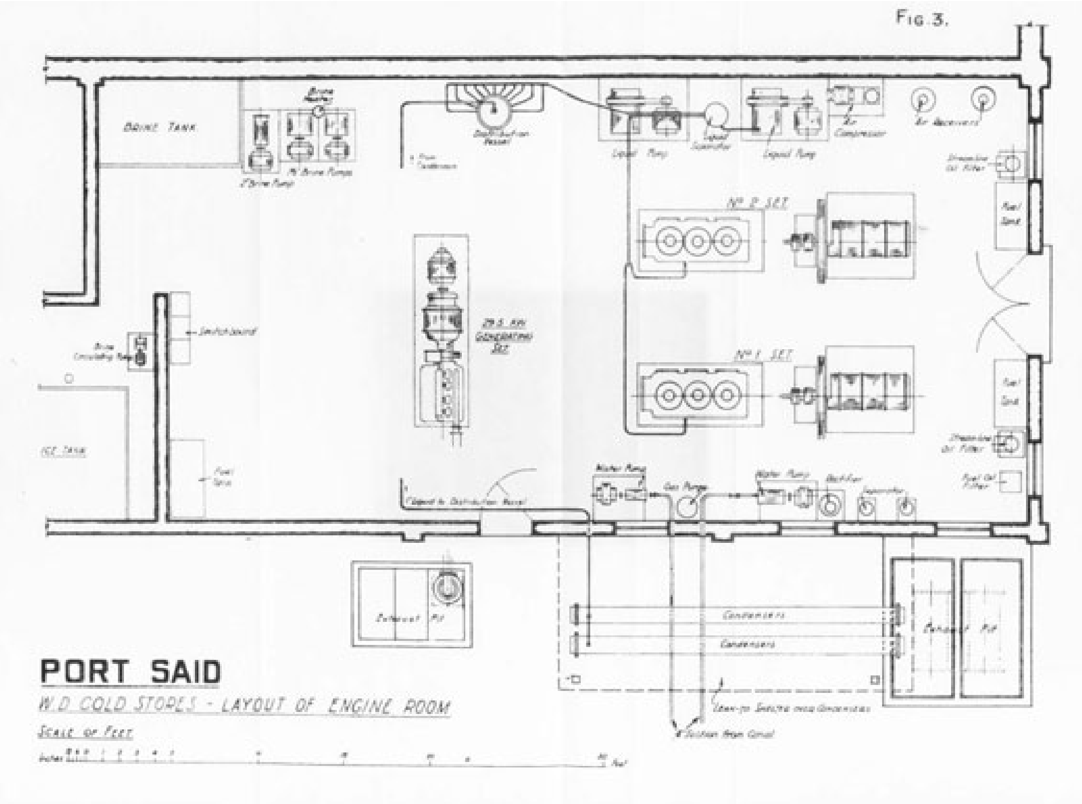


Fig. 7.—Liquid receiver.


Fig. 8.—Condensers.

Cold storage plant at Port Said 6 7& 8



Post Said cold store

trucks anyhow, and frequently fouls the sides and ends of the lifts (which were not at first fitted with gates) and the doors of the store. The iron wheels of the trucks and their springs come in frequent contact with the concrete apron in front of the store and with the door frames, and considerable damage results. It is unfortunate that foundation considerations required a floor-level several inches above the quay, so that a ramp is necessary. While four natives are required to push loaded trucks up the ramp, one can sit on an empty truck and free-wheel down.

The writer would recommend that, in future installations, trucks should have rubber tyres on all wheels, and that the clearance between end wheels and the ground should not be more than one-quarter of an inch. They should also be very heavily galvanized or otherwise protected from rust. Instead of lifts a portable belt elevator, driven by a 5 h.p. electric motor, taking crops and hinds straight from quayside to first floor, would be a great improvement. Such an arrangement would be cheaper in capital and in running costs than lifts, more fool-proof, and less expensive in maintenance. Lifts may be suitable in many instances, but not for rapid handling of meat at night with a poor class of labour.

APPENDIX A.

Method of Testing Port Said Cold Store.

1.—*Requirements.*

Two principal points require verification :—

(A) The ability of the plant as a whole to maintain the average specified temperatures with the specified running hours and fuel consumption and without overloading engines.

(B) The ability of the insulation to maintain the daily temperature variation within a reasonable limit.

2.—*Method of Test.*

(i) The tests will be run with cooling water at the specified temperature and the results are to be adjusted to the specified ambient air temperature of 90°F.

(ii) A by-pass and valve will be arranged between the cooling water outlet from the condenser and the suction to the pump. Hot water will be re-circulated as necessary to maintain the pump suction temperature at 90°F. The total quantity of cooling water will be kept constant.

(iii) Fifty tons of meat will be put into one chamber on the ground floor and the same amount into one chamber on the upper floor. These two chambers will be reduced to a temperature of 19°F. on the morning of the first day of the test. The regulators of all rooms will be adjusted to ensure correct conditions of evaporation and the coils in each of the rooms in order that the suctions gas returning from each circuit is, as nearly as possible, in the same condition.

(iv) One ton of ice will be drawn daily from the ice plant and the bacon- and margarine-rooms automatically kept at 28°-30°F.

(v) Doors of all rooms will be opened for two minutes twice daily. The outer doors will be opened only for the ingress and egress of personnel and will normally be closed when the inner doors are opened as above.

(vi) Under these conditions the hours of running will be as nearly as possible proportional to the temperature conditions and they shall not exceed one period per day of

$$9\tfrac{1}{2} \times \frac{t - 15}{90 - 15} \text{ hours,}$$

where t° is the shade air temperature at noon.

(vii) Each set of plant shall be run daily for one week under the above conditions, records being kept of external temperatures and hourly temperatures in all rooms, hours of running, fuel consumption, quantity of cooling water, etc.

3.—In accordance with 1 (A) above, the average temperature of all rooms shall be maintained at 15°F.

In accordance with 1 (B) above, the range of temperature in the two chambers half-full of meat shall not exceed 8°F.

PORT SAID COLD STORE.

ENGINE TEST SHEET. ENGINE NO. K1./44962A. DATE: 2nd August, 1935.

TIME.	Engine-Room Temperature.	Lubricating Oil. Inlet to Cooler.	Lubricating Oil. Outlet from Cooler.	Lubricating Oil. Pressure.	Cooling Water. Inlet.	Cooling Water. Outlet.	Cooling Water. Pressure.	Cooling Water. Volume Circulating.	Exhaust Temperatures. Cylinder 1	Exhaust Temperatures. Cylinder 2	Exhaust Temperatures. Cylinder 3	Maximum Pressures. Cylinder 1	Maximum Pressures. Cylinder 2	Maximum Pressures. Cylinder 3	Fuel. Gross Weight.	Fuel. Remaining Weight.	Fuel. Difference.	B.H.P.	R.P.M.	Remarks.
	°F.	°F.	°F.	Lbs./sq.-in.	°F.	°F.	Lbs./sq.-in.	g.p.m.	°F.	°F.	°F.	Lbs./sq.-in.	Lbs./sq.-in.	Lbs./sq.-in.	Lbs.					
9.20 a.m. ...	80	85	85	21	84	95	16		420	390	410								350	
9.30 ,, ...	80	89	89	22	87	99	16		560	520	525								370	
10.00 ,, ...	80	91	91	19	89	100	15½		610	570	580								390	
10.30 ,, ...	80	95	95	15½	89	101	16		630	580	600								400	Suc. Gauge: 6, ½ gall., 24·7 lb. per hour.
11.00 ,, ...	81	97	97	15	89	101	16		630	580	600								400	
11.30 ,, ...	81	100	100	14	89	99	16		630	580	600								400	
12.00 ,, ...	81	100	100	14	89	99	16		630	580	590								400	
1.30 p.m. ...	81½	102	102	12½	89	100	15½		670	600	600								400	Suc. Gauge: 0°F., ½ gall., 23 lb. per hour.
2.00 ,, ...	81½	102	102	12	89	100	15½		700	620	620								400	
2.30 ,, ...	82	102	102	12½	89	100	15½		620	570	580								400	
3.00 ,, ...	81½	102	102	12½	89	100	15½		600	560	580								400	
3.30 ...	82	102	102	12½	80	100	15½		600	580	580								400	
4.00 ,, ...	82	102	102	12½	89	100	15½		610	580	550								400	
5.00 ,, ...	82	102	102	12	89	100	15		610	570	570								400	Suc. Gauge: −5°F., ½ gall., 23 lb. per hour.

Total for 8 hrs. 10 mins.: — 22·5 galls. — 23·3 lb. per hour.

PORT SAID COLD STORE—TEST SHEET. BRINE, COOLING WATER & ELECTRICITY

DATE: 2nd August, 1935.

TIME.	Brine Temperatures.						Ice Plant.				Brine Flow.	Electricity.	Air Temperature.	Cooling Water.											Remarks.
	Pump Suction.	Returns.				Temp. in Tank.	Cans filled.		Ice drawn.					Temperatures.					Flows.					
		Ice Tank.	Ice Store.	Butter Store K.	Bacon Store A.		No.	Time.	No.	Time.				Pump Suction.	Comp. Outlet H.P.	Comp. Outlet L.P.	Condenser Outlet.	Intercooler Outlet.	Total.	Compressor.	Engine.	Condenser.	Intercooler.	
	°F.	°F.	°F.	°F.	°F.	°F.					g.p.m.	kW.	°F.	°F.	°F.	°F.	°F.	°F.	g.p.m.	g.p.m.	g.p.m.	g.p.m.	g.p.m.	
9.10 a.m.	25	—	—	32	43	25							84	84	86	64	66	85						Plant under test: Engine K1/4496A. Compressor 9682. Condenser, Inner. Intercooler, Inner.
9.30 ,,	24	...	...	27	35	22							85	87	92	87	98	90						
10.00 ,,	17½	—	—	25	31	17½							88	89	94	89	99	91						
10.30 ,,	13	—	12	19	25	13							89	89	94	87	99	92						
11.00 ,,	8½	—	13	24	20	8½							90	89	94	89	99	92						
11.30 ,,	10½	22	15	35	20	10½							91	89	94	89	99	92						
12.00 ,,	9½	16	14		19	9½							91	89	94	89	99	92						
1.30 p.m.	4	9	8	—	13	4							92	89	94	87	99	92						
2.00 ,,	2½	7	7	—	19	2½							90	89	94	89	99	92						
2.30 ,,	1	6	5	...	10	1							92	89	94	89	99	92						
3.00 ,,	...	5	4	—	12	...							90	89	94	89	99	91						
3.30 ,,	—	5	4		6	—							91	89	94	89	99	92						
4.00 ,,	—	5	4	—	6	—							90	89	94	89	99	92						
5.00 ,,	2½	7	5	18	—	2½							90	89	94	89	99	92						

PORT SAID COLD STORE—TEST SHEET. AMMONIA AND COLD-ROOM TEMPERATURES. DATE: 2nd August, 1935.

Air Temperatures.

Time.	Cold Store B 2.	Cold Store C 3.	Cold Store D 4.	Cold Store E 5.	Cold Store F 6.	Cold Store G 7.	Cold Store H 8.	Cold Store J 9.	Banana Store A 15.	Cheese Store K 10.	Ice Store L 11.	Gd. Floor Passage.	1st Floor Passage.	Open Shade.	Engine Room.
	°F. 1	°F. 12	°F. 1	°F. 5	°F. 1	°F. 2	°F. 2	°F. 1	°F.	°F.	°F.	°F. *	°F. *	°F.	°F.
9.10 a.m.	17	19	18½	17½	20¼	19½	18	18½	27½	30	36	63	64	84	80
9.30 "	17	19	18½	17¼	20	19	17½	*?	27	30	36	—	...	85	80
10.00 "	17	19	18	17	19¼	18	17	?	?	29	36	—	—	92	80
10.30 "	15	18	17	16	17¼	16½	15	16¼	?	27½	34½	—	—	93	80
11.00 "	13½	17	15½	15	16	14½	13½	9	33½	25½	31½	63	63	90	81
11.30 "	11¼	16	13½	13¾	14	12½	12	4½	32	26	28½	—	—	90	82
12.00 noon	10¼	15½	12	13¼	13	11¾	11½	3	31	26½	28	—	—	91	83
1.30 p.m.	8½	14½	10	12	10½	9	11	11	29	27½	25	63	64	91	84
2.00 "	7½	13½	9	11¼	9¼	8½	10	10¼	28	27½	23½	—	—	90	84
2.30 "	6½	13	8½	11	9¼	8	9½		28	27½	23	—	—	92	84
3.00 "	5½	12½	7½	11	9	7½	9½	9½	27½	27½	22½	—	—	90	84
3.30 "	5	12½	7	10½	8	7	9½		26½	27½	22½	63	64	91	82
4.00 "	4½	12	6½	10	7½	6½	9	9	26½	27½	23	—	—	90	84
5.00 "	4	12	6	10	6½	6	9	9	28½	28½	23	—	—	90	85
9.10 a.m.	16	19	18	16½	19½	19	17½	20½	30½	26½	36				

Gauges. / Thermometers.

Time.	Crankcase Case.	Condenser Delivery.	Evaporator Suction.	Oil Pressure.	Intercooler Intermediate.	L.P. Suction.	L.P. Delivery, cyl. 1.	L.P. Delivery, cyl. 2.	H.P. Suction.	H.P. Delivery.	Suction Separator End (top).	Suction Manifold.	Brine to Tank.	Room Suctions. B	C	D	E	F	G	H	—
	lbs./sq.-in.	°F.	°F.	lbs./sq.-in.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F. 4	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
9.10 a.m.	23	96	5	37	34	69	108	—	84	172	44	27	30	31	30	25	31	26	22	22	30
9.30 "	25	103	10	38	42	41	130	—	86	232	32	15	15	15	15	15	15	15	15	15	15
10.00 "	23	104	6	37	43	28	133	—	90	239	14	8	7	7	9	7	6	8	6	8	8
10.30 "	20	105	6	35	40	13	130	—	92	242	6	4	4	5	5	3	4	5	5	5	5
11.00 "	18	104	7	33	35	15	132	—	92	250	1	1	0	1	2	0	1	1	1	0	0
11.30 "	18	105	5	33	38	15	134	—	90	256	4	−1	0	−1	0	−1	−1	−1	−1	−1	−1
12.00 noon	18	105	0	32	37	15	134	—	93	257	3	−2	−1	−1	−2	−1	−1	−1	−1	−3	−2
1.30 p.m.	15	104	0	26	34	14	134	—	92	261	½	−4	−4	−4	−3	4	−3	−7	−3	−5	−4
2.00 "	15	103	0	27	33	14	134	—	94	262	0	−5	−5	−5	−4	−5	−4	−8	−4	−7	−5
2.30 "	14	103	0	27	32	13	135	—	94	263	−2	−5	−5	−5	−4	−5	5	−5	−5	−7	−5
3.00 "	14	103	−2	26	32	13	135	—	94	265	−2	−6	−6	−6	−4	−5	−5	−7	−6	−6	−6
3.30 "	14	103	−2	26	32	13	134	—	94	266	−2	−6	−7	−6	−5	−6	−5	−7	−6	−7	−6
4.00 "	15	102	−3	26	32	13	135	—	94	265	−2	−7	−6	6	−5	−6	−5	−8	−6	−7	−7
5.00 "	13	102	−3	27	31	12	135	—	94	265	−3	−6	−6	−6	−6	−6	−5	−6	−7	−7	−7

Remarks.

50 tons of meat in room C.
50 tons of meat in room H.
60 tons of meat in room E.
*Thermometer changed in Store J at 9.45 a.m.
Thermometer changed in Store A at 9.45 a.m.
A and J changed over to L.D. thermometers.
Compressor in use— No. 9082.
Humidity.
J. Store: temperature, by thermometer in room at 1.30 p.m. and onwards.
Ice being stored in chamber 3.30.
Closed down at 5.15 p.m.
Variation A ... 7½°.
" K ... 4½°.
Fuel consumption :—

		lbs. per hr.
½ gall. test,	10.45	= 24·7
"	12.45	= 25
"	5.00	= 23

Total for run of 8 hrs. 10 mins. = 22·5 galls. = 23·3 lbs. per hour.

* Occasional readings only required.

FOOLPROOF FINANCE FOR PART I SERVICES.

By MAJOR W. G. R. NUTT, M.C., R.E.

WITH the Special Works Programme that has just commenced, and which is estimated to last some five years, almost every officer employed on works is going to have charge of at least one large contract, and many quite junior ones are liable to have several on their hands at once. There is going to be an increase of work all round, and the Works Officer is going to have more important work to do and less time in which to do it. The purpose of this article is to explain methods, which simplify the financial control of large services and which place at the disposal of the officer (and of his inquisitive superiors) the information required at any moment.

CONTRACT WORK.

For the benefit of those who have not previously had works experience, let us examine exactly what a Contract is. The Contractor agrees to do a certain work, which is shown on the contract drawings and described in the Specification, for a certain sum. To save the several contractors who tender for the work the labour and expense that would be entailed if each of them were to take out quantities, the W.D. prepares a "Bill of Quantities" which each contractor prices. There is usually one bill of quantities for each building, a bill for external services, another for electric light and, in cases where the design of the building varies slightly from the standard barrack design, one or more for variations.

Each bill is divided into trades and the total for each trade is carried to a Summary for the bill, while the total of each bill is carried to a General Summary, the total of which is the tender price.

The bill of quantities, then, is the basis of the tender.

ELEMENTS OF FINANCIAL CONTROL.

Let us now see what it is that you want to know in order to control a contract.

The first thing you will be required to do is to give a revised estimate based on the accepted tender price. This, when approved by higher authority, is known as the "approved estimate" and it must on no account be exceeded, unless the consent of higher authority has been obtained prior to the excess being incurred.

Then, as the work proceeds, the contractor must be paid on account, each month, a sum representing 90 per cent. of the value of work done plus 50 per cent. of the value of materials delivered.

From August to February you will have to fill in a form giving the latest revised estimate for the work, and throughout the job you will be harried to give the date of completion.

Revised Estimate.

The first revised estimate is a simple matter. You compare your contract documents with the approximate estimate on Army Form M.1426, which will have been prepared (possibly in the C.R.E.'s office) before the service was placed in the Estimates Book, and verify which of the items on the Army Form M.1426 are included in the contract, which of them have to be added to the tender, and whether the prices in the M.1426 still hold good. You may now have better information as to the cost of these items than was available when the A.F. M.1426 was prepared, or the amount of work required may have altered (for example) on account of part of the external services having been done already under another contract. In particular, there are two important items which may not have been included in the Army Form M.1426. The first is "supervision"; for although the normal supervision by the G.E., and Clerk of Works is not chargeable against the allotment, many big jobs, and especially reinforced-concrete jobs, require a temporary civilian foreman who can be on the job the whole time, watching the contractor, and *his* pay *is* chargeable against the allotment.

The second item is "Credit for Demolitions."

A large part of the Special Works Programme is "Replace Huts," so a "Credit for Demolitions" item will frequently appear in the contract. In other words, the contractor allows so much off his tender price in the general summary, as representing the value which he will get from the sale or re-use of the huts to be demolished.

Simple enough, you say; but this is only the beginning of the tale. This credit for demolitions is not, as you might think, credited to your allotment for the service. No! it is credited to Vote 10 G 1, "Sales of buildings, works stores and miscellaneous receipts," and as such passes entirely out of your control. So, when the contractor puts in his final bill, this credit is taken off, but, as it must be credited to Vote 10 G, it is debited to your construction account (Vote 10 C). You must therefore allow for this credit for demolitions as a liability in every estimate that you make.

In the "General Summary" you will find allowed a certain sum for "Contingencies," but it is unwise to earmark this for any of the larger items which you can foresee before the service starts; let it remain as intended—a contingent provision for the unexpected.

In a word, in making up this revised estimate, you must try and think of everything which has got to be done out of the allotment for the service; for while it may not be difficult for your superiors to get approval to anything essential which is reported with the revised estimate, they will be distinctly embarrassed (with unpleasant consequences to yourself) if, later on, you have to report an excess which could have been foreseen.

CONTRACT PROGRESS RECORD.

The next financial problem is to pay the contractor each month what you owe him; in other words, to arrive at the correct value of the work done. The simplest way is to take the first trade in the bill, probably "Excavator," which is nicely totalled to (let us say) £150. You then look at the job and say, "Oh, he's done two-thirds of the excavation and hasn't started any other trade, that'll be £100." All very well, but it is not so easy to apply when you are halfway through the job and find that "Concretor" includes foundations, which have been done, floors which are half-done, and lintels which are five-eighths done.

The method which I advocate is this. Analyse your bill for each building into trades (and sub-divisions of trades), which you can pick out easily on the job, and take the value of each, making any corrections required by the variation bill. Then fill in the first two columns of the "Contract Progress Record" (a specimen of which is attached). The total of the value column will, of course, be the total cost for that building. With a slide rule it is then only a few minutes' work to complete the "fraction of contract" column.

One "percentage of trade" column is then filled in at each inspection (once a month will do). Then, in the office, multiply each "percentage of trade" by the corresponding "fraction of contract" and enter the result in a "percentage of contract" column. The addition of this column gives the percentage of work done.

A similar form may be used for combining the progress on several buildings into a percentage progress for the whole contract.

This method, besides being quick, is extraordinarily accurate, and the errors are not cumulative; as each trade is completed, any inaccuracy in computing its progress disappears.

It is distinctly comforting to be armed with this table when confronted by a blustering contractor who complains that you have underpaid him by £1,500, and that he cannot find the money to pay his men, particularly if he has already made some impression on your C.R.E.

The only apparent drawback to the method is the time that the preliminary analysis takes. Here I would say that, even if the method produced no results at all, it would still be worth while on account of the knowledge of the bills of quantities, drawings and specification gained while making the analysis. Once you have put that much work (about 2 to 4 hours should suffice) into studying and analysing your documents with this definite end in view, you will be on top of your contract.

Completion Date.

After three or four months' work, you can begin to get some idea of the completion date by plotting percentage progress against time. By this time the curve should have settled down to a pretty straight line, which will be held until about 85 per cent. progress is reached. After this it will tail off badly (the degree is an index of the contractor's inefficiency) and the last 15 per cent. will take about as much time as the previous 30 per cent. With some such allowance, plus an additional allowance for bad weather, frosts, disputes, non-arrival of stores, sub-contractors who do not turn up and a host of other things, you may make as reasonable a forecast of the completion date as is humanly possible.

Further Revision of Estimate.

Having told your C.R.E. in a firm tone that your building will be boarded by the end of June, at the same time offering a silent prayer to the god of your choice, your C.R.E. will probably enquire whether you are going to have an excess over the allotment. Let us study, therefore, labour-saving and foolproof methods of producing the latest revised estimate.

We can classify the expenditure under two heads—" Contract " and " Other than Contract."

To get an estimate of the final expenditure on the contract you must keep a climbing total of deviation orders issued; that is to say each deviation order is priced or estimated by the Clerk of Works before you sign it, and your finance clerk adds it to (or deducts it from, in the case of an omission) the climbing total.

If this system is extended to cover provisional work and provisional items, you have ready to hand the estimated final expenditure on the contract.

" Expenditure other than Contract " is different.

You pay as you go; for stores, for supervision, and for a lot of other little things. All this is posted up in your ledger, mixed up with your payments on account to the contractor; these have already been included under "Contract," and must be deducted. There will also be shown in your ledger, under "Orders Placed," your liabilities. Make a suitable allowance for any other liabilities, and the addition of your ledger total (less payments on account) and your liabilities will give you the estimate of expenditure other than contract.

A further complication may arise when a service spreads over two or more financial years, but this and other complications, such as our old friend "Credit for Demolitions," can be quickly resolved once and for all by the use of the simple form for revised estimates which is attached, and which has the advantage of preserving in a handy form for your next estimate the information which you have collected.

CONCLUSION.

In conclusion I should like to acknowledge my indebtedness to Major G. MacL. Ross, on whose article, "Progress Records for Major New Works," in *The R.E. Journal* for June, 1933, the Contract Progress Record is based. A study of this article will certainly assist anyone to prepare a contract progress record and also (if he has the time) the very interesting graphs advocated by Major Ross.

REVISED ESTIMATE FOR 24 MARRIED SOLDIERS' QUARTERS.

ITEM 10 c.3. Pt. I. ITEM 68.—APPROVED ESTIMATE £10,800.

		21.11.35.	25.3.36.	11.6.36.			NOTES.
Amount Billed	Last Year	—	—	£6,500			Deductions in respect of provisional work not done or additions for extra provisional work should be included in the climbing total of deviation orders.
	This Year to date	£35	£5,584	2,541			
	Total	35	5,584	9,041			
Deduct Total Payments on Account		—	5,072	8,113			
Expenditure other than Contract to date		35	512	928			
Add Contract £9,380, less Contingencies £300		9,080	9,080	9,080			
Add climbing total of D/O's to date		190	362	481			
Add Credits for Demolitions		130	130	130			
Add Liabilities	Stores	451	110	14			
	Electrical Work (External)	390	220	—			
	Mechanical Work	—	—	—			
	Supervision at £4 per week	164	96	52			
	Contractor's Claim	—	65	65			
Add unforeseen Contingencies...		250	150	30			
Revised Estimate		£10,690	£10,725	£10,780			

CONTRACT PROGRESS RECORD. REGIMENTAL INSTITUTE.

AMOUNT OF CONTRACT £7,749.

SHEET [illegible].

Trade.	Value.	Percentage of Trade. 1935. 20/10.	22/11.	21/12.	25/1.	1936. 22/2.	24/3.	Fraction of Contract.	Percentage of Contract. 1935. 20/10.	22/11.	21/12.	1946. 25/1.	22/2.	24/3.
Excavator	£89	80	80	80	80	80	80	·01	·8	·8	·8	·8	·8	·8
Foundations ...	202	20	100	100	100	100	100	·03	·6	3·0	3·0	3·0	3·0	3·0
Bricklayer	1851	—	10	30	60	75	100	·25		2·5	7·5	15·0	18·8	25·0
Structural Steel ...	514	—	25	80	90	100	100	·07	—	1·8	5·6	6·3	7·0	7·0
Concrete Floors ...	430	—	—	40	50	90	100	·06		—	2·4	3·0	5·4	6·0
Carpenter	521		—	10	25	60	100	·07	—	—	·7	1·7	4·4	7·0
Joiner: Floors ...	219						20	·03						0·6
Doors and Windows...	379				10	15	30	·05				·5	·8	1·5
General ...	297						10	·04						·4
Slater	391						30	·04						1·2
Founder and Smith	580						20	·08						1·6
Plasterer: Internal	585						5	·08						·4
External	191						10	·03						·3
Wall Tiler	292							·04						
Plumber: Internal	162							·02						
External	108	10	12	12	12	12	12	·01	·1	·1	·1	·1	·1	·1
Painter and Glazier	266							·03						
Electric Light ...	185							·02						
Roads and Paths ...	52							·01						
Drainage	193		10	15	40	80	80	·03		·3	·5	1·2	2·4	2·4
Contract (less contingencies, etc.) ...	7,417							Totals	1·5	8·5	20·6	[illegible]	[illegible]	57·5
								VALUE	£116	£659	£1,596	£2,446	£3,293	£4,440

FIELDWORKS TRAINING WITH MODELS.

By MAJOR J. G. O. WHITEHEAD, M.C., R.E.

THE following are some examples of training that has been carried out with "models," which may serve to show the scope contained in this form of teaching; the word has been put in inverted commas so as to remind that its direct interpretation may be misleading —scale models are not intended; anything which gives a tangible representation of engineer construction comes within its meaning, ranging from building with miniature stores to the use of cardboard and string. The essential characteristics are for the articles to be capable of being assembled or arranged by hand, and to be of such lightness that they may be done and re-done in a short space of time. Engineering has been divided into constructional fieldworks and tactical fieldworks, the one representing the trade and the other the combatant side of R.E. work; both concern all ranks, although in varying degrees.

The use of models will be found of value for small classes of all kinds—officers, N.C.O.s, or men—and for discussions; it should go a long way towards overcoming Territorial drill-night difficulties. Its value depends a great deal upon the instructor being clear in his own mind, beforehand, as to what he intends to teach: whether he means to teach something new, or whether to refresh the class's memory over what has already once been learned, whether to give an N.C.O. practice in commanding a party, or whether to provide material for a discussion; each requires different treatment, and preparation accordingly.

CONSTRUCTIONAL FIELDWORKS.

Figs. 1, 2 and 3 are photographs of practice in ropes and spars with miniature stores. The kind of stores needed are: 2-in. to 3-in. larch poles, and small pickets; ⅜-in. cordage or picture cord, and twine for mousing; single, double and treble blocks of the kind used on dinghies; miniature chains, ⅛-in. wire rope and clips; and such-like stores. As an example of time, a party of five N.C.O.s, unrehearsed, went through the whole reproduction of erecting the swinging derrick illustrated (except for building the jib) in 45 minutes: the positions of the anchorages, spars and lashings were measured out from the reference point of the weight to be lifted; tackles were rove and the blocks moused; the erection was carried out in the proper manner, starting with a hand lift, taking it up on the struts, and the guys being handled to correspond. The whole object of the work was to give the N.C.O. in charge practice in command.

In the subject Ropes and Spars, the teaching which can be given is :—

Lay-out of anchorages and measurement of stores.
Correct lashings.
Reeving tackles, anti-twist devices (with mallets instead of mauls), mousing.
Joining cordage tackles to wire-ropes.
Various types of anchorage.
Use of chain and wire rope slings, and the precautions needed.
Methods of erection, including a lever.
Orders for moving a weight with the completed derrick, etc.

In the last two of these, there are many faults that can be simulated for the purpose of training N.C.O.s ; and in an N.C.O.'s cadre class the "idiot boy" method of trying to catch out the N.C.O. in charge affords great opportunities for sharpening observation. The kind of faults which can be made are : going under instead of round a suspended block or weight, tackle men not paying attention, men standing with a leg inside a coil of rope that is being paid out, making fast a guy without orders, men chatting on the work, two N.C.O.s giving orders simultaneously—all of the hundred and one iniquities that are seen perpetrated unblushingly during normal fieldworks.

Figs. 3 and 4 are photographs of a water-supply installation completed* and in course of erection ; the water stores consist of gas piping, hessian troughs, and two-gallon petrol tins to represent 400-gallon G.I. tanks. The staging was made of 4 in. × 4 in. scantling, etc., with 9-lb. rails to represent girders ; fieldwork with squared timber, though, needs a comment that is given separately later. The particular constructional points taught were :—

The most economic depth for pitching a canvas tarpaulin (*i.e.*, one-sixth the width of the paulin) ; this could also have been applied to digging a model sailcloth-lined reservoir.
The "envelope" method of folding a tarpaulin to avoid strain at the corners ; the use of this method for rapidly pitching tanks on the ground was also demonstrated.
The field service joint between piping and canvas tanks.
The lead washer joint between piping and metal tanks.
The arrangement of settling and chlorinating, and expense tanks, and the pipe connections that are needed.
The procedure for removing, cleaning, and replacing settling tanks.
The protection of stand pipes and horse troughs from injuring animals.

* The distribution system is not complete.

Particular points taught in the lay-out and erection of the staging and pipe-lines were: levelling the site (using a spirit-level instead of a field-level), the need for mud sills as the ground beneath the staging would become damp, alternative methods of erection—hand or derrick, drainage lay-out, lay-out of horse troughs (which ought to be to scale) with guard rails, drains, and marked traffic routes, and cinder metalling round water-points.

Fig. 5 is a photograph of a pile pier under construction; the materials used were 4 in. by 4 in. piles and capsills, 16-ft. lengths of 9-lb. rails to represent R.S.J's, and a raft was built from which to drive the piles—which was done by hand, with a maul. The special features brought out by the exercise were the accuracy needed

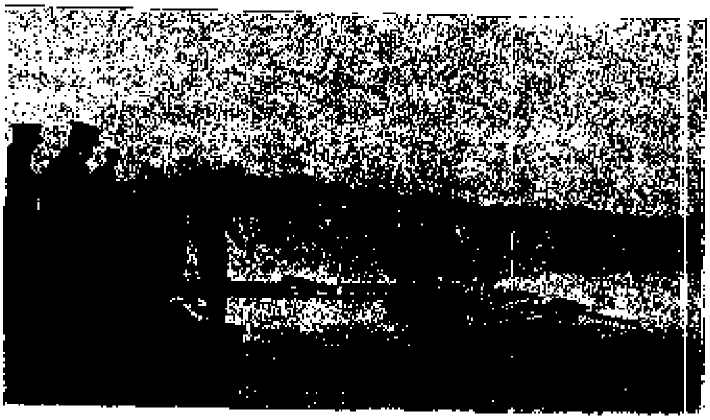


Fig. 5.—Pile Pier.

in laying out and driving, methods for getting heavy R.S.J's into position and the problems that arise in fixing the capsill and bracing when the piles are not dead accurate; the need for fixing loosely the lower ends of the diagonal bracing before driving was a practical detail that was clearly demonstrated. As a guide for the amount of work involved, a pier took somewhat over an hour to complete, exclusive of drawing stores, and with all stores cut to length and prepared beforehand; it was found that the degree of supervision called for requires an experienced N.C.O. in charge and six working numbers are as many as can usefully be employed. Fig. 5 shows the method of rolling a baulk with a turn of the rope being taught.

Fig. 6 is a rather blurred photograph of a demonstration of the effect of shell-fire on different kinds of revetment. The trench is a 1-in. to 1-ft. model, on a sand table; the lower part is revetted with miniature A frames and tin (representing C.G.I.); the upper part is revetted, half with zinc gauze hurdles (representing expanded metal), and half with zinc gauze gabions; the hurdles are stiffened with glued wooden strips, and anchored back with pickets and buried holdfasts to scale. Before the demonstration was begun the class were reminded of the difference between revetments against weather and revetments against shell-fire, and told that this was a test of shell-fire revetment; they were also reminded of the difficulties met with in repairing a damaged trench—the clearance of twisted metal and the necessity for keeping under cover below the parapet—and they were called upon afterwards to discuss the procedure when the trench had been damaged. Shell-fire was represented by exploding No. 13 detonators buried vertically, their tops just beneath the surface; the result was a close resemblance to the burst of a 6-in. shell; a distance of 5 in. from the crestline was found best. The effect on the model was very realistic: the hurdles were stove in, and the holdfasts in the crater were destroyed; the gabions (nearer end) were pushed back to vertical or nearly so in varying extents; the identical problems in rebuilding were presented as appear in actuality, and the appearance of the model was like a bird's-eye view of a shelled trench. Slightly damp sand is probably the best material to work in; when the gabions were filled with clay (which dried) they were blown about in an unreal way; filled with sand, however, they bound together in the same way as full-scale ones, and in this instance they were strengthened with pickets, but without holdfasts.

Squared timber structures have to be prepared beforehand by carpenters; the field engineer training of N.C.O.s is in laying out the site for their erection, preparing the footings, the erection, and putting on the superstructure. The sight of a ready-made trestle, however, is liable to make the organization of the work forgotten, and for the erection and completion of the superstructure to be done without simulating reality, as of course can all model erection. Control is the business of the instructor, and it is over this that he needs to appreciate clearly what are the lessons to be taught: if the appearance of the finished structure is the object, then the intermediate work may be skipped; if the object is to practise the N.C.O. in charge in organizing work, then all details of the work must be gone through realistically. In this the class can help: if told to place a 400-gallon tank by hand on a model trestle 4 ft. high, the individual can reply to the N.C.O. in charge that he cannot do it, it is too heavy, the lift is too high, and he can oblige the N.C.O. to send men on to the staging with ropes or to rig a derrick. In general, as regards N.C.O.'s classes, the object will be to make the N.C.O.s use their brains, and there can be no surer way of doing so than by setting his fellows the task of catching out the man in charge.

The foregoing are examples of structures that can be built with models, and perhaps will indicate the scope that lies in the system. On the other hand, certain subjects are better taught by different

Fig. 1.—Ropes and Spars.

Fig. 2.—Ropes and Spars.

Fig. 3.—Water Supply.

Fieldworks training with models Fig 1, 2 & 3

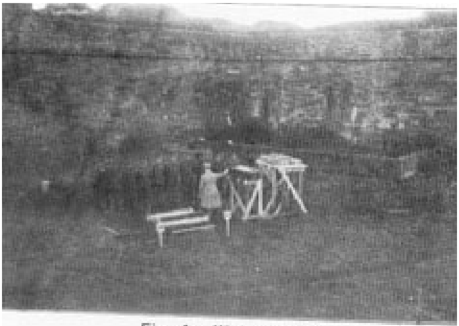


Fig. 4.—Water Supply.

Fig. 6.—Trench Revetments.

Fig. 9.—The Shenandoah Valley.

Fieldworks training with models Fig 4 6 & 9

methods: for instance, camp structures and bivouacs are probably best treated as a discussion—everyone has seen various types, and from discussion their respective merits and faults will become more surely fixed in mind. Again, explosives is a subject that needs teaching partly with the real article; but when practice in laying charges is intended, dummies only are needed, and when practice in firing a series of connected charges is intended, detonators and fuze or leads (and a resistance box) suffice. This is akin to work with models, and much of the care and supervision required in the subject can be taught without the actual explosion.

Tactical Engineering.

In this, the basis has been taken that fire-trenches are primarily an infantry responsibility, and communications that of the R.E., but that the R.E. can and should be employed on preparing rear positions for the infantry, and consequently need full training in the subject; also, in defence works that require tradesmen's construction, the R.E. must have specialized knowledge. Some exercises that have been carried out are described below in the sequence they would logically follow.

As preliminary remarks, the first axiom in defence works is that in times of stress a man's attention becomes riveted to his front and he will fire to his front, that is to say, at right angles to the parapet against which he is leaning; therefore, in order to produce the desired fire effect, trench parapets have to be aligned accordingly. The object of any defence work or trench system being, firstly, to bring a certain volume of fire on to a specified front, and secondly, to maintain itself, it is the duty of the infantry commander, or of the R.E. officer who knows his wishes, to lay down the fire tasks of each trench, and for R.E. N.C.O.s to be able to lay out trenches that will conform to their fire tasks.

The first exercise is in siting trenches. On the floor of a room a landscape can be sketched out in chalk or represented with cardboard or toys—a few trees, a house, a haystack, or any common feature of the countryside. Fig. 7 is an illustration of this. The class is then told (for example) to lay out trenches for a platoon, in which 6 rifles are to cover from A–B, 6 from B–C and 6 from C–D. The points A, B, C and D are marked by drawing pins to which tapes are attached—these tapes mark the arcs of fire; the other ends of the tapes are attached to strips of cardboard, through holes which allow the cardboard to be slid into different angles, and the cardboard strips represent the general alignment of the trenches. Features of the ground where the post is to be sited can be drawn in chalk—a hedge, a railway bank, a copse. It should then be demonstrated that the trenches may be shifted into any arrangement to conform with the ground without altering their ability to carry out their fire tasks, provided that the alignment of the trench is shifted so as to keep it at right angles to the axis of its arc; this is illustrated in Fig. 7. When the best arrangement for the purpose has been arrived at by discussion, the next stage is to determine the alignment of the several bays or weapon pits, of each trench (if required), one aligned to cover one part of the arc, one to another, and so on; after this comes the addition of bays or modifications to meet local defensive needs and concealment. The ruling principle to be established is that fire tasks are the governing factor: position may be altered in order to make use of cover, but cover must not govern alignment; R.E. work is the adaptation of cover to alignment.

Following on this is an exercise on the defence of buildings, in which the axiom of a man firing to his front reappears in the form that he will fire along the axis of his loophole. Cutting loopholes is essentially an R.E. speciality, and their positioning perhaps needs more thought than is at first apparent; the subject relates to European warfare, the design of semi-permanent posts in a country like Mesopotamia, and of hill piquets in country as on the North-West Frontier of India. Like trench posts, buildings can be shown usually to have two distinct functions—distant fire tasks such as covering certain ground and mutual support (generally done by automatics), and self-defence; the latter alone is being considered here. The exercise is done with a cardboard model of the house to be defended, showing doors and windows, which is placed on a table, as in Fig. 8; round the outside of the house is drawn a cross-section of the walls, showing the windows and doors, in chalk, so that the class is faced with an elevation and cross-section simultaneously. The position of the wire entanglement can be represented by a piece of string. The points for discussion that arise come in the following order:—

Distance of the entanglement from the building (range of vision by night).

Number of rifles required to be brought to bear on any point in the wire, so as to stop a rush.

Arc of fire that one man can cover when in action.

Resultant alignment of the loopholes.

Splay of the loopholes—outwards or inwards.

Position of loopholes in corners—it should be demonstrated that the left of a corner is different from the right; it is best shown practically with a rifle and in the corner of the room, with two men standing side by side firing.

When sufficient loopholes cannot be brought to bear from one

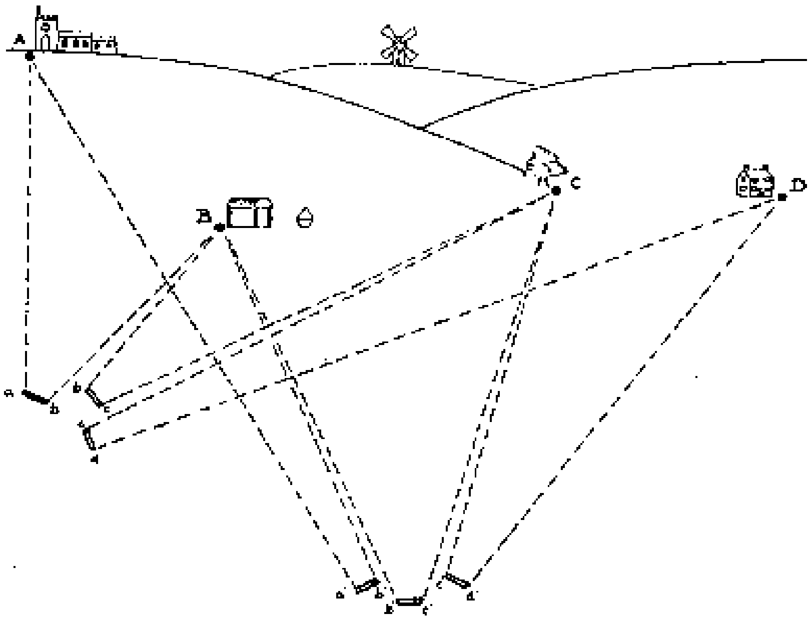
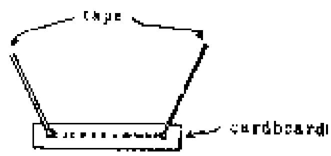


FIG. 7.—Trench siting.
a-b, b-c, c-d, a'-b', b'-c', c'-d', alternative position of trenches that carry out the same fire tasks.



Detail of the attachment of tape to cardboard.

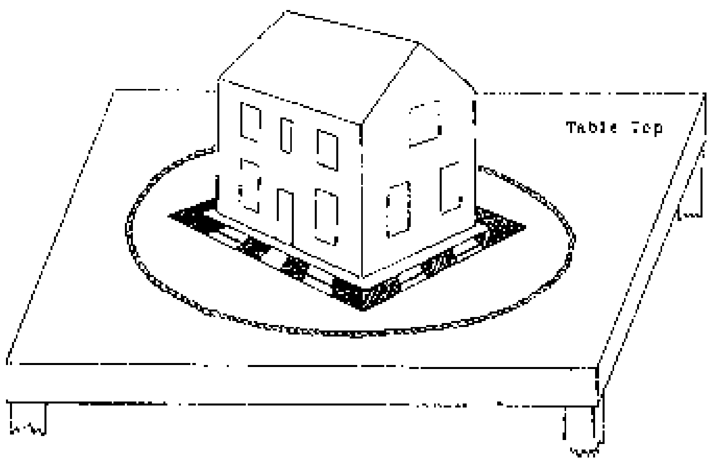


FIG. 8.—Defence of buildings.

storey, then the possibility of augmenting them from the one above.

The height that the loopholes should be above the ground outside.

Bullet-proofing of doors and windows.

Means of providing an all-round field of view for the sentries.

Minimum number of sentries.

Protection against silhouetting.

Means of allowing the garrison to throw bombs.

Protection against enemy bombs.

Means of signalling to neighbouring posts and headquarters.

Protection for the signallers.

Means to allow the garrison rapid movement within the building.

Position of water tank, stores, etc.

Position of day and night sanitary and cooking arrangements.

After the discussion, the class can be formed into two groups and be made to try out their ideas in a game of attack and defence, with moves at 15-second intervals. The conditions of the game have to be devised as realistically as possible. The following are the lines they should follow—opinions will differ as to the actual figures: stealthy approach to within 100 yards unseen by night; charging pace, 50 yards in 15 seconds; time lapse between sentry shouting "stand to" and garrison opening fire 15 seconds; rate of fire, four rounds in 15 seconds, 50 per cent. shots effective at point-blank range (this is a very moot figure at night); the resistance of the entanglement against the weight of a determined rush will depend upon the amount of wire that has been allowed and the length of time for building—it is a good subject for discussion. With a garrison of 10, the defence will be found to have a difficult task in the face of the feints, smoke and covering fire that the attack can use in aid.* The desirability of calculating on the attack being pressed with the utmost resource and determination will be recognized, and the class may be reminded that without being able to visualize the attack accurately they will not be able to design an efficient defence.

An exercise for officers, that would follow the above, was done in 1936 when the Mesopotamian campaign was the subject for winter study. The situation set was that of the line of communication in the summer of 1916. One infantry brigade at 50 per cent. modern war establishment, which corresponds to the depleted 35 Infantry

* As an example of the intensity with which an attack on a small post may be pressed, the description of the Mahsud attack on a piquet in Waziristan, given in the October number of *The Army Quarterly*, 1934, should be read.

Brigade in history, was given the task of protecting 17 miles of desert (Shaikh Saad–Sinn) against Arab marauders. A British and an Arab syndicate were formed; the British had to submit a plan of their system of defence, with cardboard models of various types of posts that their members proposed; the Arab syndicate was given the plan and the models, and devised attacks on each one in turn. The special conditions of the game were laid down, such as the limited quantities of defence stores available; and the Arabs were given a Turkish emissary who provided them with *bhoosa* bales (bullet-proof along the grain) as portable sangar walling. The game was played out in 15-second moves, British and Arab lead soldiers being the pieces. Some of the attacks were successful, but, in spite of a Bengal Sapper umpire, the Bangalore pattern Frontier defence work held out inviolate in its peculiar shaped virginity. The effect of the exercise was to demonstrate the very difficult proposition that existed in 1916, and to develop ideas on the design of posts for such warfare.

Outdoor Schemes on a Model.

For engineer exercises *with* troops the benefits that can be gained from taking the principals through their parts beforehand, on a model of the ground, are as follows:—

- It ensures that orders will be given on the right lines, and safeguards the men from being badgered about.
- It ensures that essential measures during the exercise will not be overlooked.
- It ensures that the preliminary organization of troops, transport, stores and tools will have been done thoroughly.

The procedure need not in any way detract from encouraging initiative among N.C.O.s during the work on the ground; on the contrary, it should add to it, because, deliberation on the main matters is got over beforehand, with the result that hampering mistakes are not made and full time on the spot can be devoted to detail. Nor is the novelty of a fresh situation spoiled, for no matter how realistic the model there will be features that are not reproduced, which will necessitate the adaptation and modification of the broad outline of method arrived at on the model. A model of the ground is not an essential, as a map will suffice, but under certain circumstances the model is better, in that it gives a stimulus to imagination which a drawing may not.

The sand table is the best-known model of this nature, but there is another variety that has several advantages, which is a large dust sheet (preferably khaki-coloured) spread on the floor, with hills reproduced by sandbags or crumpled newspaper underneath; on the surface, roads are made with white tape, railways with red, and rivers and giving the orders relating to them—and it ensures a proper organization. It has been remarked that the same could be done from a map, but less demonstratively; the more closely that an engineer exercise relates to tactics, the more useful and vivid does a model of the ground become.

This kind of a model used for the first tactical exercise given above adds to it greatly by introducing the slope of the ground.

CONCLUSION.

The foregoing are instances of work that has actually been done; they are written partly from memory, as some were done independently and they had not previously been thought of as a connected whole. A principle, however, can be seen common to all of them—that of helping the imagination; maps, pictures and descriptions illustrate to a certain extent, but a miniature reproduction does so in a far greater degree. The writer has only recently learnt the astonishing variability between persons in their capacity for visual imagery; and when it is realized that the man with the best brains may have the smallest power of visual imagery, the benefit of placing the least call on the imagination can be appreciated. Organization is a subject which some men find difficult to visualize, nor can it be represented tangibly; but by this method its absence can be demonstrated, through making an exercise with models a game of catching out the offender, and herein lies a source of much profit. Small-scale fieldworks stores have the additional value of enabling a lengthy piece of construction to be done in a short time, through using light materials; the simplest serve for the most seasoned veterans, and after the first time that ropes and spars were practised a Q.I. warrant officer remarked that all of the party of N.C.O.s had been reminded of something or other they had forgotten. From this it may be gauged that properly handled, with a definite purpose in mind, the method enables a great deal of instruction to be compassed within a limited time. Teaching with it, though, is not every man's *métier*, and cannot be handed out to all and sundry with the bare military benediction "Carry on"; the instructor who is to handle it must know his part, and even more than a knowledge of technical detail he needs a flair for organizing and controlling work. For teaching novices technical knowledge comes first in importance, but for training N.C.O.s—who themselves know the detail or will quickly recollect it—the ability to organize and control takes its place. Perhaps one of the greater values of this method of training is in the opportunity it affords of studying a man's aptitude for taking charge of work.

PALESTINE DEMOLITIONS—42nd FIELD COY., R.E.

By LIEUTENANT I. W. B. EDGE, R.E.

Demolition of Masonry Arch Bridge at Mejdal-Yaba on October 19th, 1936.

Introduction.

One of the features of Palestine is the solidity of many bridges, which carry the most abominable roads over dry gaps. Owing, however, to the tremendous rush of water after the heavy rain which sometimes falls in the winter, these bridges, solidly built though they certainly are, frequently get washed away.

The bridge in question, a well-built masonry bridge of four 13-foot arches, had an abutment and the pier next to it washed out during last winter—a striking reminder that a bridge must be sited so to have a straight flow of water under it without swirling and scouring.

The Public Works Department wished to have the rest of the bridge—two piers and the remaining abutment—demolished in order to build a new reinforced-concrete structure in its place. The 42nd Company gladly undertook the demolition and the 19th October was appointed for blowing.

Reconnaissance.

The request was made too late to make a reconnaissance possible. All that was known of the bridge was that it was masonry, that the piers were about 3 feet thick and the abutment about the same, and that the P.W.D. had boreholes ready prepared for the insertion of explosive charges. On arrival at the bridge this information was found to be correct within limits, but the boreholes proved to be only 4 in each pier and of such a size that one and a half sticks of gelignite could just be crammed in—*i.e.*, four charges of ¾ lb. each!

The dimensions of the bridge are shown in the drawings E and F, where it can be seen that the piers have an overall width of 24 feet and a solid masonry thickness of 3 feet, hard limestone in P.C. mortar. It was certainly ambitious to hope to blow these with just the amount of explosive that could be placed in such boreholes barely 15 inches in and about 1¾ inches in diameter!

Method Adopted.

It was only in the afternoon of 18th October, that the P.W.D. asked for the demolition to be effected in the morning of the 19th;

so it was evident that the demolition party would have no time, in the absence of power tools, to prepare boreholes, should those made by the P.W.D. prove unsatisfactory. Accordingly we took sufficient gelignite to make up cutting charges—it was fortunate that we did.

Immediately on arrival it was obvious that the boreholes provided were useless and that there was no alternative to a cutting charge on each pier. On the abutment wall, however, an excellent opportunity was offered by two weep-holes about 10 inches square in section that came out to the face of the wall some 5 feet above the bed of the watercourse. The clear space inside varied—owing presumably to stones that had squeezed into the weep-holes from behind—so that one weep-hole was packed with 50 lb. of gelignite and the other with only 30 lb. In order to obtain the fullest possible effect the weep-holes were loaded flush to the face of the abutment wall, and it is therefore of no particular interest to attempt a comparison either with the calculated weight of correctly spaced mined charges behind an abutment wall, or with borehole charges in correctly spaced boreholes having the charge at least 8 inches back from the surface. (*M.E.* Vol. IV, p.36.2.)

Calculation of Cutting Charges.

See drawings E and F. The overall width of each pier, B = 24 feet, and thickness of masonry, T = 3 feet.

Formula for cutting charges on masonry piers:

$$C = \tfrac{2}{3} BT^2$$
$$= \tfrac{2}{3}\, 24 \times 9 = 144 \text{ lb.}$$

and (see Table "B") take gelignite as equivalent in cutting power to guncotton.

Actually 140 lb. were used on each pier.

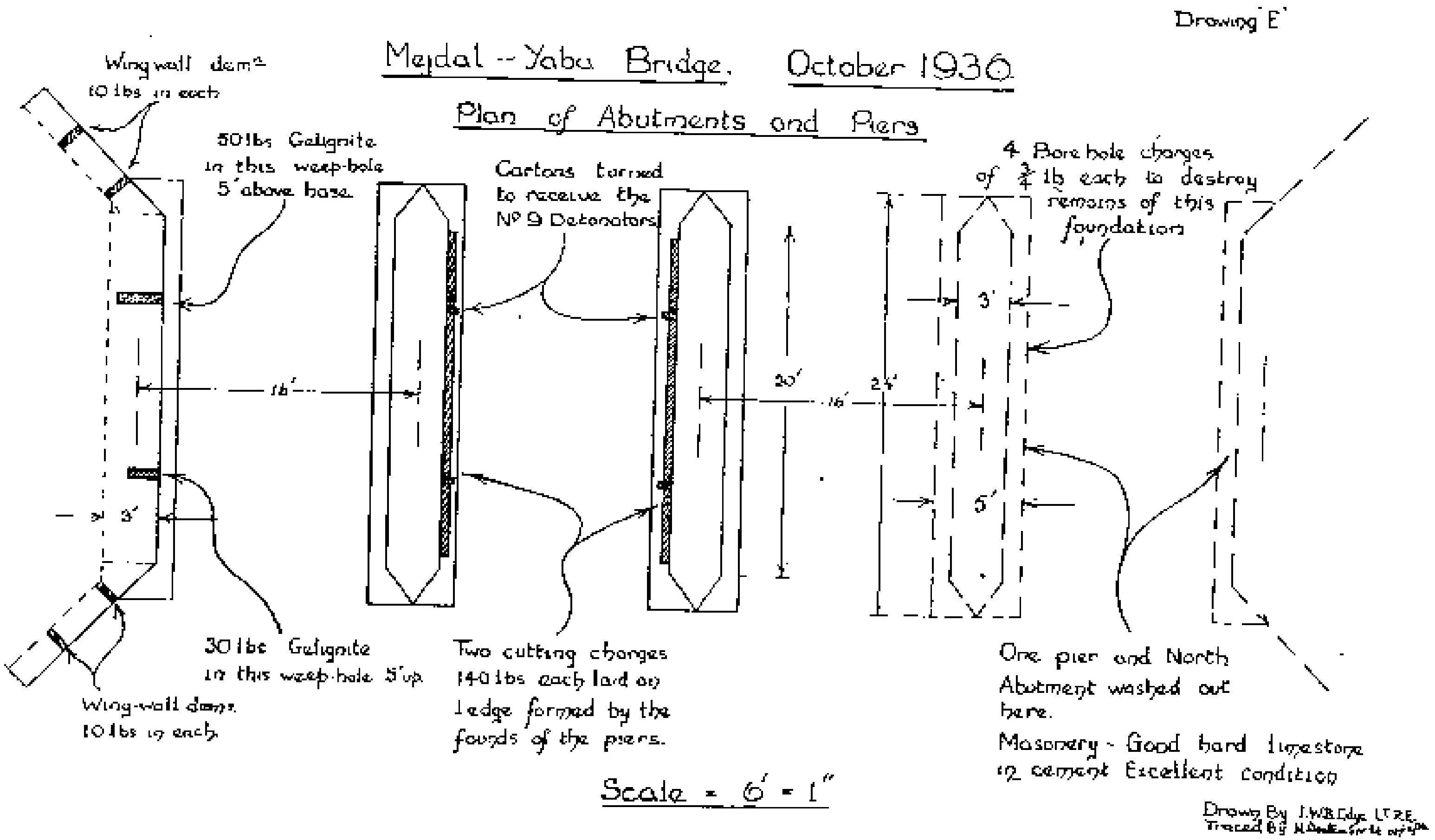
Description of Explosive used.

The Public Works Department supplied the explosive—60% gelignite made up in ½-lb. sticks 8 inches long and 1¼ inches in diameter. The sticks are packed in cartons, 10 in each, so that each carton holds 5 lb. of gelignite. Cartons measure 8½ inches × 5½ inches × 4 inches approximately; they are conveniently laid end to end in making up cutting charges. In order to insert a detonator the selected carton must be turned broadside on and the outer end stripped off to expose the ends of the gelignite sticks for the insertion of a detonator in one of them.

In the abutment wall weep-hole, cartons were packed in tightly and the space left was filled in with the separate sticks.

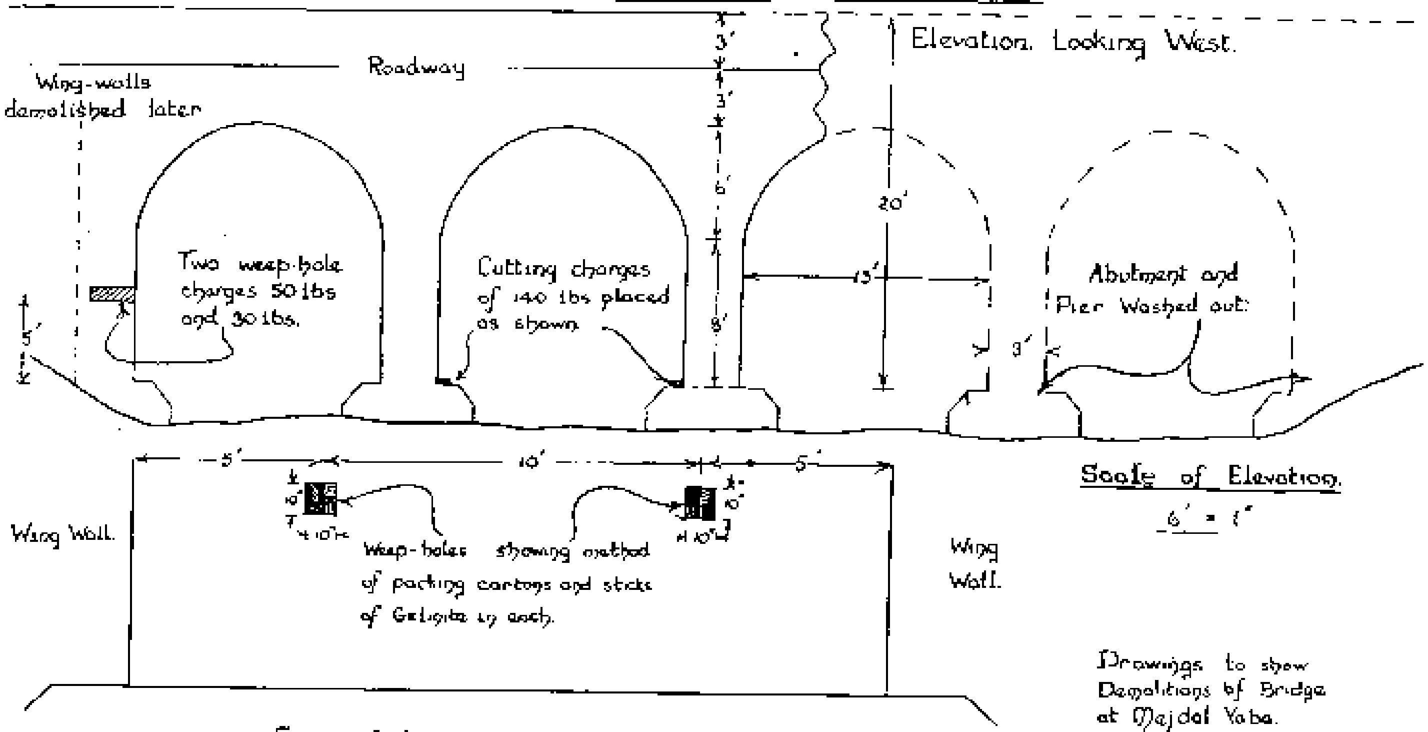
Method of Firing.

Electrical. The advantages of securing simultaneous detonation throughout the system of charges easily outweigh any slight


Drawing E
Mejdal -- Yaba Bridge. October 1936
Plan of Abutments and Piers
Wing wall dems 10 lbs in each
50 lbs Gelignite in this weep-hole 5' above base
Cartons turned to receive the No 9 Detonators
4 Bore hole charges of 3/4 lb each to destroy remains of this foundation
16'
20'
24'
3'
5'
30 lbs Gelignite in this weep-hole 5' up
Wing-wall dems. 10 lbs in each
Two cutting charges 140 lbs each laid on ledge formed by the founds of the piers.
One pier and North Abutment washed out here.
Masonery - Good hard limestone in cement Excellent condition
Scale = 6' = 1"
Drawn By J.W.B. Edge Lt R.E.

Mejdal-Yaba Bridge October 1936

Drawing "F"



Face of Abutment Wall

Scale: 3' = 1"

Drawings to show Demolitions of Bridge at Mejdal Yaba.

Drawn By I.W.D. Edge. Lt R.E.

additional trouble in connecting up. One detonator only was used in each weep-hole charge and two to each cutting charge, the resulting resistance to the firing current being within the capability of a Mk.VI Exploder.

$$(6 \times 2{\cdot}6 + 4 \times 1{\cdot}31) = 21{\cdot}6 + 5{\cdot}24 = 27 \text{ w. approx.}$$

The Demolition.

The demolition party left camp at Lydda 0800 hours on the 19th, started work at 0930 hours and the bridge was blown at 1130 hours. The time taken was spent chiefly in clearing the weep-holes as far in as time permitted and carefully packing the charges into them.

The demolition was completely successful. Both piers were razed to the ground and the abutment wall entirely demolished. The abutment wing walls were forced out to an overhang of 10/1, but did not collapse.

Subsequent Clearing Demolitions.

A. A large block of concrete roughly 15 feet × 4 feet × 2 feet, part of the foundation under the pier that was washed away, was destroyed to clear the site. Four small boreholes 18 inches deep were ready prepared by the P.W.D. Each received $1\frac{1}{2}$ sticks of gelignite tamped down and the four charges were fired with four separate safety fuses. The explosions were nearly simultaneous.

B. Seeing that the wing walls already inclined outwards, it was first attempted, by way of experiment, to kick their feet from under them with 10 lb. of gelignite simply placed at the foot of each wall. The result was failure.

Recourse was then had to the weep-holes in the wing walls. Each wall had two weep-holes about 8 inches × 8 inches in it. 10 lb. was placed 3 feet into each weep-hole—20 lb. of gelignite to each abutment wall—and fired by means of safety fuse. The result was success.

Note.—Although these weep-hole charges were tamped as well as could be done with dusty rubble, the value of the tamping was undoubtedly nil.

1.—View of bridge from south-west. Pier charges laid. Sappers placing weep-hole charges. P.W.D. coolies looking on.

2.—The instant of demolition. View fro[m] 400 yards, north.

3.—After demolition. View from same stand-point as No. 1. Village and Crusader Castle of Mejdal Yaba.

4.—View of demolished bridge from nort[h] west, showing how the abutment wing wal[ls] have been forced outwards at top.

Palestine demolitions 1 - 4

WIRE ROPE BRIDGES FOR MOTOR VEHICLES.

(*A Suggestion for Consideration.*)

Translated from an article entitled "Drahtseilbrücken für Kraftfahrzeuge," by CAPTAIN DIPL.-ING. HARTUNG, in *Vierteljahreshefte für Pioniere*, November, 1936, and republished by permission of that magazine.

[Note by the Editor of the *V.f.P.*—*If the following scheme seems rather fantastic, we see no reason for withholding it from our readers, as it undoubtedly deals with an interesting problem.*

We have been informed that the wire rope bridge described in this article is not to be constructed by engineer units on their own responsibility, but only on the orders of higher authority.]

WHY encumber ourselves with the many chesses, baulks, trestles and pontoons, the numerous transport wagons and men for bridge construction? Does not simplicity mean success in war?

Two rails—that is all that a motor-car needs to cross a stream or gap. Two cables, stretched across and anchored back, are enough to carry a vehicle across a river. All else is unnecessary ballast that can be dispensed with.

Is the passage over such a wire rope bridge a trick? Not by any means.

In order to travel over the cables, each wheel is provided on the outside with a pulley-wheel attachment (rotating with it). The latter does not in any way interfere with driving the vehicle on the ground. The groove of the pulley-wheel attachment grips the cable so firmly that a motor can be driven under its own power up a steep incline. The groove forces the front wheels to take the rope in such a way that steering is unnecessary. The vehicle can be placed on the cable with the engine running, without a driver, and will make its own way across to the other side.

Tight-rope driving is, consequently, no trick.

It is obvious that such a bridge equipment, consisting merely of two cables and their anchorages, offers many advantages, even if it is only suitable for comparatively small spans and loads (about 40 metres—135 feet—and 4 tons). It is light and takes up little space. A trailer is sufficient for its transport. It can be erected and dismantled in a short time and with little personnel. To construct a corresponding bridge, to erect trestles, or to handle chesses, baulks and pontoons in the same time would be impossible. The only work—the anchoring and straining of the cables—is carried out on dry land in a convenient site. It is only necessary to carry one end of the cables and the anchorage across the stream on a small kapok raft or boat. A wire rope bridge is independent of the width of the stream (provided it does not exceed 40 metres), the river bottom, depth and velocity.

Not only does the equipment offer no fire-target when on the road or under construction, but, once it is erected, it can hardly be spotted by aircraft or destroyed by gun-fire. A motorized unit loses much of its value if it is held up at every small river-crossing to await the construction of a bridge, especially when the bridge site cannot be concealed.

The standard bridging equipment is comparatively complicated and vulnerable, notably in the case of narrow crossings. However narrow the stream, the number of bridge sites is limited.

Every formation can carry a wire rope bridge along with it and erect it. The preparation and transport of the equipment are so simple and cheap, that it can be turned out in large quantities; it can always be on the spot and so offer the opportunity for a surprise crossing on a broad front.

A wire rope bridge is a type that motorization has called for to supplement previously employed bridging systems in negotiating small rivers. With its help troops and equipment can be carried across at the right time and in many places. It will continue to provide a safe and speedy connection under the heaviest fire. Even if only one vehicle at a time can be carried on the cables, it can make its way across safely in top gear at high speed and reach the next cover quickly.

The wire rope bridge is of special importance to a motorized reconnoitring detachment. Here comes an important point. The enemy, whose vehicles are not equipped with the special wheel-pulley attachment, and have not the same wheel track, will not be able to use the bridge.

Now many a reader will think: "Yes, that is all very well, but what about the technical execution of the work? What about the anchorages, the suspension and straining of the cables, the equalizing of tension, and driving over the ropes? What about safety? Can all these problems be solved?" It is a comparatively simple matter.

The anchorage presents the greatest difficulty. The well-known ferrying-cable anchorage suggests itself, but it is not strong enough. The surface of the rounded anchoring piquet buried in the ground is too small. If the piquet is given a cross-section shaped like an open cross, and if the top half is encased in steel sheeting at the point of attachment of the cable, the result will be a greater surface and resistance, as compared with a round piquet of the same weight. The open cross-section enables the piquet to be driven in easily, and the resistance to the bending moment, which increases towards the top, admits of a longer projection out of the ground. The passive earth pressure

$$Ep = \gamma \frac{h^2}{2} \lambda p \times b$$

is increased. Rankine's rough formula may here be considered applicable.

Example:

With γ = 1·8 ton/m³ = specific gravity of the soil,
λ_ρ = 4·5 = figure for passive earth pressure (corresponding to ζ = 40°, angle of repose of the soil),
b = 0·3 m = width of piquet,
h = 1·6 m = length of piquet,

the passive earth pressure becomes:

$$Ep = 1{\cdot}8 \text{ ton/m}^3 \times \frac{1{\cdot}6^2\text{m}^2}{2} \times 4{\cdot}5 \times 0{\cdot}3 \text{ m},$$

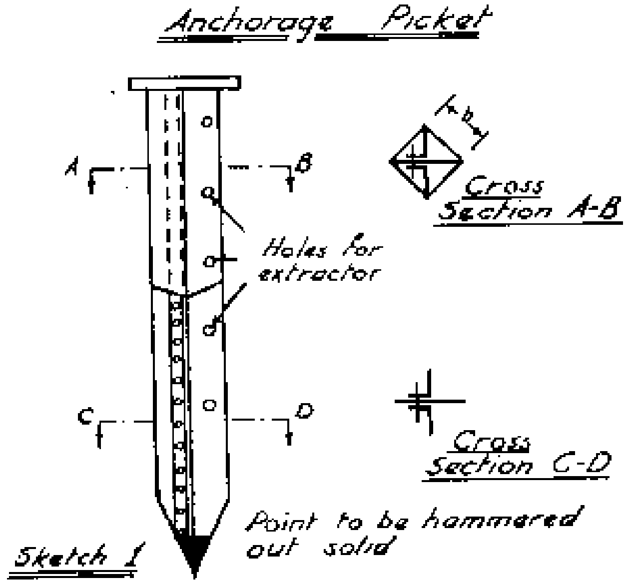
$$Ep = 3{\cdot}1 \text{ tons (passive pressure).}$$

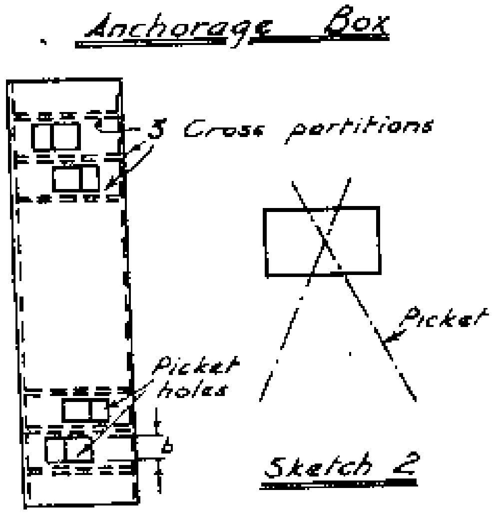
With four piquets in one anchorage box—if the soil is favourable—a tension of 12 tons can be taken up. The cross-shaped piquet can be pulled out with a jack; the box-shaped anchorage will float. (See Sketches 1 and 2.)

But this anchorage need only take up part of the strain on the cable. Is it not possible to take up the remainder of the strain on the same principle as the brake of a motor vehicle, by utilizing the friction of a ramp? To do this, the cable is carried over the ramp, and after it has been fixed in position it is clipped down to the ramp.

When the weight of the vehicle comes on to the cables, the pull on the latter is transferred to the ramp, which is then pressed downwards. The ramp can thus—like a motor-car with the brakes fully applied—take up a certain amount of tension, before it slips and further increases the load on the anchored end of the cable. In order to increase the friction, a set of iron angles is attached to the underside of the ramp.

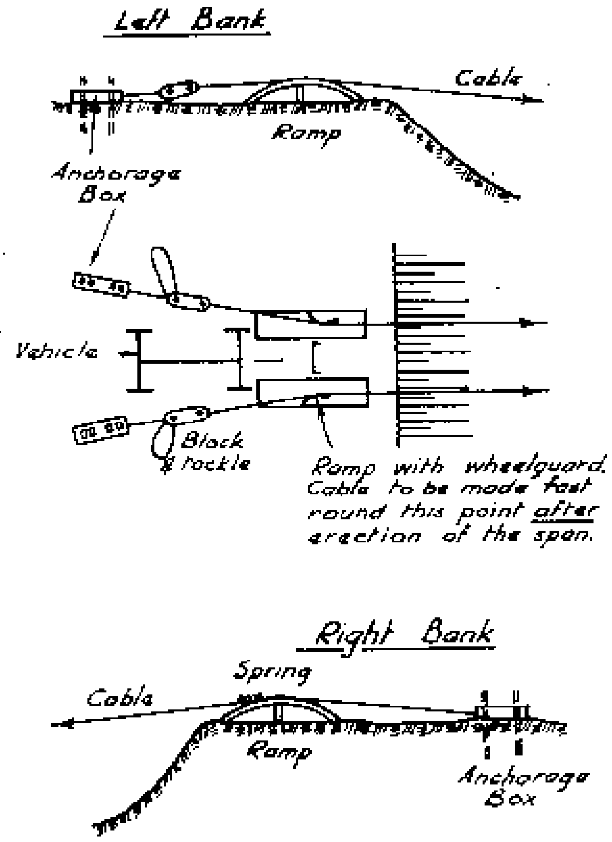
The employment of the "ramp" does away with three doubtful points: the passage of the vehicle, the dip in the cable, and the tension. A "ramp," 60 cm. (2 ft.) high and 50 cm. (1 ft. 8 in.) wide, for each wheel track is conveniently portable. If the two ramps are coupled together with a distance-piece, and are provided with wheelguards, there is no chance of the pulleys attached to the wheels missing the cables even at a high speed. (See Sketch 3.)





A dip of 1 metre can always be attained with a ramp.

Let l = 40 metres (distance between supports), P = 2 tons (load on one cable, due to a 4-ton vehicle), then a dip f = 1 m. is obtained



Sketch 3

from the similarity of half the triangle of forces to the actual cable diagram.

$$\frac{H}{\frac{P}{2}} = \frac{\frac{l}{2}}{f} \qquad \text{(See Sketch 4.)}$$

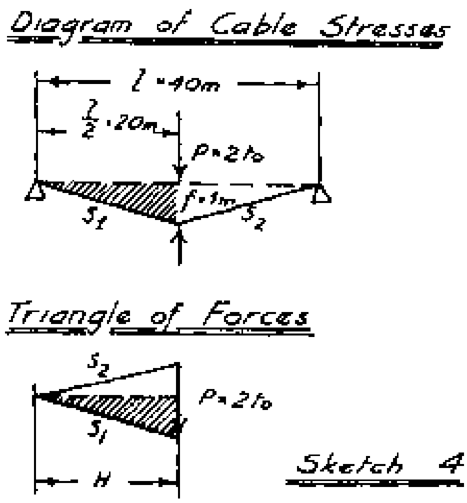
$$H = \frac{\frac{P}{2} \times \frac{l}{2}}{f} = \frac{P \times \frac{40}{4}}{1}$$

$$H = 10\,P = 20\ \text{t.}$$

Owing to the trifling amount of the dip in comparison with the span, S and H can be considered approximately equal. Thus, with the assumed span of 40 metres and a dip of 1 metre, the tension of the cable can be taken as 10 times the load. A 4-ton vehicle will cause a tension of 20 tons in each cable.

Tables given by manufacturing firms show that a wire rope of 30 mm. (1·18 in.) diameter has a breaking strain of 61,000 kg. (taking K = 18,000 kg. per sq. cm. as the tensional strength of the material). This gives us a factor of safety of 3.

The system of anchorage described above will take a strain of 20 tons. This is the most unfavourable case. The more the dip can be increased or the span decreased, the less will the tension on the cable be; this follows from the cable diagram and the triangle of forces.



Sketch 4

The equalizing of the cables and the question of safety remain to be considered. The simplest method of measuring and compensating forces is by the aid of springs. Here the shock-absorbing "Ürding" spiral spring can render valuable service. If each cable is attached to such a spring (see Sketch 3), both can be given exactly the same tension, according to the spring diagram. If, through an unequal distribution of the load, one cable should be loaded more heavily than the other, it will sink lower. The increased strength of the spring counteracts this tendency, as also does the reduced tension of the cable (owing to the greater sag), so that a compensating balance takes place quickly and automatically. But every vehicle causes a certain amount of inequality in the cables. The groove, however, makes a side-slip impossible. The spring acts as a safety-valve in protecting the cable and the anchorage from any sudden overloading, so that the possibility of either giving way is negligible. Thanks to the spring, every overload causes the cable to give, if ever so little—but this little is enough for safety.

Similarly, further tests will overcome all technical difficulties.

Motor-cycles, coupled in pairs, can be taken over the wire rope by means of a guiding-rod, provided that there is enough space between fork and wheel-rim for a wire ring about 30 mm. wide to be attached.

If it is decided to dispense with pulley attachments on the wheels, two wire ropes must be stretched across where the wheel tracks come, and decked over with planks. It is possible to drive over such a wire rope bridge by motor power without swaying, whereas pedestrians and horses will cause the bridge to oscillate as they walk over it. But this type of bridge, with the tracks planked over, loses some of the advantage of simplicity and invisibility.

Motorization presents us with new possibilities and problems. A war material can be developed in two directions: it can either be light, rapid and handy, or it can be heavy and ponderous. Here we have sketched a light, rapid and handy type of bridge for motor vehicles. It will have an increased importance as modern methods develop, in which the object will be to hamper the rapidity of enemy motorized units by obstacles placed along watercourses, and to interfere with their crossing visible bridges by aeroplane and artillery action. Are chesses, baulks, trestles and pontoons really necessary?

D

TANK STEPPING-STONES.

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

How the " I " tank is to cross a water obstacle and give close support to the infantry immediately after they have effected a river crossing, is still an unsolved problem.

By means of stepping-stones is a possible solution when the depth of water does not exceed six feet.

Up to now, three different kinds of stones have been tried: Light, Heavy, and Hexagonal.

LIGHT BOXES.

The 17th Field Company (Major G. le Q. Martel, D.S.O., M.C., R.E.), in 1926, built boxes 3 ft. 8 in. high, 4 ft. 8 in. by 12 ft. wide, and proved that these were capable of carrying a 12-ton tank in water 4 ft. and 5 ft. deep. One box was able to take the whole weight of a tank. It was found that the boxes should normally be spaced 3 ft. apart and that special " shore boxes " were necessary if the stream was shallow near the bank.

These were tested fairly extensively in 1927 and improvements in detail added during 1928, producing the final design as shown in Plate 50 of Part I of *Military Engineering*, Volume III, 1934.

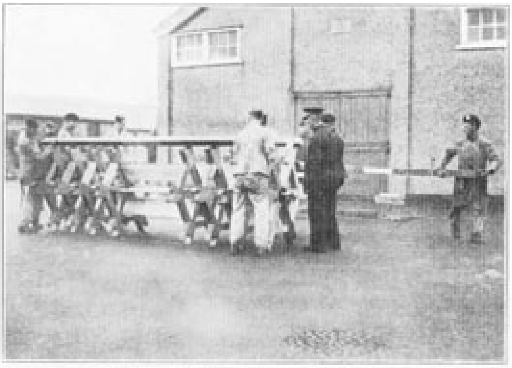
A string of these boxes can be rapidly launched as a tank assault bridge. Four men cross on an infantry assault bridge (or in a folding dinghy) with the ropes of the leading boxes, two 6-ft. piquets and two mauls; the carrying party for each box is six men.

HEAVY BOXES.

In May, 1927, further trials were carried out by the 17th Field Company in deeper water at Christchurch, with boxes 6 ft. high by 5 ft. by 12 ft. wide; these were not strong enough to allow a tank to change direction on them. It was also found that :—

(i) Where opposite banks are very divergent, difficulties are experienced due to the tilt of the boxes at one end of the bridge.

(ii) Though single boxes were easily handled, the launching of a string of these large boxes was a difficult and deliberate operation, compared with a string of the small boxes.



1.—Assembling a tank stepping-stone.

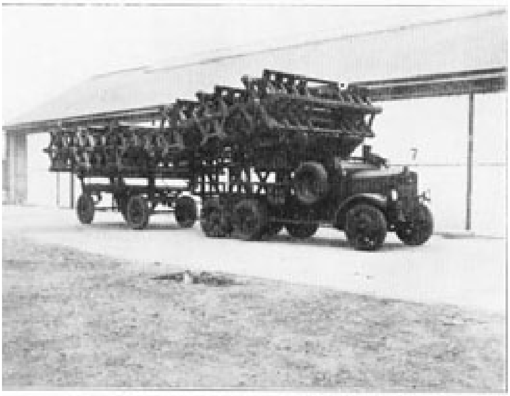
2.—Medium tank on second stone, just about to drop on to third stone. This is considered about the maximum amount of drop advisable when a large number of tanks have to cross.

3.—Showing stones after several tanks have crossed.

Tank stepping stone 1-3

4.—Medium tank on second and third stones.

5.—Tank climbing up last three stones.



6.—Pontoon lorry and trailer carrying six stones.

Tank stepping stone 4-6

HEXAGONAL TYPE.

In 1934 Colonel Martel designed an hexagonal type of stepping-stone, 4 ft. 2 in. high and 12 ft. wide, as shown in Plate No. 1. This has the advantage that, being hexagonal, it is both stronger and can be rolled about more easily than the square boxes, but the disadvantage of being very much heavier. The weight of one of these stones as now designed is 1,160 lb. It is built entirely of 3-in. unselected deal, except the transoms, which are 4-in. by 4-in. pitch pine, and various stock sizes of G.I. piping and mild steel sheets. The time required to make a stone depends mainly on the organization and equipment of the workshop. A well-equipped workshop, properly organized, should be capable of turning out these stones at the rate of one every four hours, once production has begun. The work of construction requires about 50 per cent. of skilled labour.

If required to save space in transit, this type of stone can easily be dismantled and reassembled. A party of one N.C.O. and eight sappers is suitable for building up a stone from its component parts. Untrained men can assemble a new stone in 20 to 30 minutes, with the centre-section already erected; with very little practice this time could be reduced. (Photograph No. 1 shows the assembly party at work.)

A pontoon lorry and trailer will carry six stones loaded transversely, as illustrated in Photograph No. 6. The stones are very quickly unloaded from this position by rolling them off the ends of the lorry or trailer. This is the most suitable method of transport across open country, but is not suitable for narrow lanes, etc., as the width is 12 ft. To carry the stones along roads they must either be in pieces or carried longitudinally on a lorry. A 30-cwt. lorry can carry :—

(*a*) 3 stones completely in pieces, or
(*b*) 2 stones with the centre positions only assembled, or
(*c*) 1 assembled stone longitudinally.

It should be practical to carry an assembled stone on a 15-cwt. Morris truck, longitudinally.

TRIALS OF HEXAGONAL STONES.

In 1936 the 23rd and 38th Field Companies carried out trials of hexagonal stones at Aldershot in connection with the 2nd Battalion, R.T.C.

Preliminary tests with a medium tank across a dry gap indicated that the stones might be safely spaced at 7 ft. 6 in., centre to centre, in the middle of the gap, and that slightly closer spacing was required for the shore bays. Also that there is a tendency for the stone to be rolled through one-sixth of a revolution as the tank approaches it; this is prevented by connecting the stones together and anchoring them to the banks by a ¼-in. galvanized iron chain. Once the stone is carrying any weight there is no tendency for it to move, unless the tank has to climb off it on to the next stone or the far bank.

On the 16th of October, 1936, a test to determine how many tanks a set of these stones would carry over a wet gap was conducted.

A crossing over the Basingstoke Canal was reconnoitred and selected, with good approaches and a straight run on and off. The width of the gap was 46 ft. The maximum depth of the water was 3 ft. 6 in. The bottom was muddy.

First the gap was bridged with seven stones, over which two tanks crossed. But it was found that this arrangement gave too big a drop on to the second stone and from the last stone to the bank. So one stone was removed; two more tanks crossed. The drop on to the second stone was still excessive, so the first stone was replaced by spiked balks 2 ft. 5 in. high. This prevented the drop on to the second stone.

Twenty-five medium tanks crossed the stones. The only difficulty experienced was the breaking of the chain securing the last stone to the far bank. This was overcome by inserting a pile of sleepers between the last stone and the far bank.

The only damage done to the stones was, when the sixteenth tank had crossed, one of the upper transoms of the third stone broke between two spokes due to the impact of the tanks dropping on to it. The transom broke more and more as each successive tank crossed it, until about the twenty-second, when it disappeared completely. Nevertheless, three more tanks crossed on the remaining two adjacent transoms quite successfully.

It would appear that a smaller stone, about 2 ft. 6 in. high, is required for use at each end of the gap of this nature. In this particular instance four such stones could have been used.

Owing to the extreme shortage of men, no trials could be made to determine the best method of launching the stones or the time required. It was, however, found practical to launch three stones at a time and it should be possible to increase this number appreciably with a reasonable number of men.

CONCLUSION.

All the stones, except the third one with the broken transom, were in very fair condition at the end of the trial. Even the third stone would have carried a few more tanks as it was. So it may be assured that these stones are capable of carrying all the medium tanks of a battalion. They could also be used for light tanks, provided that they are arranged so that no gap exceeds five feet, and probably any tracked vehicle, with a length of track resting on the ground of more than three feet and a total weight not exceeding 14 tons.

Provided that the two uppermost transoms are horizontal or nearly so, the tank balances on each stone as it crosses, and drops gently on to the next. The maximum safe drop, in the writer's opinion, is about that shown in Photograph No. 2.

In the past, the stepping-stones have been placed in a few minutes to make a crossing place, whereas bridging equipment would have taken over an hour. The weight of a stepping-stone crossing is between one-third and one-half of a proper bridge. Furthermore, stepping-stone crossings could be tried in many more places than regular bridging operations.

So there would appear to be distinct possibilities for the use of stepping-stones, both as an expedient and as an assault bridge for medium and "I" tanks across a shallow water gap.

A RAFTING EXPEDIENT.

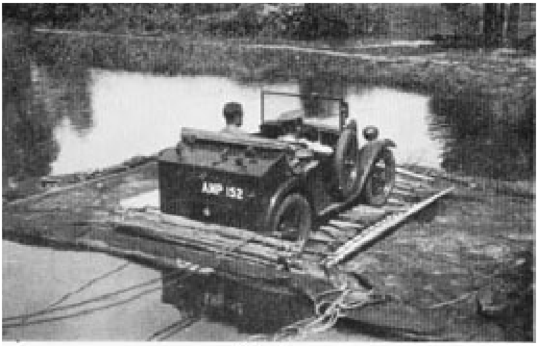
By MAJOR H. T. S. KING, R.E.

THE recent issue of the new *M.E.*, Vol. II, with its chapter on "Improvised Floating Bridges and Rafts," brings to the surface a type of problem which we are very apt to neglect in these days of "Meccano" bridging, and it may therefore be opportune to give some account of a rafting expedient tried out this year by the 23rd Field Company, Royal Engineers, at Aldershot.

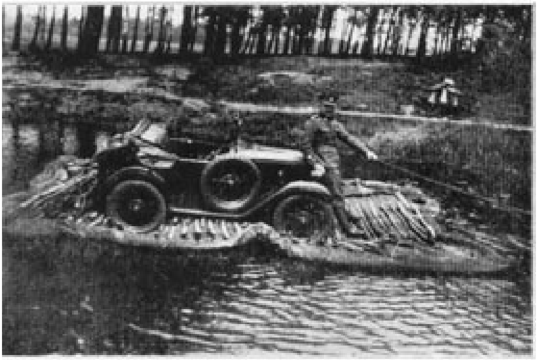
The expedient, referred to in Vol. II, of wrapping a light car in a tarpaulin, led to an examination of the possibility of running the car into its envelope on the water, and so saving carrying. To simplify running the Austin into the tarpaulin it was decided to lay a 6-ft. chestnut paling mat, and it was then found that, if the tarpaulin was prevented from flowing in over the edges of the mat, the weight of the Austin could be carried with a submersion of only a few inches.

The object now was to provide neither an envelope nor a boat, but a mat on which a vehicle could be towed across a stream. A tarpaulin was to form the waterproof skin, and something was required to keep the edges above water. After various trials a light, springy, brushwood roll was selected as the best expedient for the purpose. (It was a cardinal principle that there should always be so much slack tarpaulin to spare all round the mat that no submerging strain could be conveyed to the buoyant edging, whose function was merely to keep the edge of the tarpaulin above water, rising and falling with any "lop," and thus giving a high effective freeboard.)

To spread the load it was necessary to provide a mat which would not snap, and whose edges would come above water-level all round, so that there should be no tendency for the tarpaulin to flow in over them. Chestnut paling (6-ft. width) was selected as the most suitable article available, and three methods of bringing the sides of the mat above water-level were tested. In the first place a 9-ft. sheet of 22-gauge C.G.I. was laid under each edge of the paling. This is shown in Photograph No. 1. Secondly, a strip of 3-ft. chestnut paling was laid under each side of the main mat. This is shown in Photograph No. 2. Thirdly, a "V"-ed mat was provided by running out two 6-ft. widths of chestnut paling side by side. At this stage also some longitudinal stiffness was provided by laying 9 in. x 1 in. x 9 ft. boards under the wheels of the Austin. This is shown in



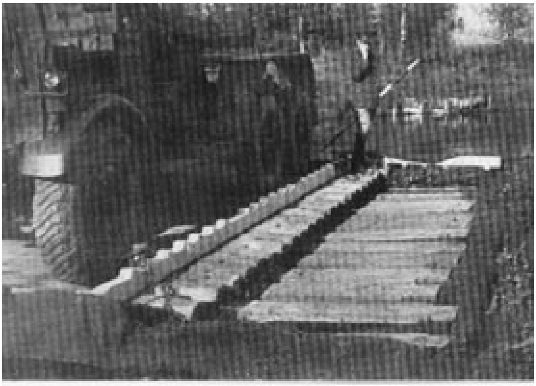
No. 1.



No. 2.

No. 3.

A rafting expedient 1 - 3



No. 4.

No. 5.

No. 6.

A rafting expedient 4-6

Photograph No. 3. In each case the paling used as an approach to the raft is seen rolled up behind the car and there should, of course, be a similar roll in front for off-loading on the far bank.

Given a reasonable slope into the water this raft could be very simply and quickly loaded, it merely being necessary to pull the edge of the tarpaulin on to dry ground and roll out the spare chestnut paling. The slowest part of preparation was the cutting and tying-in of the brushwood. Apart from this the whole preparation was only a matter of two or three minutes, the paling being rolled out as soon as the tarpaulin was launched.

It was realized that no raft that will not take infantry first-line transport could be of much value, and the empty 15-cwt. truck weighs nearly 2 tons, about four times the weight of the Austin. There was insufficient time this season to carry out trials to determine the lightest and simplest materials and designs for a raft on these lines to carry loads up to 3 tons, but in order to demonstrate the feasibility and suitability of such rafts for heavier loads, it was decided to make up a shallow raft, however clumsy and inefficient, and Photographs Nos. 4 and 6 show the general arrangement adopted.

A 30 ft. x 30 ft. tarpaulin in really good condition was requested urgently from Ordnance and, thanks to the good offices of the various channels concerned, we received almost immediately an article which turned out on site to be roughly 24 ft. square and very far from waterproofable, even by soaking, for which there was no time. In the event, however, this tarpaulin served its purpose admirably and demonstrated one advantage of the very low water-pressure on the skin of a shallow raft.

Owing to the smallness of the tarpaulin it was not possible to provide the loose floating edge on the ends of the raft, as will be seen in the photographs, the tarpaulin having to be pulled up over a riband on the decking.

In the place of chestnut paling for the mat, F.B.E. chesses were laid, overlapping at the centre sufficiently for a lashing to be laced through the holes near the chess-ends, and at either end of the row was laid a pontoon equipment stiffening chess.

To provide longitudinal stiffness to the raft, two pontoon road-bearers were laid in the outside slots at either end of the stiffening chesses.

The raft was then completed (most uneconomically but simply) by decking down with pontoon equipment on top of the road-bearers. The general arrangement can be seen in Photograph No. 4.

This clumsy decking, with an abrupt end some 12 in. high, necessitated a low ramp for loading (Photograph No. 6) after the end of the mat was grounded.

The vehicle loaded on to the raft was an unloaded pontoon lorry weighing 4½ tons, and all the men available (12) made an adjustable load of rather more than ¾-ton. In order to test the stability of the raft under eccentric loading, the party was lined up along one extreme edge (Photograph No. 5) and no visible tilt resulted.

The tarpaulin let in very little water in spite of its condition, and there was in any case enough surplus buoyancy to accommodate a very considerable quantity without danger.

If such a raft is overloaded, so that the edge of the mat is forced down below water-level, the tarpaulin starts to flow in over the latter and this if not restrained will soon destroy first stability and then buoyancy ; it can, however, easily be held back (in the early stages at any rate) until the overload is removed.

There are many possible varieties of this type of raft, both for improvisation and possibly for equipment, and there was insufficient opportunity this year to experiment beyond the stage described, but, if others will think it worth while to carry out further trials on their own lines and under varying conditions, it is possible that something of real value may be evolved.

In this connection there seems also to be scope for trials in the use of explosives in breaking down high banks to form approaches and so save many man-hours. The camouflet method should be suitable for large excavations, and small charges dropped down pipes should in themselves be sufficient for most cases, without the intermediate stage of forming a camouflet.

FROM KARACHI TO ADEN UNDER SAIL.

By Lieutenant. T. M. T. Bostock, R.E.

"All in a hot and copper sky
The bloody sun at noon
Right up above the mast did stand
So did the bloody moon."
"The Ancient Mariner," as far as I remember.

A good furlough, to both of us, was measured by the amount of time spent afloat in a sailing-boat. It seemed, therefore, on the face of it, a waste of time and fair yachting weather to spend six days in a B.I. or P. & O. getting from Karachi to Aden, with the N.E. monsoon blowing a steady force four across the Arabian Sea. So, as soon as we were posted to India, we started hatching a variety of schemes.

Early ideas proceeded on ambitious lines. We fondly imagined four or five enthusiasts investing their capital in a country-built yacht, to be sailed the whole way home, when by some miracle the four or five would all get their furlough simultaneously. The prospect of thrashing through Cowes Anchorage in a high-pooped lateen-rigged dhow, possibly flying the skull and crossbones, had a certain appeal. Alas, when it came to the point, only two were left—Teddy Parker and myself—and, neither of us being overstrong financially, it was necessary to seek another solution.

The next scheme that presented itself was to buy or hire a large dhow, sail it home, fill it full of Birmingham made "eastern curios," and sell them to trippers off Brighton pier, thus recouping our losses. This wild flight of fancy was strangled by lack of immediately available funds.

Eventually it was decided to meet in Karachi about the middle of March and see what would turn up: so we parked ourselves on John Cameron and the hospitable Baluch mess, and started to "explore every avenue."

The chief organizer was Haroun, the *bunder* boatman, a pleasant fellow, who produced fishermen and dhow skippers, Indian and Arab, one after the other, as quickly as each proposition broke down—which it did mainly on the score of expense. True, there was a cheap passage to Basra, in a well fitted-out 100-ton *bagalah*; but there was not a single available inch of deck space free of cargo (which smelt abominably) and the skipper and crew of twenty (no less) Arabs were the crookedest crowd of toughs I have yet seen. Then again, a passage to Zanzibar in a similar craft had to be turned down, since it would take so long to get away from there. In the end we decided on a charter, which would leave us masters of the ship, free to choose our crew, and to lay our course where we would. Naturally, with limited cash, it had to be rather a lowly craft: but the weather was settled for at least a month, we hoped, and after all one sails about wilder European waters in smaller boats and enjoys it.

After a few preliminary trials and their attendant errors, a Catchi fishing-boat, 35 ft. on the water-line, ketch rigged, with shallow draught, a square stem and rather sweet lines was selected. She had no deck, and it was obviously not the slightest use trying to put one on. We went over the gear piecemeal and stipulated that it should all be renewed. A ½-inch plank 9 inches deep was built on all round as a gunwale, leaving a space at the bows clear for working the giant *purman* or light-weather-yard. The gaps between this and the rail were tacked over with *chitai* matting, made of palm leaves. Three new sails, a jib, a storm mainsail and a mizzen were pegged out on the sand of Bhitt Island, and stitched up before our eyes. An enormous new *purman*, with a gigantic light-weather sail attached, was produced from another boat. This yard must have been 60 feet long, no mean hoist for a boat 42 feet over all. Water tanks, to a total capacity of 280 gallons, were installed, charts and rations bought, meteorological records consulted for prevailing winds, an automatic pistol (precaution against pirates) borrowed from John Cameron, floorboards were nailed down over the naked bilges and we began to be nearly ready to start.

Our crew consisted of three Catchmandi fishermen and the *mallum* or mate; it was a democratic company, and the taking of any action involved the hearing of at least four sides of the argument. The three sailors were; Haji Ismail Jacob, the owner of the vessel, who had been to Mecca, and had a face, if you can imagine it, rather like a faithful gorilla's. He worked harder than anyone else on board, and was aged about fifty. Next was his brother, another Haji, Mahomed Ali by name, whose original occupation was that of deep-water diver. While working on the foundations of the Chenab bridge, he had been paralysed from the waist downwards, and was only capable of steering. I was going to add cooking, but this would have been misleading. The third was Old Ali. The others explained him by saying he was so old as to be past caring. He spent most of the time like a tortoise on the foredeck, scarcely speaking a word. His chief accomplishment was the tying of *pagris*, in the Catchmandi style, but even these usually fell off.

The *mallum* was the navigator who was to take the vessel back to Karachi. He possessed a pocket sextant and a two-year-old nautical almanac, together with a set of traverse tables. He was a Catchmandi-Arab cross-breed, about 30 years old or less, of a hideous cast of countenance and quite devoid of the ordinary natural manners of the poor Indian. He could manipulate his sextant and read the vernier with surprising accuracy, but the actual latitudes he produced were up to 15 miles wrong, since he normally used a two-year-old nautical almanack, and there was also, as we discovered later, an 8-foot error in the mechanism of the sextant. Naturally, the actual additions and subtractions involved even in a simple noonday sun observation were complete mumbo-jumbo to him, and he omitted also the correction for refraction. He did not know how to use a chronometer and in any case, we did not carry one. His navigation was by the time-honoured method of setting a course well clear of his objective until he reached its latitude, after which he would sail along this latitude. He also owned a traverse table, from which he used to produce theoretical and completely inaccurate longitudes, but he admitted himself these were of little value as long as the Sahibs would insist on altering course if the wind changed. He made no attempt to keep any form of dead reckoning, and was rather disdainful of doing any work about the boat for the first week at sea, after which he improved a great deal.

The *mallum*, under the terms of our agreement, was responsible for producing the compass. The instrument that actually appeared was a spidery affair without a card, which jammed fast at small angles of heel, and was unanimously condemned by both Sahibs and crew. Strangely enough the utmost difficulty was experienced in obtaining another one, though we combed the bazaars of Karachi from the city to the docks. A typical interview with the usual Parsi shopkeepers ran rather like this :

" We want a boat's compass."

" Yes, of course, Sahib ; bring the compasses here, boy ; Rs. 3, Sahib."

" Not a pair of dividers, a *compass* : a compass for a ship : a *kamán*——."

" Yes, of course, Sahib, I know what you want : boy, bring that commode here. . . ."

Eventually we ran one to earth in a watchmaker's shop. The card could not be described as being geometrically accurate, but the north point always seemed to point in the same direction. A slight error in the painting-on of the lubber line was corrected by siting the compass box at an angle to the centre line of the ship.

We bought also a complete set of large-scale charts of the Persian, Arabian and African coasts as far as Aden, including Socotra, to which island we intended to pay a visit.

The M.E.S. Karachi very kindly provided us with some condemned colas barrels and one or two old G.I. tanks for our water, and in addition to these we hired a huge iron boiler of about 180 gallons capacity, from the inhabitants of Bhitt Island. The M.E.S. also made us an excellent chart table.

During these preparations, we were careful to inspect progress in the work on the boat every day. Teddy became expert in detecting soft patches with a penknife, which were skilfully patched by Ibrahim, the carpenter, on the spot. A new rudder and tiller were carved out. They were attached to the stern post, to our amazement, with three lashings of string. A queer compound of fats, which we were assured was a good anti-fouling mixture, was smeared on the bottom, and we painted the name " Salamat Sawai " (freely translated " Safety Last " ?) on the counter, where it was later unfortunately totally obscured by the thunder box.

The day appointed for the start arrived, and, though everything was slightly behindhand, as usual, we were actually ready to sail in the afternoon. We had crossed the harbour in order to borrow a harbour plan whereby we sought to check the compass, when we were handed a telegram from Poona Meteorological Office, forwarded by the Port Trust Authorities. This predicted rough weather and strong winds " extending to Sind coasts " and was accompanied by the advice of the Port Trust officers not to sail. Now at first our course as planned lay south, and a westerly gale would have brought the Catchmandhui shoals unpleasantly close under our lee ; so that all things considered, we decided to wait until the morrow, and contented ourselves with a practice sail just outside the harbour. We found the boat easy on the helm and generally more seaworthy than her appearance had at first suggested. Some minor faults in stowing rations and kits were rectified, and the lids of all the water tanks were packed up more tightly, as the water showed a regrettable tendency to spill out of the top.

The next day, Thursday, the 26th of March, we again crossed to Manora and borrowed a harbour plan from the Chief Pilot, who was also good enough to provide us with a tin-lined box for the " navigational instruments " and books, and a tarpaulin, which came in very useful later as an awning. We let the boat drift out into the stream at the end of our anchor warp, and checked the compass on several bearings, for different attitudes of the ship. Rather to our surprise, no error was apparent. Nothing now remained to be done, and we let go our warp for Socotra, about 1,100 miles distant to the S.W.

A note as to our course may be of interest. The final objective was Aden. A glance at the chart of winds and currents in the Arabian Sea during April (Plate 1), shows a clockwise circular tendency on the part of both, the tail of the N.E. monsoon prevailing as a N. and N.W. wind on the Indian side, and the beginnings of the

S.W. monsoon pushing up S.E., S. and S.W. on the African side. This disposition of the winds prevented our coasting along the Makran and Arabian coasts, probably the most interesting procedure and certainly the easiest from the navigational point of view. This theory, it is worth noting, was also held by the crew, who had, of course, consulted the weather experts among the trading dhow skippers in the port. We therefore decided to start in a southerly direction, changing slowly to westerly as we approached Socotra on a wide curve. The winds as it turned out were very much as

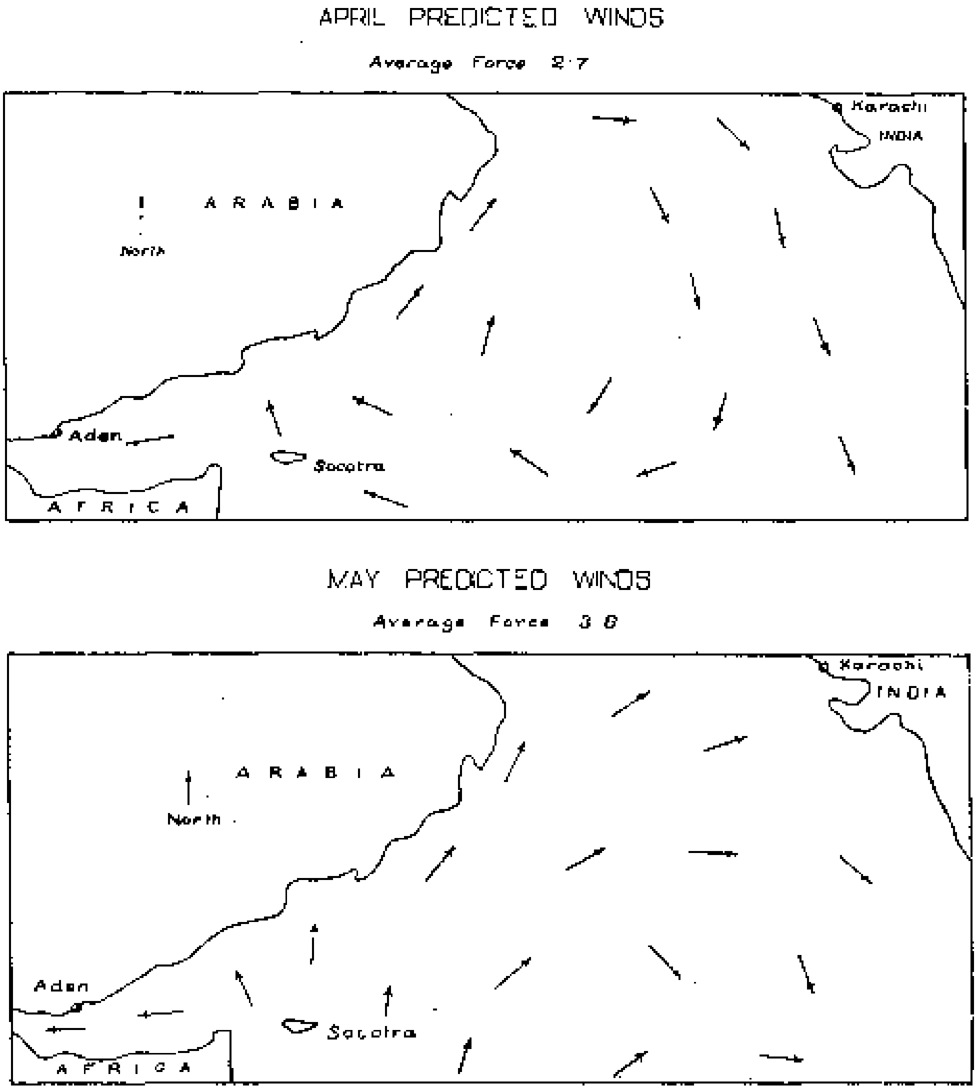


Plate 1.

predicted, except for three days of S.S.W. wind, which was responsible for the kink in our track chart shown in Plate 3.

The first day was not a happy one as far as I was concerned, as I had suffered both T.B. inoculation and vaccination two days previously. A slight fever combined with a lumpy sea over the surroundings as far as the Bunder Lightship were in the process of reacting unfavourably on my by no means cast-iron stomach, when the cook produced his first meal. I will "spare the reader" an intimate description of this, except that it consisted of rice and old, old fish curried up together, and was literally the most astoundingly horrible form of food I have ever seen. I crammed back a few mouthfuls and quickly evacuated them, though Teddy managed to keep his under control. Even the crew complained, and Haji Ismail, the cook, was forced to admit being a bit out of practice. Henceforth the rule was made that no fish, unless freshly caught, was to be put in the Sahibs' curry. Unfortunately the crew had bought 20 seers of dried fish and were loath to forgo it themselves: as a result all our food cooked in the crew's pots tasted slightly of this abominable stuff. The dried fish was kept in a basket for'ard, and one look at it was enough to make the most hardened shudder. It had the appearance of having been squashed out, head and all, by a very dirty steam roller.

It may as well be confessed at the outset that the food was our greatest mistake. After a certain experience of "native food" (while out on Shikar)—which most people will agree is usually fairly reasonable—we had decided not to complicate the cooking with too much European food, and had only brought enough tinned stuff to provide one "titbit" a day between us. Well, we tried hard to get used to the sailors' food, but had to admit ourselves defeated in the end; the dirt in which it was prepared had to be seen to be believed, and the taste was always the same—just red-hot curry powder.

We soon settled down to a routine, and the ship sailed on, reeling off 100 miles a day on an average, and even achieving 120 once. At night we set three watches at first, consisting of Teddy, the *mallum* and myself, with one hand each. Later, we found that Mahomed Ali could steer by compass, and that it was unnecessary to have more than one man awake at a time; for if any sail had to be changed, the whole crew had to be roused in any case, and often for days on end the same sails remained set on the same tack, without more than slight adjustment.

Naturally, we had no patent log. We prepared a kind of log line in the time-honoured style, consisting of a plank on the end of a line with a tripping device to allow it to be drawn in, and with knots at appropriate intervals on the line. It was not very satisfactory, as an enormous quantity of line was required to obtain an accurate reading, and it was such a bother to perform the whole operation. We tried it once or twice, and these attempts formed a basis on which we judged our speed; which speed was entered hourly in the log to give us our D.R. Eventually this plan was superseded by the "Bromo-Parker" method, a simple and accurate scheme; the apparatus consisted of a fishing line 60·8 feet long and a small ball of paper which was dropped over the stem and timed as it passed the bait. A table of seconds corresponding to knots was drawn up, and our speed could easily be checked at any time. Considering how crude it was, our D.R. was to prove surprisingly accurate.

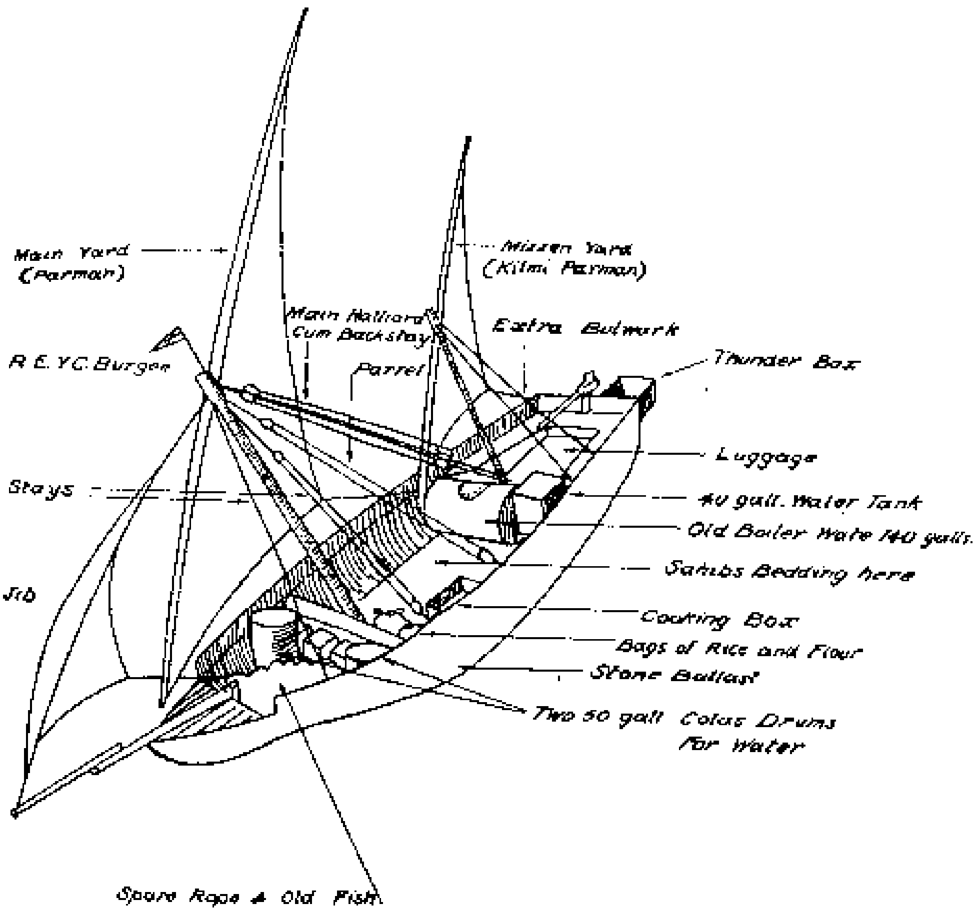
The D.R. was checked every 24 hours by the noonday sight of the sun, which gave us our latitude. This was performed alternately by the *mallum* and Teddy, who were the most accustomed to handling a sextant. The *mallum's* readings were generally accurate, but his calculations were frequently at fault. We made our own calculations—not that they were very complicated in this case—and plotted our position religiously each day at noon.

As long as we were sailing between S. and S.W. we were reasonably sure of our position, since the course cut the latitude at a broad angle; but when we turned westerly we had to rely entirely on the D.R. for our longitude, and this was of frightfully problematical accuracy.

We kept one or two fishing lines over the stern, each provided with a hook of stupendous proportions, on to which was tied a nice smelly piece of old fish. Personally, we thought it would have to be a pretty tough fish to approach within fifty yards of this bait, but it must be recorded that we caught one fine sea-marhi, 4 feet 9 inches long and weighing rather over 100 pounds. The boat was sailing 5 knots at the time and it made no fight, but was dragged in along the surface, seemingly unable to get under water. This was the only fish caught between Karachi and Socotra.

Until the end of March, that is to say for the first five days, the wind blew fairly steadily W. and N.W., so that we made good speed with the little *parman*, or storm sail-yard, together with the jib and mizzen. On the second day, sailing in a light breeze there was a loud crack for'ard, and the bowsprit broke off at the roots. Teddy and I started up in panic, not used to this kind of disaster; not so the crew, who continued calmly to eat their curry. Eventually Ismail rose to his feet, muttering "It was a bad piece of wood, anyhow," and picked the trailing spar out of the water, in which it was dragging at the end of the sail. Pushing it out to its original position he fastened it to the old part with a piece of string, and the voyage continued.

It may be remarked here that the entire boat was held together by string. Cleats were not used for making fast ropes, but instead the running end was passed through a hole in the side of the ship, and a running hitch made to the standing part of the tackle, the whole being moused with string. This procedure held good even for ropes like the main-halliard or main-sheet ; as a result it was impossible to let go anything quickly. The bottom of the boat was full of



FISHING BOAT "SALAMAT 'SAWAI"

Plate 2.

little pieces of string which you picked up at random and tied things up with. We estimated there was enough string aboard to reach from Karachi to Aden.

Another procedure unorthodox to the normal yachtsman was the method of altering the lead of a sheet. If you didn't like the position of the lead, you took a chisel—or possibly the rusty hatchet—and made a different hole in the side of the ship. It was all *barabar*, as the crew would say: there was a general atmosphere of "Who cares, anyhow?"

We sailed on. The wind became fluky, and finally dreadful periods of flat calms ensued. As long as there was a breeze, however light, the temperature was quite reasonable, but in a calm it certainly stoked up. We hung blankets, sails and tarpaulins all over the rigging as awnings, and lay flat on our backs wearing only towels, until we were as black as the crew. Occasionally we read the "Ancient Mariner" to each other; Coleridge's opium-fevered imagination could be remarkably accurate we decided. Sometimes a groan of "ALLah" would come from one of the crew. At first this used to cause us some alarm, it was emitted with such emphasis; but later we found it was only their method of yawning.

As we approached the steamer track, a sharp look-out was kept for smoke on the horizon. To our great excitement it appeared one day, and what looked like a City liner, probably the *City of Simla*, which had left Karachi for Bombay and England a few days after us, passed hull down, about seven miles away. We were a little worried as our latitude seemed to be about 15 miles out, until we remembered that the steamer would probably be on the Bombay-Aden great circle, not the rhumb-line course. By a terrific exercise of mathematical ingenuity and much delving into the mysteries of spherical triangles, we succeeded in plotting the great circle, with the aid of Aquino; and the position of the steamer lay on it exactly. A tremendous feeling of confidence now set in as regards our navigation—a feeling not shared by the crew, who decided our position was at least 200 miles farther east than we thought.

The calms did not usually last more than 12 hours, though one ghastly day we only scored 19 miles for the day's run. In between we got quite reasonable winds, so much so that after a short time the parrel tackle pulled a huge piece out of the ship's side. Old Ali, who was nearest, wedged a piece of firewood into the hole, and thus it stayed until the end of the voyage.

One morning I was sleeping in the bottom of the ship when I was awakened by a great commotion and saw, to my horror, a blue shark about 4 feet long impaled on a sort of harpoon, writhing about three feet from my head. The crew were wild with excitement, and we had shark curry for breakfast. I personally managed to eat a certain amount, but Teddy for once was not hungry, though he ate a little; he had caught a grisly glimpse of the *mallum* preparing the meal, kneading unmentionable pieces of shark in his grimy hands.

After this we were followed for a long time by two much larger sharks, who would rub along the bottom of the boat in a hungry way, a moody expression on their beastly faces. I tried to shoot one with John's automatic, but something was wrong with the striker and the cartridge case wasn't dented. The sharks were about 8 feet long each, and one carried a baby on its fin. They were preceded by the usual striped pilot fish and came quite close enough to be touched by the hand. The crew told fearful stories of how men had been knocked into the water off the edges of boats by the more cunning sharks, which used their tails for this purpose.

One day, in a calm, we were surrounded by literally hundreds of porpoises, which remained blowing and snorting for three or four hours with us. The sea was simply black with them, and you could have touched them as they rose under the bows. Sometimes they jumped clean out of the water, sometimes they reared up their snouts and sank back on to their tails giving contemptuous snorts.

One night, Teddy was unrolling his bedding in the waist of the boat, preparatory to sleeping, when something hard and cold and slimy, travelling at great speed, hit him in the eye. He picked the flying fish off the floor in a rage and threw it at me, who was sitting at the helm. It bounced on my knee, and recovering its senses, gathered flying speed again and disappeared overboard. The incident recalled books on former ocean passages that we had read; for some unknown reason all flying fish visiting us either hit Teddy or fell on his bedding. They were used as bait for our fishing lines.

Another strange fish often seen we christened the Great Leaping Fish. It was about 4 or 5 feet long and jumped not less than 15 feet into the air. Small Leaping Fish appeared in great numbers on calm days close to the boat; these were only a foot or two long, but we could never catch one.

About 300 miles from Socotra we met a S.W. wind and had to lay a course towards the Arabian Coast. This caused a mild panic as we feared it might be the beginning of the monsoon. If it had been we should probably have had to run back to Muscat; however, after three days the wind went back to S.E. and we turned towards Socotra again. We had recrossed the steamer track and again saw a steamer a long way off, this time the eastbound P. & O.

Calms and light airs now prevailed, and it definitely began to be rather hot. A horrible smell of sulphuretted hydrogen began to make itself noticed, and was traced to the bilges. We took up the floorboards, baled the ship dry and splashed the bilges with strong "pinkie." It had no noticeable effect, and we had to complete the voyage smelling like a gas works.

It is strange that the bilges went bad on us, for there was a big leak present, and the ship had to be baled out every three or four hours. Teddy and I used to take this job on occasionally, so as to get some exercise. One of us used to squat in the bottom of the boat with a small can, with which he filled a bucket: the other threw the contents of the bucket violently overboard or, more frequently, into the sail. On a hot day, it was certainly good for the stomach muscles.

Another form of exercise which promised well at first was climbing the mainmast. Unfortunately the ropes were brand new and very rough, and our feet were cut to ribbons the first time we tried it. After a time the heat wore us down and we no longer performed this feat. Ismail used to stagger up occasionally in order to reeve the jib-halliard, a process necessary every time we went about. Otherwise we remained mostly in a state of coma.

At last the time came when we should have sighted Socotra. It was a flat calm day, and a cargo steamer had been sighted crossing our stern, bound for the East on the Colombo route. We stared around all day, but though the glare was intense, there was obviously much haze. The crew became very sceptical. At length, as the sun set, a cloud on the western horizon resolved itself into a craggy shape, and our landfall was made. Our estimated position was only 15 miles wrong ; rather lucky considering the methods at our disposal and the fact that we had been three weeks out of sight of land, having covered about 1,200 miles.

We continued drifting during the night ; but a breeze from the S.E. arrived about three o'clock in the morning, which freshened rapidly to about force 6. As dawn broke we passed the low and dangerous eastern headland, Ras Radressa, at about 7–8 knots, since we had our huge light-weather sail up, and couldn't do anything about changing it. Not having seen land for so long, it was impossible to estimate our distance from it, especially as the coast consists of enormous cliffs up to 2,000 feet high. The " Gulf of Aden Pilot " describes the detail of the coast, but only as seen while approaching from a westerly direction, and it was very difficult to check up on the various " Rases " (or capes) which were flashing by at high speed. The wind backed to the east, and a fair-sized sea was just getting up, much to the alarm of all (for we were grossly over-canvassed) when suddenly the wind fell to a flat calm as if turned off by a tap, and then commenced to blow lightly from the west. Since it was no use beating to windward with our lateen sails, we ran into a small bay and anchored 100 yards from the shore. It was rather a pleasant feeling to be hooked on again after three weeks in an average depth of 2,000 fathoms. Some rough piles of stones were visible on the shore which we assumed to be huts, since human figures were visible around them.

Presently a narrow dug-out canoe put off, piloted by a naked savage and a small boy, both of incredibly primitive appearance. Talking by signs we persuaded him to ferry us ashore, an extraordinarily tricky business for those not accustomed to dug-outs. We were led up to a circle of strange creatures, who proceeded to offer us cinchona bark tea. This we made a show of drinking for politeness' sake. The backward appearance of these natives can be estimated by the fact that we were constantly expecting them to drop on all fours. They are an ancient mixture of Portuguese, Arab and Somali, and of repulsive and emaciated aspect: this is hardly surprising as they live almost entirely on fish.

Teddy and I went for a walk up a small stony hill behind the huts. It felt very much like climbing at high altitudes when not acclimatized; since our leg muscles had atrophied in the confined spaces aboard the *Salamat Sawai*. We came back through a neglected date grove, and passed caves where hundreds of birds had built their nests without fear, apparently, of disturbance, for all the nests were in the open. When we were eventually ferried back to the dhow, the wind still blew from the west, so we slept till next morning, the first undisturbed night for a long time.

A light off-shore breeze took us into Tamrida Bay, where lies the village which is the capital of Socotra. As we entered the bay swarms of dug-outs came alongside, and our crew, whom we had hitherto considered as the most poor and wretched creatures we had yet encountered, assumed a lordly air, and distributed rice and old clothes to the natives in the manner of rajahs. Altogether our entry resembled more that of a P. & O. than a fishing-boat. Teddy and I, with the *mallum* and Ismail, were taken ashore, leaving the old men in the boat. We sent our salaams to the Rajah of Socotra, adding a card as an afterthought which might impress him. It must be admitted that the inhabitants hitherto had exhibited more curiosity than awe at our appearance; hardly surprising, considering our black beards and unwashed clothes.

We inspected the town which is about the size and status of a small Punjab village, but somewhat more clean (or had we forgotten all our previous standards ?). A sheep and twelve eggs were purchased for rather excessive prices and after much haggling, also some Dragon's Blood, which sounds dangerous stuff, but is actually the product of a tree, and is used as a foundation for boot polishes.

Eventually we were taken back to the dhow in the usual one-passenger dug-outs, Teddy having a particularly exciting passage struggling with the live sheep.

We sailed off with a light head wind, and beat all night and the next day along the coast. When we reached Ras Shoab, the western point of the island, a violent southerly cross swell was encountered, which threw the boat about considerably for some hours. Then a good breeze arrived from the south and we sailed on for two days with the wind on the quarter, setting our course for Makalla, the capital town and harbour of the Hadramaut, 200 miles distant. By now our bottom was very foul, being covered with long, stiff weeds; for this reason our daily runs were only about 90 miles, even with the most favourable wind possible, and in light airs our speed was negligible. Scrubbing was not possible for fear of sharks.

In Makalla Bay the April wind charts showed the southerly winds of the initial monsoon spreading east and west against the Arabian coast. We hoped to catch the easterlies, and were successful in so far as there was any wind at all; but we spent the first three days hardly moving in a fairly dense fog, which lifted slightly morning and evening to disclose a craggy and mountainous coastline. Occasionally steamers would pass quite close, but our latitude readings disagreed so violently with our D.R's that we supposed we were the playthings of extremely strong currents.

One evening, after staring for a long time into the sunset, trying to identify the peaks, I began to feel a headache, which I attributed to sunstroke; but on reconsideration I now think it was something in our diet which had disagreed with me. In any case, I decided to omit Makalla and make all speed for Aden, now 250 miles away; which proved a fortunate decision, for I had an acute attack of jaundice.

Eventually the land cleared, and we discovered ourselves fairly close inshore about 15 miles east of the Ras al Kalb or Dog's Head Cape. A fine easterly wind gave us a good run across the Ghubbet Ain (Bay) and we passed two weird volcanic islands, covered with guano, against which the swell broke with great violence.

We came close inshore again near Sheikh Abdur Rahman (an Arab village). At four o'clock in the afternoon the wind fell to zero, and we were drifting past the houses about half a mile from the shore, when a small dug-out appeared ahead. We expected the usual appeal for *baksheesh*, but this time the two paddlers after inspecting us from about 20 yards away, paddled off without so much as a "Salaam Aleik um," laughing at the same time a crude laugh.

At this the crew flew into a panic. "Sahib," cried the *mallum*, "get out your pistol for the love of Allah, for I am certain that we shall be attacked to-night." He then recounted instances of small fishing-boats having been plundered while becalmed off Arab villages, and was so obviously genuinely frightened that I made frantic efforts to repair the hammerless automatic.

I succeeded in producing a small dent in the cartridge case with the aid of a piece of wire, but nothing would make the cap explode. The tide, meanwhile, drifted us farther and farther from the village, and by the time darkness had fallen we were some miles off. A light wind took us well off shore in the night and no attack materialized: I feel doubtful now if it were ever really contemplated, but panic is always catching, and I certainly felt rather uncomfortable.

Alternate winds and calms ensued for the next two days, while we made steadily along a coast of sand, backed with picturesque and wild mountains.

Fish life, as ever, was interesting.

We saw a huge square ray which used to leap high out of the water and land with a tremendous report. For several hours we were followed by a swordfish about 12 feet long; Teddy and I were preparing to harpoon it when the crew begged us to desist: they said this fish, the *gora macchli*, when angered, frequently attacked and sank boats with its long beak. Thoughts of a fencing match with such a beast were rather discouraging, so we abandoned sport on the score of prudence.

Sixty miles from Aden a strong N.E. wind started us off at a cracking pace for our final objective. The direct course for Aden here leaves the coast, which trends away in a deep bay to the northward. Nothing could convince old Ali and the *mallum* that we were still steering towards Aden, and we had to keep a sharp watch on the compass to see they did not commence creeping back towards their beloved land. After six hours, we saw the rocky crags on our bowsprit, and the old men had to admit they were wrong, which they did with an ill grace.

Ras Marshaq was abeam as night fell, and we beat to windward into the harbour through the warships. The ship's bottom was so foul that several attempts were frequently necessary to bring her about. The night rang with cries of "Allah," as the crew worked furiously at the ropes with their little bits of string. Eventually the process became too exhausting and we anchored in what afterwards proved to be the native craft inspection anchorage. As soon as it was light we moved to a berth about ten yards off the steps of Steamer Point, much to the disgust of the Somali policemen on duty, and to the inconvenience of the launches proceeding to and from the liners. However, the manœuvre secured us prompt clearance by the harbour authorities, our chief object, for all the beauty of life was now for us contained in a civilized breakfast and a glass of beer.

Having consumed this, I staggered off to hospital for a week of jaundice, and we both continued our journey by more normal means.

It was on the whole an enjoyable trip, with many days of really good sailing. It is a pity we could not have started a fortnight earlier, for we were badly caught in the calms which always herald the change of monsoons. Otherwise we might have made the passage in a fortnight. Our water supply was ample, but smelt badly at the end of the trip; so did the bilges. Our food, as I have said, was not a success, and I actually lost two stone, through a combination of malnutrition and inactivity. When any wind at all was blowing, it was surprisingly cool; navigation with such limited resources was interesting and exciting, and we gained useful knowledge of the complete inefficiency and danger of the lateen rig, even when well handled. The wild islands and coasts visited provided an unusual experience, and, although most people will disagree, we thought the whole thing a month not wasted.

PROFESSIONAL NOTE.

NOTE ON WINDOW-LEAK SOAKAWAY.

By T. T. B.

THE perpetual trouble which all, or almost all, casement windows give on a full southerly or south-westerly exposure during winter storms of wind and rain, is well known. Even sash frame windows sometimes let the water through. The prevailing storms of rain of hurricane strength force the water through the minutest crevices and pinholes; leaded glass soon leaks, and putty, when it gets hard, begins to do so too. Nevertheless we seem to be committed to the fashion of casement sashes in contemporary domestic architecture.

The water collects on window-sills, and running down the plastered wall spoils the decoration and brings complaints of damp in quarters. A radical cure entails pulling out the window-frames and substituting windows of a different design—itself an expensive and difficult operation while the rooms are occupied. Competitive reduction of building costs has usually prevented the more expensive and water-tight kinds of casement window from being provided in the house when first built; and partly for cheapness, but mostly on grounds of fashion and appearance, sash frame windows have more often been ruled out.

If we admit, then, that storm-driven rain cannot permanently be prevented from coming in, we can at least catch it, when it appears, before harm is done and put it gently but firmly out again.

The accompanying sketches show what has proved an unfailingly successful way in practice. Seamless copper tubing ¼-inch internal diameter, 18 S.W.G. is being used (Vocab. G.2.).

The water is caught in a small trough, as close to as the construction permits and all along the bottom edge of the window. Holes are then drilled (one or more) through the bottom surface of the trough to the outside, slanting steeply downwards. A fine copper pipe, seamless copper tubing which has been bell-mouthed at the upper end, is put down and fixed securely in each hole, so that the bell mouth forms an efficient "waste" in the bottom of the trough. (See Fig. A.) About 9 to 12 inches of pipe is generally a sufficient length, and if the wind, blowing up these empty vents, is an objection, this is prevented by turning up about 2 inches at the lower (outer) end into a "U" tube in which the water will resist the difference between inside and outside air pressures in the pipe. (See Fig. C.) The holes drilled through sills, walls, etc., must be just large enough to take the copper pipe, and allow of it being held in position with a jointing coat of paint.

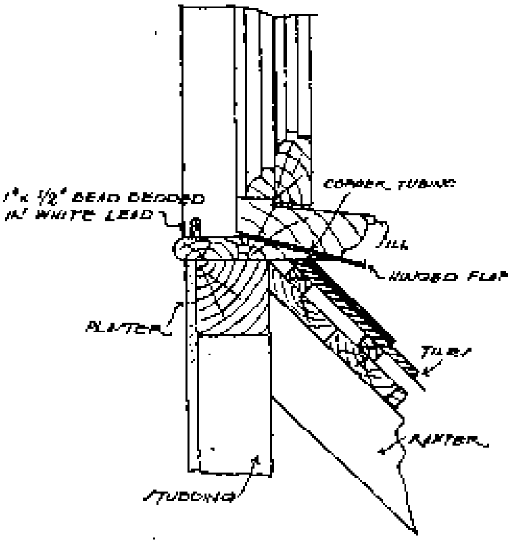
The neater and more inconspicuous the trough is, the more expensive is the fitting likely to be. The job is one for the best handyman of the D.E.L.; for neat appearance and perfect drainage depend on good workmanship in details, and on the ingenuity of the workman.

The copper tubes must be kept open; this can be done in the case of the straighter ones by clearing occasionally with a stiff, steel wire, but with the "U" tubed ends a cycle-pump (with a nozzle to fit into the bell mouth, screwed into the pump in place of the flexible air tube) must be used to blow each pipe periodically clear.

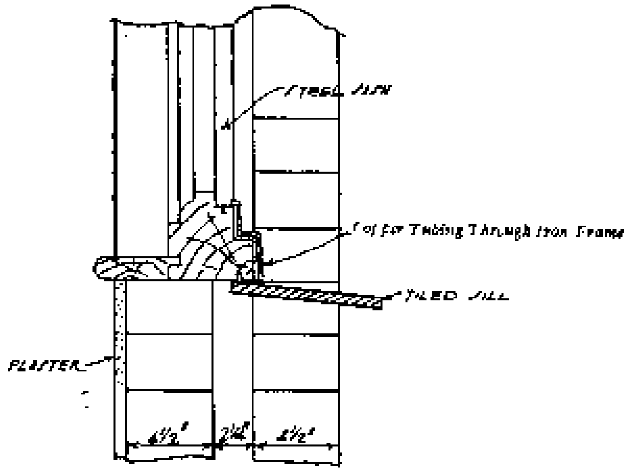
An attempt was made to drain the water out of the lower and shaped member of some cheap iron casement frames by drilling through the ironwork, but for some reason (probably connected with wind pressure, surface tension, and the very shallow trough) it did not prove successful. (See Fig. B.)

The same principle has been most successful in putting out the water, which, in spite of water-bars and complicated drip-bars on the doors, always drives under those outer doors which are exposed to southerly gales of wind and rain: leaks under or around badly-built, badly-bedded window-frames can be more cheaply dealt with on this principle than by taking out the frames.

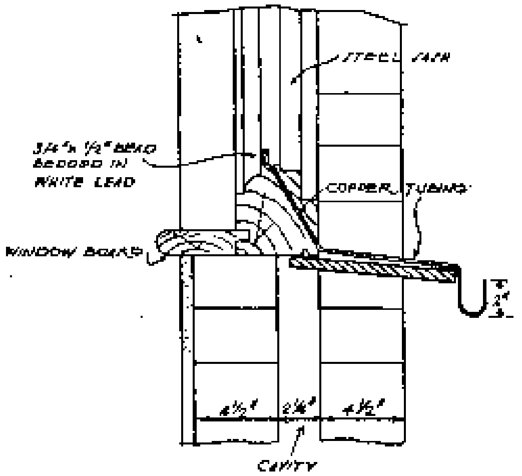
A.


1" x ½" BEAD BEDDED IN WHITE LEAD
COPPER TUBING
SILL
HINGED FLAP
PLASTER
TILES
RAFTER
STUDDING

B.


STEEL SASH
Copper Tubing Through Iron Frame
TILED SILL
PLASTER
4½"
2½"
4½"

C.


STEEL SASH
¾" x ½" BEAD BEDDED IN WHITE LEAD
COPPER TUBING
WINDOW BOARD
4½"
2¼"
4½"
CAVITY

MEMOIR.

MAJOR-GENERAL SIR ANDREW MITCHELL STUART, K.C.M.G., C.B.

SIR ANDREW STUART was the son of Major-General John Ramsay Stuart, C.B., who served in the Crimean War with the Royal Scots Fusiliers and was afterwards the Colonel of the Dorset Regiment. Stuart was born in 1861 and entered the Royal Military Academy from Dulwich College in 1877, passing out second in his batch into the Royal Engineers in 1879. At the conclusion of his course at the S.M.E. he was detailed for the Submarine Mining Service. He did the usual course of instruction on the *Hood* and, after some work with the Submarine Mining Company at Pembroke Dock, he was employed with the General Post Office Telegraphs at New Cross, then the Headquarters of the 2nd Division Telegraph Battalion R.E., and in January, 1884, joined the 1st Division Telegraph Battalion at Aldershot. In September, 1884, the section of the Telegraph Battalion to which he was posted was sent to Egypt with the Nile Expedition of that year. This section first took over a length of 1,130 miles of telegraph line from Cairo to the south, which was in very bad repair, and then had to maintain connection with the advanced base of the column sent to relieve Gordon. Stuart was employed for three years at various stations from Cairo to Korti until he returned home in September, 1887. He was mentioned in dispatches and received the British Medal and clasp and the Khedive's bronze star. For the next two years he was employed on telegraph work at Aldershot, New Cross and Chatham. In September, 1889, he was appointed Assistant Instructor in the Electrical School at the S.M.E., and held that appointment till February, 1894, when he was appointed Inspector of Royal Engineer Stores at Woolwich. This included an *ex-officio* membership of the R.E. Committee (now called the R.E Board). There was at the time a great development of electrical work in the Corps for submarine mining, electric light and telegraph work. The Inspector R.E. Stores was also very often the experimental officer trying out many small details, and as any article was adopted into the Service it was Stuart's job to prepare a specification to govern future supplies. In such work his meticulous attention to details and his sound knowledge as an engineer proved most valuable.

Special mention may be made of the development of the defence electric light plant which accompanied the introduction of the

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internal combustion engine. Stuart designed the Service generator and his pattern was in use 20 years later throughout the Great War, when it stood the strain of four years' continuous running. He was also responsible for the development of the parabola-ellipse reflectors, by which the whole light from a three-foot reflector can be passed through a vertical slit from 6 inches to 18 inches wide. This type had been suggested almost jokingly at a meeting of the R.E. Committee, but Stuart saw the possibility of the suggestion and, discussing details with the manufacturers of reflectors, made the apparent impossibility into a reality.

He was promoted Major in 1898 and, in April, 1899, was appointed Inspector of Submarine Defences in India, and O.C. Indian Submarine Mining Company. This company was divided into four sections in charge of mine defences at Bombay, Calcutta, Karachi and Rangoon. The Headquarters of the I.S.D. was at first at Poona, but there was just beginning a big increase in electrical work in India, partly for electric light in barracks and for punkah pulling, partly for electric lights for defence. Stuart was therefore moved up to Simla, to take charge of the electrical section of the office of the Director-General of Military Works in addition to his other duties. Defence electric lights were installed at the four ports named above and also at Aden and Madras, but the most interesting job carried out by him was the electric lighting of Delhi Fort and the Central Camp at the Coronation Durbar at Delhi, in 1902 and 1903. Stuart designed the scheme and supervised the execution, assisted by an officer and some N.C.O's from the Indian Submarine Mining Company. This involved the installation of 100 arc lamps and 800 incandescent lamps and the erection of a central station of 600-kilowatt capacity.

Returning home in 1904 he served for a year as Division Officer, R.E., at Exeter, and was promoted Lieut.-Colonel in 1905. From October, 1905, to 31st December, 1907, he was the R.E. Member of the Ordnance Committee, and from January, 1908, till placed on half-pay in May, 1910, on completion of five years' service as Lieut.-Colonel, R.E., he was C.R.E. Liverpool, and Commander Mersey Coast Defences, with the local rank of Colonel.

He reached the Brevet rank of Colonel in May, 1908, and the Army rank in September, 1910, when he was appointed Assistant Director of Fortifications and Works at the War Office. He was in charge of the Fortification Branch and while there he carried out a programme for the installation of quick-firing guns and lights for the close defence of our important dockyards. On completing four years at the War Office he was selected for the appointment of Chief Engineer, Southern Command, with the rank of Brigadier-General, but before he could take up this duty the outbreak of the Great War upset all other arrangements.

For some time Stuart had held the dormant appointment of Director of Works for the Expeditionary Force, so as soon as war was imminent he, with other heads of Services, mobilized at an hotel in London, and thus began a period of nearly five years' strenuous service, which made his name familiar to all officers of the Corps. To properly appreciate the great work done by Stuart during this period, some detailed explanation is necessary.

When the Army organization began to take a firm shape after the South African War and the fundamental changes which followed the Esher Committee, it was decided to organize the Home Army so as to be capable of providing a force of six divisions, equipped and trained to take part in a European war on the Continent.

The administrative services which work behind the Field Army were necessarily somewhat undefined, but were based on a typical line of communications consisting of one base port, connected by a line of 100 miles of railway to a railhead, from which two roads, each 30 miles long, led to the field armies. To provide for the charge of the engineer services for such an organization, an establishment was laid down of a Director of Works, with one Deputy Director and one Assistant Director, with a few clerks.

The provision of engineer stores for use by the Director of Works in case of war had always been carefully considered by the War Office, and a list of special stores was maintained at Woolwich by the A.O. Dept. This list was reviewed annually by the R.E. Committee. None of the ordinary engineer stores, such as timber or cement, was included, as it was thought that supplies could be obtained, in the first place, at the seat of war and could be readily supplemented from stocks in England.

In the peace establishment of the Corps, one special unit was included called a Works Company (29th Company). It was stationed at Chatham and some of the special stores from the list held by the A.O.D., including two portable workshops, were transferred to its equipment and went overseas with it. The war establishment of this Company included a staff of officers and N.C.O's sufficient to open an R.E. office at the base and at railhead, and also of quartermasters and store-keepers to open an R.E. Store Depot at each centre.

In 1908, when a definite scheme of operations was being discussed with the French Government, it was proposed to use three base ports, but the French undertook to carry out all engineer services in France and to transport the British troops to their agreed position. While this met all immediate engineer requirements, it was arranged to detail a group of about 25 officers, drawn from the Home commands, to be placed at the disposal of the Director of Works on mobilization. Also arrangements were made to make available for work on the L.-of-C. two R.E. Fortress Companies—20th and 42nd—held on the peace establishment. It was further laid down that to provide for the wants of the Field Army, Directors of Administrative Services were to be represented at Army Headquarters by a deputy. And under Financial Instructions, directors were given full power to order any services required with a high financial limit. An officer called the Inspector-General of Communications was appointed to co-ordinate the work of directors and also to command all troops behind the Field Armies. The Director of Works was to receive his orders through the Quartermaster-General's staff.

In pursuance of the above, the Director of Works on mobilization had an interview with the Quartermaster-General of the Expeditionary Force, who instructed him to proceed at once *via* Havre and report to the Inspector-General of Communications. Stuart arrived at Havre on 10th August and found that the French had provided camp sites and horse lines at Havre, Rouen and Boulogne. They had also allotted part of the large hangars at Havre and Boulogne for army service and ordnance stores. Stuart arranged for additional services for hospitals, bakeries, remount depots, veterinary hospitals and offices, sending some of his officers and staff to each port.

On 17th August, 1914, the Director of Works joined the I.G.C. at Amiens, which had been selected as the advanced base, taking with him the 20th Company and a section of the 29th Company. On the 27th August, consequent on the retreat of the armies, orders were issued to evacuate Amiens and the three base ports, and to form a new base at St. Nazaire, with advanced base at Le Mans. On the 10th September, when the advance of the Germans had been checked, the British Headquarters was at Coulomniers, and the D.W. sent the 42nd Company, which had just arrived, to that station under the charge of a Works officer, to carry out work for the Army, and on the 12th September the I.G.C., with the D.W., moved his headquarters forward to Villeneuve St. George, near Paris.

On the 17th September there was an urgent demand from the Army for entrenching tools and Stuart was sent into Paris to see what he could do. He succeeded in obtaining a large supply from the G.O.C. Paris Defences, who nearly depleted his own stock, and the tools were transported to the front in 72 taxi-cabs. At this time the British Headquarters were anxious about the roads at the front, which were much worn by heavy traffic. The French Government Department in charge of roads was unable to do the work required and Stuart was called on to help the French Government.

So far everything may be said to have proceeded according to plan, and Stuart himself told the writer that he had had all the labour and assistance he required. But shortly afterwards a change of organization took place, the Brigadier-General, R.E., who was advising the General Staff at Army Headquarters, was put in the position of Engineer-in-Chief and took over the responsibility of all works services with the armies. The 42nd Company and, soon after, the 20th Company were placed under the orders of the Engineer-in-Chief. A little later the Brigadier-Generals, R.E., on the staff of armies were made Chief Engineers and given the full responsibility of a Director of Works. On the removal of the British Headquarters to St. Omer, the 29th Company was ordered to the front and became the R.E. Works Company at that station. This change of organization relieved the Director of Works of a good deal of work and responsibility, but affected him adversely in several ways, as each army developed a works organization on its own until there were six separate "works" authorities in France, all competing for the limited personnel and stores available. The R.E. officers who had joined him on mobilization were nearly all withdrawn to fill gaps in the Field Armies.

On 15th October, 1914, the I.G.C., who was accompanied by the Director of Works, moved his headquarters to Abbeville, where the D.W.'s office remained for nearly four years. An urgent question at once arose as to the arrangements for hutting for the coming winter. At home, Kitchener, foreseeing a long war, had given instructions for the preparation of hutted camps for a large number of men, but in France Army Headquarters did not consider it desirable to put the men into huts, so schemes were prepared for tent camps with hutted accessories. By this time the original bases had been reoccupied and a base for the Indian contingent opened at Marseilles. Stuart also opened a buying office in Paris. The French had now practically ceased to assist directly with "works" services. At all stations there were considerable schemes in hand for camps, hospitals, bakeries, remount depots and many other items. To carry out this work, Stuart made contracts with French contractors for the inland towns and with English contractors for Havre and Boulogne.

All these various jobs involved a good deal of local correspondence with French officials in connection with the supply of water, gas and light and the upkeep of roads. Also, rentals had to be arranged for land and houses occupied by the British. For all this work Stuart proved the right man in the right place. He had not only to get out detailed schemes for camps, hospitals and other services, but to divide the L.-of-C. into areas, organize a staff and to a large extent train it, settle financial procedure and responsibility, arrange contracts and decide what stores should be obtained locally and what from overseas. By arrangement with the Director of Fortifications and Works, a special branch was formed in the latter's office, which was known as F.W.5, which dealt in the first place with all questions affecting the supply of stores or works personnel; also, the branch of the D.F.W.'s office which purchased stores was much enlarged, and a special organization formed at the London Docks for the shipment of engineer stores to France. Stuart was much hampered by the shortage of officers and labour, but the situation improved as more senior R.E. officers became available from the retired list or were withdrawn from foreign stations, while he gradually obtained the services of a number of civilian engineers who did most valuable work. For labour, arrangements were made to send out six works companies drawn from the Territorial Engineers and these were supplemented later by various units, R.E. companies or labour battalions, all of which were, however, constantly drawn on either as units or by drafts to help the Field Armies. In February, 1915, an additional Deputy Director was appointed and the L.-of-C. area was divided into two parts: the northern, under a Deputy at Boulogne, included Etaples and Boulogne and, later, Calais and Dunkirk. The remainder, which included Dieppe, Havre, Rouen, Abbeville and Marseilles, formed the southern area.

Meanwhile three special groups of services had devolved on the Director of Works in connection with roads, docks and forestry. All of these were, properly, services which should have been carried out by the French authorities, but the latter, owing to the increased strain on their resources caused by the war and the loss of labour withdrawn for their armies, were unable to expand their organizations to meet the British requirements. The damage to roads has already been mentioned and, as the armies increased in number and settled down to trench warfare, the demands for stone far exceeded what could be found locally. Stuart arranged for the supply of granite from the Channel Islands and some from Great Britain. He also arranged to develop some quarries in France, especially one at La Marquise, near Boulogne, where he put a special C.R.E. in charge. The work was much hampered by shortage of labour but, by the end of 1916, the supply of road metal from all sources had been raised to 3,000 tons per day.

The extensions to docks began early in the war. In addition to the three original ports of Havre, Rouen and Boulogne, use was made of Fécamp, Dieppe, Le Tréport, Calais, Dunkirk and, later, Harfleur. At all these places additional accommodation was provided and additional lifting gear installed. At Boulogne a large area of reclamation was completed by the French authorities and the Director of Works installed sheds covering a space of 8½ acres. At Dieppe, Fécamp, Rouen and Havre additional wharf accommodation was provided for handling ammunition and R.E. stores, sometimes on a very large scale. In 1916, extensive schemes of pneumatic elevators with electric conveyors for handling oats in bulk were started at Havre, Dieppe, Boulogne and Calais, and at the latter port a military power station fitted with 1,000-kw. turbo-alternator was started.

The supply of timber began to fail early in the war owing to the closing of the timber traffic from the Baltic and to the enormous demands of the armies for trench warfare and for mining. France is a timber-producing country and at first there were large stocks of timber available, particularly at Rouen. As these were used up, the Director of Works sent officers to centres all over France to purchase stocks. Of these areas the most fruitful was Bordeaux, which had large pine forests, suitable for pit props and slabs for wooden roads. A series of contracts, known as the Foden contracts, were placed in this area, which gave a supply which reached 12,000 tons a month. But this was insufficient.

In August, 1915, the French Government, after considerable discussion, arranged to place at the disposal of the British some of the French forests in the neighbourhood of Rouen. It was hoped at first to provide about 3,800 tons of timber per month with a similar quantity of fuel wood. A C.R.E. was appointed in charge and, as the supply of labour improved and demands increased, the output was increased to about 15,000 tons per month by the end of 1916.

Although separate works organizations had been formed by the armies at the front, it was arranged that all supplies of engineer stores for these armies, other than what they could purchase locally, should be provided through the Director of Works.

For hutting, the Field Armies adopted the Nissen hut, a combination of curved iron sheets for roofing, with wooden ends and floor. Up to the end of 1916 all these were made in Great Britain and sent out in parts. About 25,000 huts were required each winter. There were also special forms of stoves, bathing establishments, water supply and many other items. All these stores had to be taken over by the D.W. and sent on to the front under instructions from the Engineer-in-Chief. The French railway authorities, in order to save double handling, asked that all stores on receipt at ports should be loaded into railway trucks, which could be consigned direct to stations at the front or on the L.-of-C. This is obviously most difficult with engineer stores which must be ordered many months in advance and for which there is not a steady demand. In every shipload there were always some stores which were not required at once and had to be unloaded on the wharf. To dispose of these, store-yards were opened at Boulogne, Les Attaques (for Calais), Havre, Rouen and later at Blargies. At all these stations base workshops were formed in connection with the store-yards. R.E. companies withdrawn from foreign stations were allotted as Base Park Companies.

In addition to hutting, each army made large demands for timber prepared for use in trench warfare and by degrees all these demands were co-ordinated in the E.-in-C.'s office and definite patterns were prepared. It was then possible to manufacture such articles in the base workshops and dispatch them to the front as instructed by the E.-in-C. The best known of these fittings was what was known as the trench board,' a short, ladder-like structure about 6 ft. long, used for footpaths in the bottom of trenches and on muddy ground. The demand for these eventually reached 180,000 a month.

Another army requirement was for bridges for use in case of an advance of the armies. A large park of bridges was formed at Havre. Designs for steel bridges were made in the War Office for spans up to 85 feet, and many of these were made up and sent out in sections suitable for loading into railway trucks. Smaller sizes were made up locally. The total reached several hundreds. The whole were in charge of a special officer and were so stacked in the park that a complete bridge could be put on rail in a few hours. These bridges could only be used on the direct authority of the E.-in-C. At the Havre Base Park a depot was established of spare parts which covered all machinery used by the British Army in France.

In the arrangement of all the above details Stuart took the keenest interest and his previous intimate experience of store work was of great value.

This general organization continued till the autumn of 1916, when it became evident that the administrative services in France had reached their maximum. The key to the position was the rail movement, which the French for several reasons were unable to increase. The British Government then appointed Sir Eric Geddes as Director-General of Transportation. This officer took over all the work connected with railways, also roads, docks, inland water transport and light railways. Each of these groups was under a separate director who was responsible not only for the work on the L.-of-C. but also in army areas. Each of these directors was given a staff of deputies and other subordinates which far exceeded the very limited staff allotted to the Director of Works. The latter handed over all work on quarries to the Director of Roads, and the work on ports and docks to the Director of Docks.

While this change was being carried out a reorganization was in progress at Army Headquarters, under which the Engineer-in-Chief was recognized as the responsible head of all engineer services, whether with the armies or on the L.-of-C. The Director of Works was placed under the orders of the E.-in-C. and was relieved of the detailed control by the officers of the Q.M.G. staff. At the same time the Director of Works' staff was enlarged and reorganized. Up to now, although additional officers had been added, the Deputy Director for the Southern Area of the L.-of-C. and the Assistant Director for Stores were only acting as superior staff officers of the D.W. ; the latter was dealing with all papers and deciding all replies ; he generally signed all out-going letters. He worked very long hours, stopping in the office to past midnight. This was partly due to a natural reluctance to hand over work, which he knew he was doing well, and partly to a feeling that while everyone was short-handed he must set an example by working with the smallest possible staff. It was now decided to add another Deputy Director for charge of the R.E. Store work and to expand the number of officers and men employed on this branch.

The labour position had been much improved by the use of native labour from India, Africa and China and the formation of a special organization to command and co-ordinate all labour units and to distribute them daily to the best advantage.

It was also found that German prisoners of war could be employed on work which was not directly connected with munitions, so selected men were formed into units and allotted to base workshops. The Deputy Director for Stores became responsible for dealing with all correspondence connected with stores, thus relieving the Director of Works of a lot of detail.

Early in 1917 the Deputy Director of Works for the south line was moved into a new office in Abbeville and given a separate staff, thus further relieving the Director of Works.

In March, 1917, the estimates of the Engineer-in-Chief for the timber likely to be required during 1917 much exceeded the probable supply, while the increased submarine warfare had reduced shipping, cutting off supplies from Canada and threatening the movement of the Foden timber from Bordeaux. The French Government was also short of timber and, at the end of 1915, had limited the amount of building timber which might be used in France by French contractors. After discussion between the British and French Governments, the latter agreed to give up some more of their forests for the British to exploit and a new Director of Forestry was appointed to take over the work from the D.W. and the smaller forestry groups in army areas. Stuart was personally sorry to lose work in which he took great interest, but this did not prevent him helping the new Director in every way in his power. Among other things he handed over his own staff officer, who had been with him since the beginning of the war, as the Deputy Director of the new organization. Like the other new directorates, the Director of Forestry formed at once a large central staff and was able to obtain much more personnel than had been allotted to the Director of Works. He also did much to increase the supply of timber until the amount supplied for works services for the armies and the L.-of-C. reached about 75,000 tons a month.

The increased supply of timber in France necessitated a large increase in the manufacture of woodwork in the base workshops, which took on the supply of all woodwork for Nissen huts and other forms of hutting. Among other items mention may be made of the supply of crosses and other emblems for the Director of Graves; the total of these reached 25,000 a month.

Although these changes had relieved the Director of Works of a lot of detail, more work had accumulated in other directions, such as camps for native labour and for prisoners of war, also for the new corps of Q.M.A.A.C. for which special scales of hutting had to be arranged.

About this time Army Headquarters revised their decision to keep men on the L.-of-C. in tents, partly to enable them to retain a number of convalescent men in France and partly because of a shortage of the material required to manufacture tents. The D. of W. was therefore instructed to substitute huts for tents for all camps and hospitals on the L.-of-C. The numbers affected were about 240,000 men and 35,000 hospital beds. This was a gigantic task to carry out in the third year of the war.

Fortunately it was found that the French could supply a number of their Adrian huts in exchange for an equivalent amount of timber. Huts were also obtained from contractors and a very simple form of hut was made up in the R.E. workshops, but with every effort the work dragged on until at the conclusion of the war about 75 per cent. of the troops on the L.-of-C. had been put under cover. The Army Headquarters also ordered a large increase in the hospital accommodation, existing hospitals were enlarged and six new general hospitals were added. At Trouville a new hospital group to take 7,500 beds and a convalescent camp for 15,000 men was ordered in May, 1917, to be ready as soon as possible. Even Stuart could not do impossibilities, but the first block of convalescent camps was ready in August, 1917, the first hospital in January, 1918, though the whole was not finished till May, 1918.

At the same time increased activity at the front caused Army Headquarters to consider a reorganization of the administrative organization in army areas so as to concentrate such services as bakeries and laundries on a smaller number of centres on the L.-of-C. with an increased use of machinery. This work continued during 1917 and 1918 and only some details can be mentioned here. The schemes included six machine bakeries, each providing 250,000 rations per diem, with four sets of machinery in reserve in case the armies advanced; large laundries to wash 1,750,000 pieces each week, with five sets of machines, each to serve 4,000 hospital beds; many minor services such as military prisons, hospitals for native labour, pig farms, goat farms and fat-reducing plants. There was also a large increase in the number and size of ammunition depots, also workshops for R.A.F. repairs and for motor transport. These latter were designed on a large scale to avoid sending machines to England for repairs. A large combined ordnance and supply depot was started in April, 1917, at Vendroux, near Calais, to relieve the congestion in the Calais sheds. This covered an area of 800 acres. Camps for the labour employed were required in addition. The sheds for supplies alone aggregated 2,400 feet long by 125 feet wide. Two miles of macadamized road were required and many miles of subsoil drainage, also a special electrical power station and very large water drainage and fire-prevention systems. New C.R.E.s' areas were formed in 1917 at Abancourt, Amiens and Trouville.

The transfer of part of the British Expeditionary Force to Italy caused considerable extra work at Marseilles and on the line of communications between Cherbourg and Italy. The Director of Works was made responsible for all works on this line between Cherbourg and the Italian frontier, and his staff was drawn on for officers and men for the bases in Italy, while several train-loads of stores and timber were dispatched from the base depots. A new C.R.E.'s area was formed with headquarters at Paris.

At the end of 1917 a group of aerodromes was formed near Nancy and a works staff under a C.R.E. provided for this centre. This ultimately expanded considerably and a separate Deputy Director of Works was appointed for this area.

In March, 1918, a new directorate was formed to take over all questions of property and rentals, both on L.-of-C. and in army areas. The D.W. transferred to this Director his staff of land agents, about eleven in number.

The amount paid out in rentals at this time for services under the D.W. was over seven million francs a year.

In March, 1918, the attacks of the Germans caused the retirement of the British Armies along nearly the whole front line. A scheme was prepared for the defence of an inner line extending from Fosseux, near Arras, to the River Somme, and the Director of Works was called on to carry out this work, using his staff from the L.-of-C. He was also called on to prepare schemes for the demolition of bridges and the obstruction of roads in rear of a line from Dunkirk, through St. Omer and Doullens, to the Somme.

Stuart himself took charge of these arrangements, officers were detailed from the L.-of-C. to prepare the necessary schemes, and units from the Works Directorate were practised in making up charges. In addition a scheme was prepared for the defence of the line of the Bresle in case the British were driven back on the base ports. When the advance of the Germans was checked, this work was stopped and Stuart rejoined his headquarters, but all the officers with whom he had come in contact during this temporary transfer to field work spoke highly of Stuart's military knowledge and his success in handling a very mixed personnel.

Following the check to the German armies, the latter began a series of air attacks on the stations on the L.-of-C. Several ammunition stores were set on fire at various places and camps and hospitals bombed. Stuart had to get out schemes for providing protection to ammunition stores and to spread these stores over a larger area. In camps, trenches were dug in which occupants could take refuge, but for hospitals Stuart devised a system of low walls or banks, about three feet high, round all wards to localize the blast from a bomb. On receipt of warning, hospital beds were lowered on the floor, where they were fairly safe from anything but a direct hit.

Abbeville, as the headquarters of the L.-of-C., received special attention from the raiders and for some weeks the Director and the whole office staff camped out at night in an orchard about four miles from the town. The house occupied by the G.O.C. L.-of-C. was attacked and the latter decided, in June, 1918, to move to a village near Dieppe.

In April, 1918, some changes of duties and staff were made at Army Headquarters and the general control of the Director of Works was transferred to the Quartermaster-General. A little later the branch dealing with R.E. stores was made into a separate directorate, taking over all the work and base shops under the Deputy Director of Works and also the control of the supply of engineer stores to armies and most of the work formerly done in army workshops. At the end of June the Director of Works and the Director of Engineer Stores moved into new centres near Army Headquarters at Montreuil, and the Director of Works took over the control of the works services at Headquarters. At the same time the work of the southern Deputy Director was divided, the C.R.E's at Havre, Rouen and Trouville being placed under a Deputy Director at Rouen, and a new centre area under a Deputy Director being formed with headquarters with the G.O.C. L.-of-C. at Dieppe, to include the C.R.E's at Dieppe, Abbeville, Abancourt, Marseilles and Paris.

During 1918 the work of the D.W. consisted of the preparation of schemes connected with carrying on the war into the year 1919. The army areas had been thoroughly disorganized by the fighting in March and April and were preparing for more mobile warfare. Their workshops had been absorbed by the base workshops in March, but there were many other establishments which had to be dealt with, such as officers' schools and hospitals.

Provision had also to be made for the accommodation of a large number of prisoners of war and their guards. Abbeville alone had accommodation for 60,000 prisoners.

In addition to this very large programme, arrangements were begun with a view to demobilization, rest camps were formed at the important bases, each including a large camp where men from the front could be "deloused" by hot baths and clean clothes. About 50 camps were formed in all, each taking 3,000 men. Half of these were new camps.

During the final stages of the war the area of the L.-of-C. was constantly changing as the armies advanced, and right up to the end the work of the Director of Works was continued at full pressure.

After the armistice there was the very important work of closing down contracts and dismantling buildings and hutments not taken over by the French. Stuart remained in France till June, 1919, when he accepted the appointment of Director of Works and Buildings at the newly-constituted Air Ministry.

For his services during the Great War, Stuart was seven times mentioned in dispatches, was awarded the C.M.G., C.B. (1915), K.C.M.G. (1917), and was promoted Major-General (3.6.16). He received the 1914 Star, the British War Medal, Victory Medal, Legion of Honour (4th Class) and the 2nd Class of the Order of the Crown of Roumania.

Space does not admit of any detailed account of Stuart's work at the Air Ministry in London. The job was a difficult one. The Air Force was newly formed and had started during the war with a huge mass of establishments and landing-grounds all over the world and, as was natural, with a very heterogeneous staff collected from many sources with no definite system of working and no definite system of training.

He had also the difficult job of clearing up the congestion of the war, of deciding what to keep and what to scrap, and, when it was decided which were to be the permanent establishments, to design buildings to replace the temporary buildings erected during the war, to organize the finance and to arrange future procedure. All this work he carried out to the full satisfaction of those under whom he was working and at the same time he gained the wholehearted confidence and affection of those working under him. The affection of his staff was shown by the fact that on his retirement they subscribed to present him with a gold chronometer.

Stuart left the Air Ministry in 1924. He had settled down in Fleet in 1920, where he interested himself in local affairs, served on the Parochial Church Council and the local District Council, was President of the North Hants Rifle Association and Chairman of the local branch of the League of Nations Union.

He had retired from the Active List on 26th February, 1920, but remained in the reserve of officers till 1928. In September, 1929, he was appointed a Colonel Commandant of the Royal Engineers, which appointment he held till he reached the age of 70. In his early days he was a keen yachtsman but was not interested in other games. He married in 1899 the daughter of John McGavin, Esq., of Thalimar, Ayr, who survives him ; he leaves one daughter.

During his last years he had suffered from heart trouble and on the advice of his doctor had reduced his various activities. But the end came very suddenly when he collapsed at a performance in the church institute and passed away without recovering consciousness.

An eminent civil engineer, speaking in a recent broadcast from the B.B.C., said that civil engineering was composed of one part of technical knowledge and three parts common sense, and Stuart had certainly both these qualifications in a special degree. Technically he was without doubt a first-class engineer with a very wide range of qualifications. In civil life engineers usually specialize in one of several branches, but military engineers have a wider training. Stuart was equally at home when discussing constructional, electrical or mechanical proposals and when, towards the end of the war, many civil engineers eminent in different branches came out to assist, Stuart was able to meet them on their own ground. He was equally at home in small things as in big: however small the detail under discussion, he was always keenly interested and able and willing to give useful advice. On the other hand, the above account will give some idea not only of the great range of his qualifications, but of his success in handling big engineering problems. The work was so varied that a summary only would give a very inadequate idea, and the writer has therefore attempted to give a little more detail than is usual in a memoir of this description. It is related that when the American troops were on their way to France, some of their leading engineers were sent over to see the various buildings and establishments on the British line of communication. On leaving one such establishment they said, " Well, we heard you had some pretty big things in the way of bakeries and other buildings, but we never expected to find a big cathedral."

In conclusion, one other side of Stuart's character must be noted and that was his success in dealing with all with whom he came in contact. This was due to the essential straightforwardness of his character and his own kindly nature. His superiors were not only impressed with his technical knowledge, but felt the fullest confidence that he was doing his best. His subordinates looked up to him as a friend. He never bullied or attempted to drive his officers and always credited everyone with doing his best, as indeed all were doing. If any hitch arose, Stuart would turn up in his car, ask two or three of the officers concerned to dinner or lunch and after the meal discuss and generally settle satisfactorily the point at issue. He had an extraordinary memory for individuals and their qualifications. It was calculated that during the war over 700 officers passed through his directorate, while at the armistice the number of officers employed under him was 197, exclusive of those on the strength of units. As each new service was started or emergency arose, he would pick out at once the best qualified officer and even subordinate ranks, and his judgment was seldom or never at fault. Away from his work he was the best of companions, full of information on all subjects, with a humorous appreciation of all difficulties and a good-tempered consideration for the opinions of others.

W.B.B.

CORRESPONDENCE.

WAR MEMOIRS OF DAVID LLOYD GEORGE.

812, Island Road,
Victoria, B.C.,
Canada.
26.1.37.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

The excellent review by W.H.K. of the *War Memoirs of David Lloyd George*, in *The R.E. Journal* for December, 1936, is well borne out by a sentence which occurs in the instalment of "Grey of Fallodon," by Professor G. M. Trevelyan, O.M., which appeared in the issue of *The Sunday Times* of 3rd January, 1937. The sentence referred to is as follows :—

> "His retrospective creation of situations that never existed, in order to cast blame on others, is unworthy of the great part he has played in world affairs."

Yours faithfully,

H. E. G. CLAYTON, *Lt.-Col., R.E. (retired).*

All Reviews of Books on military subjects are included in the provisions of K.R. 535c (*1935*).

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

THE WAR MEMOIRS OF DAVID LLOYD GEORGE.

VOL. VI.

(Ivor Nicholson & Watson. Price 21s.)

Mr. Lloyd George has finished his contract with his publishers, and the million words have been reached at last. Volumes V and VI contain a greater proportion of extracts from other works than the previous four, and repetition is noticeable in many places. A stray chapter on Mr. Fisher's Educational Reform has been inserted, although it has no visible connection with the war. We may thus infer that the final expansion has been laboured.

But the achievement is a remarkable one. Words come easily to Mr. Lloyd George's pen, and when he can forget his animosities he is admirable. He presents many intricate subjects, such as the abortive attempts at peace, in a clear manner. But he is no historian. He leaves out too much, and is far too bitterly prejudiced to be a safe guide. He has made the mistake of writing himself up, and in doing so he has thought it necessary to cast the deepest stigma on the characters of men who, equally with himself, devoted themselves to the service of the State. He has accused them not only of incompetence for their posts, but even of treacherous conduct. He has charged Sir Douglas Haig with wilful obstinacy, with deliberate wastage of his men's lives by pursuing attack when he should have withdrawn and, even worse, of deliberately leaving the Fifth Army to its fate in order to "pay out" the politician for his interference. No such charges have ever before been made against a Commander-in-Chief. If we had lost the war, Sir Douglas Haig could not have been more severely blamed. But are we to believe for one instant that the British Army would have followed the lead of such a Commander through the dark days of the spring of 1918 to the great victories of the summer and autumn if he had been the man whom Lloyd George depicts?

Sir Douglas Haig's mistrust of Mr. Lloyd George dated from the Calais Conference of February, 1917, when the latter sprang upon the soldiers his secret arrangement with M. Briand for placing the British Army in France under the command of General Nivelle*. Mr. Lloyd George has told us next to nothing of that episode; but Sir Douglas Haig has described the whole meeting, and Mr. Lloyd George has not questioned his account, even in the chapter which he devotes to criticism of Haig's Diaries. Thereafter, there was mutual distrust, but Sir Douglas Haig's criticisms of Mr. Lloyd George were confined to his interference in purely military affairs. Not so Mr. Lloyd George. His abuse of Haig is the outcome of his interference in Haig's sphere. Without the slightest experience in military matters, he endeavoured to dictate military strategy. It is one thing to argue, as Mr. Lloyd George does on p. 3409, that strategy is not entirely a military problem, and quite another to assume

* *See also page 164*

that a superficial knowledge is all that is required for its complete understanding. Inexperienced political eagerness thrust itself again and again into the sphere of strategy. Mr. Lloyd George does not weigh up the pros and cons for any course of military action. He argues with all the vehemence of the advocate that his particular strategy must always have been right, and that he who did not adopt it can only have been wrong.

The first chapter, "Stroke and Counter-Stroke," sketches the course of the campaign from the middle of May until the Armistice. Copious extracts from already well-known books, chiefly German, are given; but the story of the Australians' gibe at headquarters when American troops, expecting to go into action with ours, were forbidden to do so by their own G.H.Q., is inserted by way of novelty; it is just another sneer at Higher Commands (p. 3090).

Mr. Lloyd George refers at length to Sir Henry Wilson's memorandum of 25th July, 1918, on the general military situation, and although he admits that Haig disagreed with the gloomy view taken by the Chief of the General Staff, and regarded it as too verbose, he writes: "but there is ample evidence that the C.I.G.S.'s estimate of the "prospects of an Allied victory in France during 1918 coincided with those expressed "by the two Commanders-in-Chief, Pétain and Haig" (p. 3211). Thus he leaves the reader to infer that Haig joined Wilson and Smuts in their gloomy forecasts. He does not say where the ample evidence comes from. Haig, indeed, at that time had a great belief in the possibility of victory in 1918, as his Diaries show.

In another passage, referring to the decisive success won by the Fourth Army on August 8th, Mr. Lloyd George says: "Had Haig flung his army into the gap created "and pursued the broken and demoralized Germans without respite, an even greater "victory was within his grasp. When the enemy was scattered and unnerved, and "their reserves were not yet up, Haig did not press forward with relentless drive and "the Germans were given time to recover and reform their lines. Both Hindenburg "and Ludendorff dwell with gratitude and surprise on this welcome respite" (p. 3127). To "fling an army" is a favourite expression of amateurs. Mr. Lloyd George can have no conception of the processes involved in moving modern armies on a large scale. He ignores such necessities as supply rail-heads, refilling points, roads for lorries, and the fact that artillery barrages for miles do not leave the ground in a suitable condition for the rapid movement of troops, still less for their heavy transport.

He has already described to us Foch's method of successive punches, first here and then there, changing the locality each time and giving the enemy no time to move his reserves. Yet Haig, he thinks, should have flung his army—apparently his whole army—into the new gap on the Somme. A little farther on we read why Haig did not do this. "On August 21st the Third British Army struck at the German salient "in Flanders, and a week later, the First Army extended this thrust northwards. "These attacks drew the German reserves up to Flanders, and the Fourth Army was "able then to renew its advance on the Amiens front" (p. 3141). This gives a good idea of the value of Mr. Lloyd George's military criticisms. He has just blamed Haig for not "flinging his army" into the gap created by the Fourth Army on the Amiens sector, and then he goes on to describe the next successive blows prepared by Haig. What would he expect to have happened to those next blows if the other armies had been pulled about hastily and "flung" elsewhere?

Mr. Lloyd George quotes largely from the Reichstag Committee of Enquiry after the war, which, of course, seeks to find some palatable explanation of the German failure; and from German writers who have had time to digest the evidence, and obtain those views which an after-knowledge of events puts into shape. So Haig, who has been blamed so often by Mr. Lloyd George for fighting too long in one place, is just as easily blamed for not persisting in a new salient just created. Any form of blame, we must believe, is to be marshalled against the victorious British Commander-in-Chief, even when he wins a great success.

Haig is next blamed, in company with Sir Henry Wilson, for underrating the "general demoralization that had set in amongst the German people and had "extended to their Army" (p. 3150). It is easy to see, years afterwards, how great that demoralization had been, but the German troops in the field were fighting hard to stave off defeat, and their conduct alone would not have warranted extravagant hopes of early collapse. The military commanders at the time were not in possession of the vast volume of facts which Mr. Lloyd George is able to draw upon for his Memoirs, and, as his wont is, he makes no allowance for the circumstances as they were known or were ascertainable at the time. So ready is he with his stinging blame that we may be sure that he would have been equally severe if the military appreciations had been unduly optimistic.

It is this constant readiness to blame the Generals on every pretext which robs Mr. Lloyd George's Memoirs of any claim to be true history. As the volumes have succeeded one another the desire to belittle the military leaders and, by inference, to belaud himself, becomes more and more evident.

"Aftermath in Russia" is a long chapter, bringing the story of the Russian downfall to the close of the war; and there follows a chapter, "Dawn Breaks in the East," which, as its title suggests, embodies Mr. Lloyd George's favourite theory. Once again he claims that it was the Eastern "side-shows" which brought Germany to her knees. He triumphantly refers to Bulgaria's rapid defeat as the prime cause of Germany's downfall. He innocently quotes the Reichstag Committee of Enquiry (p. 3199), and the German verdict that it was Bulgaria's collapse, followed by that of Austria-Hungary, which completely changed the situation of the German Army in the field. What else could he expect from the German investigation? With so convenient a scapegoat, was any other verdict likely? But the Bulgarians did not collapse until the end of September. By that time they had seen the German waves broken on the Western rocks, and all the high promises of Ludendorff brought to naught by the steady resistance of the British and French Armies, followed by the victorious attacks, again on the Western Front, in July, August and September. The Bulgarians then knew that the game was up, and they gave in. Was it not the old, old lesson of military history? Mr. Lloyd George argues the other way round.

The description of the genesis of the Armistice terms is told in an interesting manner and then follows a chapter entitled, "A Great Educational Reform." Why this subject is interpolated at all it is difficult to conjecture. Chronologically it is out of order. Mr. Lloyd George, while acknowledging that the credit for the educational reforms of 1917 belongs to Mr. H. A. L. Fisher, the Minister of Education, evidently wishes his readers to admire the versatility displayed by his Government which, in the midst of the war, still found time to undertake this important problem, and to handle it to the great satisfaction of the teaching profession. Many other great problems were also handled, but these Memoirs have, up to this point, been chiefly confined to the war. There has been no mention, for example, of the way in which Mr. Lloyd George handled the many strikes among the munition workers, how the evil of profiteering was met, how the Ministry of Reconstruction, which was set up before the end of the war and which was heralded round the troops in France by the Minister himself, disappeared without trace.

The chapter on "Some Reflections on the War" is a résumé of Mr. Lloyd George's opinions expressed in preceding chapters. He poses three questions: Could the war have been averted? Could it have been brought to an earlier termination by negotiation? Could victory have been achieved at an earlier date by better handling on either side of the resources at their disposal and the opportunities opened to them? The answers to the first two questions are political, and as a politician who shared the responsibilities of Government before the outbreak as well as after, he considers that war ought to have been, and could have been, averted. That is a question still open to doubt. As to the question whether peace could have been made earlier, he naturally answers that "no opportunity was missed by the Entente Powers of "achieving a settlement that would not have rewarded the principal aggressors for "their action in precipitating the conflict" (p. 3349). This conclusion will probably be accepted by all who have studied the war closely. No military decision had then been achieved by the Entente. We owe it chiefly to Mr. Lloyd George that an inconclusive, premature peace was not accepted.

On the military problem as to whether victory could have been obtained earlier by more skilful conduct on the part of the leaders, he has, of course, more to say, and we are by now familiar with his arguments. Dealing with Germany first, he thinks she committed four fatal errors: the invasion of Belgium, the attack on Verdun, the forcing of America into the war, and the offensives of 1918. On page 3351 he says that "Germany neglected to construct second and third lines upon which she could "fall back in the event of her armies being driven out of the first." He appears here to ignore the existence of the Hindenburg Line and its fellows, which the Allies expected to find such serious obstacles in their way.

In examining the Allied mistakes, he regards as the worst their failure to make the most of the Russian man-power, and here he advances again his favourite theory of a strong attack in the Balkans. The ground has been well covered in previous volumes, and the question is not much nearer a solution. The advantages of a successful campaign in the Balkans were obvious; but it does not follow that they were attainable at the time when the opportunity appeared most favourable. Until 1916, the British Army was not in a position to wage aggressive war on all fronts. We had already frittered away a fine force in the Dardanelles by starting before we were ready, and every fresh front opened up meant a corresponding weakening of effort on the fronts previously involved. A really carefully considered study of the possibilities in the Balkans proposal is still awaited.

Mr. Lloyd George says "neither Germany nor Austria would have given in during "1918 had it not been for the overthrow of Bulgaria" (p. 3359). But he has already been at great pains to tell us how anxious the Austrians were for peace, even a separate peace, a long time before Bulgaria gave way; and how sorely straitened the circumstances of the German civil population had become.

Next follows a short chapter describing the Imperial character of the war, and the widespread efforts of the whole Empire. There is nothing really fresh in this chapter.

A separate chapter is devoted to a criticism of Lord Haig's Diaries, which were published while Mr. Lloyd George was engaged on his last two volumes. He epitomizes his old complaints and adds a few new ones. He darts at a few casual remarks by Haig, referring to this or that French general whom Haig met as "a "gentlemanly man and a fine soldier" or "a silent retiring gentlemanly man." "He liked conventional officers with a soldierly deportment. A soldier who fulfilled "the description of an 'officer and a gentleman' fulfilled his requirements" (p. 3384). The selection of such trivialities for carping criticism strengthens the impression that the author is out for condemnation of Sir Douglas Haig in whatever shape or form he can devise, and proclaims the frame of mind in which he wrote.

The final chapter gives us "Some Reflections on the Functions of Government and Soldiers respectively in a War." Mr. Lloyd George naïvely asks: "Ought we to "have interfered in the realm of strategy?" (p. 3409), and implies that because the Government did not interfere, the Allies were nearly ruined. "Unfortunately, they "left the decision to generals whose fortunes depended on the victories of their own "armies." This is typically Lloyd Georgian. The responsibility for the supreme direction of war remains vested in the Government. Acting or not on the advice of its military advisers, the Cabinet is responsible for decisions as to war policy. This is quite a different matter from interference in the military execution of a campaign once it has been decided upon. And interference in the execution includes attempts to divert effort from a project already in operation. The premature attempt to force the Dardanelles without waiting until an expeditionary force could be got ready, the switching over to Salonika, the political failure to obtain the alliance of Bulgaria, are all instances in which civilian responsibility stands out, and no one reading these Memoirs can be in any doubt as to the degree of interference in the realm of strategy attempted by Mr. Lloyd George. The secret arrangement with M. Briand at the Calais Conference of February, 1917, already referred to in this review, is an example of the kind of interference which is fraught with danger. Mr. Lloyd George rightly says that "strategy is not an entirely military problem" (p. 3409). When the military advisers have stated their case, it is for the Government to decide on the general course of action, but there are obviously different ways of handling situations. To blame Lord Kitchener for "overlooking" the doubling of the railway from Salonika through Serbia to the Danube early in 1915 (p. 3354) is another instance of misrepresentation of the case. We were at that moment preparing to break through the Dardanelles in order to reach Russia. Italy had not yet come into the war. Any attempt then to double the Serbian railway (and how could it have been done by Lord Kitchener without a British Expeditionary Force?) would scarcely have been left unopposed by Austria, and we should have found ourselves running a Salonika expedition concurrently with the Dardanelles expedition. Early in 1915, how could such a course have been possible? This probability does not receive any consideration from Mr. Lloyd George. It is enough for him to say that Lord Kitchener, the soldier, failed and missed the great chance dreamed of by the politician.

He stresses the fact that in the development of munitions, transport, railways, tanks, and in other matters of productive organization it was the civilian and not the soldier who took the lead. But there is nothing surprising in this. When Mr. Lloyd George took charge, all those professional soldiers who had not perished with the original British Expeditionary Forces were engaged, to a man, in fighting or training to fight. With all the resources opening up behind the theatre of war, it would indeed have been surprising if civilian capacity had not come to the fore and distinguished itself. But with all Mr. Lloyd George's sneers, we may remember that Lord Kitchener, from the very first day, prepared for a three years' war and laid down the lines on which our vast army was built. We may also remember that politicians, including not least among them Mr. Lloyd George, were in pre-war days by no means ready to give the soldiers what they asked for. There were in those days politicians who were positively hostile to military preparation.

Mr. Lloyd George also indulges in the foolish comparison between the admiral who enters the battle at sea in his ship, and the military commander-in-chief who sits well behind in an office to receive reports and does not go over the top at the head of his troops. This picture is almost too childish for notice. There is nothing in common between the admiral in an armoured conning-tower directing a modern naval action and the commander-in-chief of a 100-mile battle front on land. "When high "admirals are not immune from the jeopardy of war there is no reason why exalted "generals should be sacrosanct" (p. 3425) is a sentence typical of the author. The ex-Prime Minister seems to delight in an opportunity of breaking down the trust and confidence of the soldier in his leaders. There is nothing but harm in these stupid attacks, and he cannot be ignorant of their meaning. When Sir Douglas Haig was a Corps Commander he was frequently on horseback in the battlefield, notably at the battle of Gheluvelt in October, 1914. But all soldiers recognize that the higher commanders must be where they can readily be found; they must be located where immediate decisions can be taken, reports received, and orders dispatched without delay to all parts of the field, and the higher the commander the farther back must be the focus of all communications at which he must be found. Such a proposition is almost too elementary to refer to in a military review, and Mr. Lloyd George himself cannot be unaware of its obvious truth. His insertion, therefore, of the following sentences can only be due to his insatiable desire to cavil; "It is a new thing in war "for generals who never set eyes on a position to command their soldiers to attack "it without the slightest intention of placing themselves in any peril by leading the "attack themselves, or even in viewing the ground before action, or coming near the "battle whilst it is proceeding to its deadly end. It is certainly a novelty in war "that military leaders swathed in comfort and security should doom hundreds of "thousands of their bravest soldiers to lodge for weeks in slimy puddles with Death "as their fellow-lodger, without ever taking the precaution of finding out for them-"selves what the conditions are or are likely to become. In the olden days, when "commanders so directed a battle that it ended in a shambles for their own army, "they ran the risk of being themselves numbered with the slain" (pp. 3425, 3426). Then follow references to the presence on the battlefield of Napoleon, Wellington, Marlborough, Cromwell, Prince Rupert, Stonewall Jackson and even Julius Cæsar. If Mr. Lloyd George's idea of a modern battlefield is as archaic as this, his military criticism can have little value.

On this note Mr. Lloyd George ends his Memoirs. To military readers who do not accept everything at face value, it will be obvious that he desires that he alone should be remembered as the organizer of victory, and that he has a jealous view of the parts played by other great men. To these readers, his pictures will be clearly over-coloured, out of perspective, and untrue to scale. But in these days of hurry and thirst for sensations without study, there is a large public who may accept all that Mr. Lloyd George writes because he was Prime Minister of England. To these readers he presents some of the British generals in such terms that, even if a part of his accusations were true, the Government which retained them in their posts would have been guilty of neglect of duty.

He has endeavoured to shatter the high esteem in which Lord Haig was, and still is, held. He has done his best to shake confidence in modern military leadership by his cheap criticisms of headquarter staffs, and by the whole tone of his book. He was supposed to have undertaken this work in order to give us the picture of the war from the point of view of the chief Minister responsible for its conduct on the British side. He was indeed one of the most active and relentless seekers of victory on the Allied side. But he has betrayed himself into an egotistical and exaggerated representation, vilifying others who gave their utmost service, in order to heighten the effects of his own self-portrait. His painting has been so overdone that his colours will fade, and the true portraits will remain.

W.H.K.

ROLLING INTO ACTION.

MEMOIRS OF A TANKS CORPS SECTION COMMANDER.

By CAPTAIN D. E. HICKEY.

(Hutchinson & Co., Ltd., London. 1936. Price 10s. 6d.)

In the Preface which he contributes to the volume, Major-General J. F. C. Fuller describes it as "a personal record of one of those many gallant tank commanders "without whose courage and endurance the tanks themselves would have been no "more than soulless things of iron. . . . Though war may be ninety per cent. a "matter of weapons, fighting is ninety per cent. a matter of nerves. . . . However "thrilling may be the account of an action . . . reality will be denied unless the "feelings of the fighter clearly reveal themselves. It is in this respect that this book "is so valuable to the military student."

The author's first experience of war was in the Ypres salient in October, 1917, after the operations which culminated at Passchendaele had been in progress nine weeks. The tank battalion to which he belonged had been sent there to assist in the closing stages of the battle, but the experience of those nine weeks had made it evident that it would be useless to sacrifice more tanks under the conditions consequent on an abnormally wet autumn. He gives us a realistic but not exaggerated description of the state of the ground and of the miserable conditions in which the troops lived and fought. The battalion remained in The Salient a month, doing what it could to extricate batteries of guns half-buried in the mud, while the bulk of the personnel assisted to repair the constantly-shelled roads and tracks. On November 1st the battalion entrained for the south and detrained five miles west of Arras, whence it hoped soon to go into winter quarters far from bombs and shells.

The secret of the Cambrai offensive had been well kept. A few days after its concentration on the Third Army front, the Tanks Corps learnt that it was to go into action immediately as a whole, to do or to die. The tanks were to prove their worth or be scrapped.

The capture of Cambrai, a most important point in the German railway system, would have been as momentous as would have been the capture of Amiens a few months later. We realize from this thrilling account how near the British were to achieving their object on the first day of the battle. It was literally a question of a few more tanks and a few more infantry. Whether the supports necessary for the final effort were, or could have been made, available must be left for the historian to decide.

From Cambrai the author passes to the March retreat in 1918. He describes the plan of tank defence, the opening phases of the battle, and the struggle in the gap which developed after March 21st between the left of the Fifth and the right of the Third Army, to which his unit belonged. His tanks did their share in the rearguard fighting back to and round Barastre and Les Bœufs, but on reaching Courcelette they had to be abandoned and burnt owing to shortage of petrol and gun ammunition. The personnel was then organized into machine-gun detachments and armed with the Lewis guns and S.A.A. salved from the tanks.

In August, 1918, the author took part in the great offensive of the Fourth Army, in which 430 tanks went into action. He describes in detail the abortive tank attack, supported by Australian infantry, on the night of August 10th/11th, and sums up its lessons as follows : " After a massed attack reverses in subsequent side-shows with " tanks were only to be expected. These side-shows were usually expensive and " fruitless. It puzzled me why tanks were wasted in them instead of being kept for " another pitched battle. The proper use of tanks, it seemed to me, was in swarms " where they were not expected. . . . August 10th had been an unlucky day for the " tanks. The 85 which had gone into action had suffered heavily in every sector. " Of the 43 which went in with the Canadians, 23 received direct hits. Only too true " were the words of Ludendorff in a secret Order of August 11th : ' A tank is an easy " ' prey for artillery of all calibres.' "

On August 30th the author returned to England where new tank battalions were being formed for the campaign of 1919.

On page 260 he records his impressions of tank tactics, and writes : " Then came " the Armistice and back came the ' bayonet school ' into its own. *F.S.R.*, 1924, " reads as follows . . . ' Infantry is the arm which in the end wins battles. . . . The " ' rifle and the bayonet are the infantryman's chief weapons. The battle can be " ' won in the last resort only by means of these weapons.' " The statement is perfectly true, but the author appears to think that it is not true. The answer to him is that tanks can generally get to their objectives, but without the men armed with the rifle and the bayonet tanks cannot hold them.

On p. 189 there is a slight inaccuracy. The author states that the Germans continued their advance on April 5th, 1918, at Bucquoy. As a matter of fact the British front in that sector and south of it had already been stabilized for several days by the 62nd Division. The Germans merely rectified their line slightly, to get better observation, by a short advance to the eastern edge of the ruined village. It was one instance among many where the enemy showed initiative in quickly recognizing an opportunity for getting better observation, and reflected credit on the local commander. The 62nd Division had been relieved by the 37th Division, the 63rd Brigade of which made a successful attack south of Bucquoy with the aid of a few very gallant tanks at dawn on the 5th April. A hundred and ninety-nine prisoners were captured, but later in the day a heavy counter-attack recovered the lost ground. The German local commander opposite Bucquoy took advantage of the diversion caused by the counter-attack on his left to seize a slight rise in the ground which he had been quick to realize would give him better observation. Had the British local commander had an equally good eye for country he might have made a greater effort to secure his hold on what the gods—the 62nd Division—had given him, the loss of which caused discomfort, to say nothing of casualties, on the whole front in that sector until the final general advance on August 21st. The incident recalls the fact that the 199 German prisoners captured on April 5th included men of eleven different units, showing the disorganization which still existed on the German front nearly a week after the line had been stabilized.

The book, written many years after the war, is based largely on the writer's memory, but for the psychological reasons stated by Major-General Fuller in his Preface it is worth reading. There is no index.

H.B-W.

AIR STRATEGY.

By Lieut.-General N. N. GOLOVINE.

(Gale and Polden. Price, 7s. 6d.)

The author is probably better known on the continent, than in this country, though many will have read his book on Tannenburg. His object in the present book is to attempt to form a "doctrine" of Air Strategy based on a study of the special conditions of air defence in the British Empire. He claims, probably with some justice, that practically no previous author has tried to find such a doctrine except the Italian General Douhet. Most other authors have written either from the point of view of air propaganda, or to discuss the employment of existing air forces and equipment, rather than to discover the principles on which the demand for those particular forces arise.

He considers that only two countries, Germany and Russia, have built up their air forces on principles drawn from a fundamental study of the political and military requirements of their respective countries.

His theme then is to study the conditions of the British Empire and to discover a strategic doctrine, and then, and not till then, to discuss how this doctrine should be carried into action.

While admiring the efforts of General Douhet to form an Air Doctrine, General Golovine differs from him on some fundamental points. In the first place, General Douhet assumes that "in modern warfare the Army and Navy cannot obtain rapid "and decisive results, while such achievement is well within the powers of the Air "Force." General Golovine does not accept this and considers that "a burst of "optimism as to the potentialities of a new means of attack is always followed by a "measure of disillusionment when new methods of defence go far to restore the balance, "and thereby diminish the efficiency of the new arm." It is on the efficacy already achieved of these "methods of defence," that the author differs for the second time with General Douhet. The latter has a "marked contempt" for anti-aircraft defence, while General Golovine has a healthy respect for it, basing his conclusions on the development of the air defence of London under General Ashmore, from whose book he quotes freely.

This respect for anti-aircraft defence coupled with considerable scepticism of the efficacy of bombing raids makes the author conclude that massed air-attack on London is not so certain in future war as some would have us believe. In his consideration of British air strategy he does not, however, neglect the defence of the capital. Having reviewed Imperial needs, and discussed them in considerable detail, technical and strategic, the author considers that the Empire requires :—

(*a*) An Air Force for auxiliary strategic duties.
(*b*) An Air Force for local strategic duties.
(*c*) An Air Force for general strategic duties.

To provide for these, besides an Army Air Service, a Fleet Air Arm, and Dominion Air Forces, he suggests an Independent Air Force for Strategic Defence (I.A.F.S.D.) and an Independent Air Force for Strategic Offensive (I.A.F.S.O.).

As regards numbers for the principal divisions of the whole he suggests the following first line aircraft :—

Army Air Service ...	708
Fleet Air Arm	350
I.A.F.S.D.	435 aeroplanes and 40 small airships.
I.A.F.S.O.	1,020
Total approx. ...	2,500

It is hoped that enough has been said to show that within the limits of just over 100 pages, the author makes a fairly exhaustive and extremely interesting investigation of our Imperial air strategy and its requirements in equipment. The would-be strategist will here find much food for thought, and the more technically-minded entertaining discussion on the design and armament of aircraft for varying purposes.

R.P.P-W.

MODERN WAR AND DEFENCE RECONSTRUCTION.

By Captain J. R. Kennedy, M.C., *p.s.c.*, R.A. (Retd.)

(Hutchinson & Co. Price 12s. 6d.)

In this book Captain Kennedy turns his attention to the present plan for defence reconstruction. He examines the basis of the policy, and then goes on to investigate the programme with a view to discovering to what extent the Government proposals meet the country's needs.

Such a theme cannot fail to arouse interest, and any solution suggested is bound to encounter much difference of opinion. This the author recognizes and claims that he will rest content if he can only encourage practical thought on the subject.

It is hard to condense the author's views on the various major points which arise, for he allows himself to range widely over the subject, wandering frequently down by-paths which are of little importance to the main subject.

The policy which the author favours is concentration of all effort to produce such an offensive striking force in the air that no European war in which we were concerned could last long. He claims that the policy, expounded by our Government in speech and State paper, of being prepared to deal with various threats to the peace of the Empire, disperses effort too greatly and we are unable to provide adequately for all purposes. Here certainly he preaches the doctrine of "concentration" of force, but as usual there is another principle of war, that of "security," which must be partially vitiated by too close adherence to the first. It is certain that in the past our Government have, deliberately, either in view of their foreign policy or from penury, failed to prepare adequately to meet the threat of the air to the heart of the Empire. But whether it is wise to concentrate entirely on this protection at the expense of outlying portions and communications of the Empire, is a question which cannot be lightly solved without a thought that most of the life-blood of the Empire flows from the extremities to the heart.

Having decided on this policy, Captain Kennedy discusses the present machinery for converting policy into defence plans. He deals at length with Cabinet Defence Requirements Committee, the Committee of Imperial Defence, the new minister for co-ordinating defence policy, and the much discussed possibility of a Ministry of Defence. He favours a single Ministry of Defence, absorbing all three existing Service Ministries, and quotes committee reports, statesmen and military leaders in support of his contention. We have only an indication by inference as to where this important minister is to be found. Sir Thomas Inskip (and such-like) is unsuitable as "he had no practical experience of war" and "no theoretical knowledge." Other ministers might possibly be trained by following "Mussolini's wise insistence "on the presence of his ministers at annual manœuvres." But we fear that such experience would not greatly help a minister to decide large strategical and organizational problems. Leaders of defence forces are excluded as being too old and having been brought up in the atmosphere and tradition of one Service to the exclusion of others. There remains only one who has "served in both peace and war "in two of the fighting Services and has been closely and often practically associated "with the third also in peace and war"—the author.

Having got the machinery, the minister proceeds to his plan. For a considerable portion of the book this appears to be confined to an overwhelmingly powerful force of fast bombing aircraft. A force of this nature could, without such unnecessary frills as navies and armies, deter any antagonist from attacking the heart of the Empire. The battleship, and indeed it appears all warships except submarines, can be dispensed with. Only the conservatism and desire for self-protection of naval advisers have prevented this before, the author alleges. Now that the Committee on Bombs *v.* Battleships has reported, it is clear that the conservative sailor has some basis for his argument. Quite apart from the controversy on the value of battleships, it must be remembered, when studying the author's totalitarian views on defence, that a large part of the naval programme is for the provision and replacement of cruisers and other commerce-protecting craft, without which our essential supplies would be even more vulnerable than they must be at all times from air, surface and underwater craft. The vulnerability of harbours and docks is given as the chief reason why the Navy is obsolete, but in later chapters we find proposals for sea bases scattered all over the world. It is not clear whether these bases are confined to seaplanes and flying-boats, but even so they would suffer from many of the disadvantages of naval bases as regards air attack.

As for the Army, its role should be purely defensive. This incidentally brings the author into opposition with the Military Correspondent of *The Times*, who asserts that our Army will be chiefly required, if at all, in an offensive role. Captain Kennedy laments the great increase proposed in the strength of the Army and infers that an increase of four battalions of infantry and provision of anti-tank weapons, extra machine-guns and the equipment of existing tank units is all that is intended, and that the form of the Army is to be little altered.

Of course, as the Government have not accepted the policy propounded by the author, their plan must differ from his, but he hardly gives a fair picture of what is being done. The provision of four new battalions, even if it becomes an accomplished fact, is an infinitesimally small part of the Army programme. Cavalry regiments are being converted in considerable numbers into tank units and re-grouped on more modern lines, a very large number of Territorial Army units are being converted and equipped for the defence of that heart of the Empire for which the author displays so much solicitude.

The duty of the Army, according to the author, is confined to the defence of the home country, and of bases scattered all over the world from which the large bombing forces can operate most effectively against an enemy. He recognizes that in a major war some of these bases may be on the Continent and, owing to the size of the air forces, must be considerable in size and number. Yet they are to be protected chiefly by tank units which he insists must depend on speed rather than armour for invulnerability. Very mobile tank units do not on the face of it seem to be the most suitable forces for the defence of extensive air bases.

The cost of such an Imperial Force, the necessary training cadres in the Home Country and the *gendarmerie* which each colony is to maintain (as there will be no "Tommy Atkins" to come along when required to restore order primarily by his good nature), will hardly amount to much less than the force now being provided.

However, when all is said, and the detail cut away, the author's case for a study of the problem of Imperial defence without old prejudices, and on the widest possible outlook, demands the most careful study. Such study is undoubtedly made at the Imperial Defence College and in the Joint Planning Committee of the Committee of Imperial Defence, neither of which are mentioned in the book. But this is no reason why others should not consider the matter, even if they have not access to the relevant information.

This book gives an introduction to the subject with the author's own marked bias, but it is not an easy book to read. There is too much irrelevant detail and repetition, and though a great improvement on the author's earlier book, it gives way too easily to a certain pettiness which might with advantage be eliminated. Serious readers will not be interested in, but only irritated by, the detailed correspondence with the War Office over an alleged "scoop" by another paper.

A quarter of the book is given up to appendices, very few of which are really relevant to the argument.

R.P.P-W.

MESOPOTAMIA—THE LAST PHASE.

By Lieut.-Colonel A. H. Burne, D.S.O.

(Gale & Polden, Ltd. Price 5s.)

Lieut.-Colonel Burne has given us another most readable and interesting—indeed exciting—book of military history. In a little over 100 pages he takes us through the manœuvres and fighting which occurred between the fall of Baghdad and the end of the war. Two maps and ten sketch maps make the operations easy to follow: and they are worth following.

The commanders of both sides were skilful and enterprising and this last phase of the Mesopotamian campaign consisted of a whole series of operations of absorbing strategical and tactical interest.

A great merit of Lieut.-Colonel Burne's presentation of military history is that he gives the reader the situation; and then gives him the opportunity and sometimes even encourages him to pause and think out a solution, before reading on.

The author's comments are valuable. The lessons he draws are of real human and practical value.

The campaign is one of those set for forthcoming promotion examinations. The book, however, should not only be very useful for examination purposes, but can be recommended for general reading.

E.K-S.

TEXT-BOOK OF TRIGONOMETRY.

By Cowles and Thompson.

(Published in 1936 by Chapman & Hall, Ltd., and printed in the U.S.A. 373 pages. Price 12s. 6d. net.)

Another text-book of trigonometry, this time by two American authors. The modern science of Plane Trig. includes the general theory of angles, and Spherical

Trig. deals mainly with Spherical Geometry and its application in astronomy, etc. In this book the subject is not divided into two distinct parts, and only a few of the most common applications are included.

There are several new features in the book. Angle measure is reviewed and circular (radian) measure is introduced at the outset and used throughout the book. All through the text emphasis is placed on the distinction between, and adaptability of, different methods of computation, the natural functions, logarithmic functions, and the slide rule all being used in their proper places.

The index is a model, the printing on excellent white paper is first class and there are numerous practical exercises with answers. However, for all trig. work likely to be required by officers and men in the Corps (outside Cambridge) this book is nothing like so good as *Elementary Trigonometry for Surveyors*, produced by the Ordnance Survey Office, Southampton, in 1935.

R.E.F.

THE WILDERNESS OF ZIN.

By C. LEONARD WOOLLEY and T. E. LAWRENCE, with a Preface by SIR FREDERICK KENYON.

166 Pages. Crown quarto. 33 Plates of Photographs and 7 Plates of Greek Inscriptions, etc.

(Published in 1936, by The Palestine Exploration Fund by Jonathan Cape. Price 18s. net.)

The two questions by almost everyone on first picking up this book are :—" Where is the Wilderness of Zin ? and what is a wilderness ? " The answer to the first question can be found by looking at one of the many brightly-coloured maps at the end of the Bible which some of us may remember looking at in Scripture " prep." when, no doubt, we should have been doing something quite different. The Wilderness of Zin, however, is not a well-defined term, but if it is equated to the Negeb, or southern desert of Palestine, it may be taken as comprising the desert or semi-desert country to the south of Beersheba, generally to the west of the Wady Araba, though some of it is east of this Wady.

The answer to the second question is that the term " wilderness " does not necessarily mean an uninhabitable waste any more than the " Forest " of Exmoor means an impenetrable forest. It means rather a country such as nomads inhabit, with oases and wadies where crops may be reared.

As the book also deals with much concerning the wanderings of the Israelites, it will be well worth while to re-read various Chapters of Numbers, but particularly Chapter XX, which says " Then came the children of Israel . . . into the desert of Zin . . . and the people abode in Kadesh." This was in about 1471 before Christ.

The book describes an archæological survey carried out for the Palestine Exploration Fund by two young archæologists, C. E. Woolley and T. E. Lawrence (then only 22 years of age), in not much more than six weeks in January and February, 1914. At the same time a distinguished officer of the Corps, Captain (now Colonel) S. F. Newcombe, D.S.O., was carrying out survey work in the same area and the book has been dedicated to him with these words " Who showed them the way wherein they must walk, and the work that they must do." Lawrence in his preface gives high praise to Col. Newcombe for his kindness, help and efficiency. It had originally been intended that Col. Newcombe should have written some chapters of the book about place-names and the histories of Arab tribes and to explain the triangulation of the actual survey and its results. However, this was not to be, as the war came and Col. Newcombe soon found himself in France.

The writer, having met Col. Newcombe and seen his map,* must honestly say that the maps in the book are very poor, especially Map I, facing page 23. From this map it is extremely difficult to follow the tracks of the two authors and, moreover, the spelling on the map is different from that in the text (*cf.* Araba, Arabah, etc.).

Lawrence, on page 18 in a preface, gives the four main objects of the expedition :—

(1) To get some idea of the character of the country in successive periods.
(2) To trace the Darb el Shur, the old inland route of caravans from Central Palestine to Egypt.
(3) To identify sites mentioned in the Bible and other historical writings.
(4) To study the neighbourhood of Ain Kadeis, supposed to be the Kadesh-Barnea of the Israelite wanderings.

To carry out this ambitious programme in the short time available, Woolley and Lawrence made their way together from Gaza to Ain Kadeis, where they parted, Woolley northwards to Abda, Kurnub and Beersheba ; and Lawrence southwards to Akaba, then northwards up the Wady Araba to near Petra and thence across to Maan.

The description of this area, which, except for the few centuries of settled Byzantine government, can have changed little since the days of Moses, is contained in six chapters, of which the last is entirely devoted to Greek, Nabatean and Arabic inscriptions.

Chapter I describes the authors' routes in the desert, a chapter which would be much pleasanter to read if, as I have already said, the map was better and pulled clear of the text.

Chapter II gives a most interesting history of the Southern Desert, the surface of which, for the most part, consists of a soft limestone. In the north the limestone as it crumbles releases a layer of flints which cover the desert for miles. In only one place in all this country is there a stream of real running water—in the little valley of Ain el Guderat.

Graves and other remains of the ages are discussed, but of course the dominating factor is the Byzantine Era. The Greek Government of that time found an unreclaimed desert, and by extraordinary industry they lived a comparatively pleasant existence for several centuries. The end came suddenly, the Christian religion was replaced by that of Islam and the desert has had little or no history since.

Chapter III describes the route known as the Darb el Shur, made famous by Abraham and Isaac, and which ran from Hebron direct to Egypt without touching Gaza or the Mediterranean. There is strong evidence that the road explored was part of the old Patriarch's way into Egypt. This chapter also describes the Northern Tells, or the mounds that in Syria mark the actual remains of ancient cities. It is interesting to note that these mounds are not artificially made in the way the Normans made their mounds, but are the ruins themselves.

Chapter IV will to most be far the most interesting, as Ain Kadeis, the only water of the district, was by many supposed to be the Kadesh-Barnea of the Israelites.

An American called Trumbull spent a single hour at this spring in 1882, and wrote a fantastic account of what he called an " oasis of verdure and beauty " (page 72). Lawrence, both in writing and in his photographs, shows how completely inaccurate this description is and says " the Wady Ain Kadeis is a most unmitigated desert." Thus Ain Kadeis appears quite incapable of ever having been the headquarters of a wandering tribe like the Israelites. If Kadesh is to be connected with Ain Kadeis at all, it can only be by including the adjoining district of Kossaima as well. This vexed question is further discussed at the end of this chapter.

Chapter V, by far the longest in the book (59 pages), deals with the Byzantine Towns and Churches. Excellent plans and sketches accompany the text, and the photo-

* (Col. Newcombe's map is called The Negeb, scale 1 inch = 3·95 miles, and was published by the Palestine Exploration Fund in 1921.)

graphs at the end of the book make very clear what wonderful building work was done at this time with no wood and very little water available.

The rock-cut cistern at Khoraisha, Plate XXIII, and the great dam at Kurnub, Plate XXX, are very fine engineering achievements.

Conclusion. The whole book is excellently printed and produced and, in view of the subsequent careers of its two authors, and of the literary merit which adds charm to the description of a country of no little Biblical and historical interest, it undoubtedly deserves to be widely read.

R.E.F.

THE RIDDLE OF THE COSMOS.

By BASIL CONDON BATTYE.

(Hamish Hamilton. Price 7s. 6d.)

The Riddle of the Cosmos is a work on which Battye of the Corps was engaged at the time of his sudden and lamented death. All who knew him will be glad that, through the efforts of Mrs. Battye and Mr Grant Uden, it has seen the light.

Most of us have pondered on the most astounding miracle of all—the very fact of existence; why, in other words, should there be time and space, matter and consciousness, rather than a blank negation of everything? Very few could set down their conclusions on the subject in such a simple and logical way as the author, and in such an eminently readable form.

Adequately to review the book would need the services of an astronomer, a physicist, a palaeontologist, a biologist, a political economist, an historian and a theologian. This array in itself gives a hint of the subject matter, for, beginning with current theories as to the constitution of the minutest specks of matter, the author concludes with a foreview of the ultimate goal of all things.

Battye had laid under contribution the writings of most if not all of the best-known exponents of these sciences, but he had added thereto a vast amount of original thought. Indeed, one of the main points of interest is that the whole subject is treated, one might almost add for the first time, by a man of action, for Battye was above all a doer.

That the author did not live to complete the work must always remain a disappointment, for one whole chapter, "The Borderland," had to be omitted, as he had left insufficient notes, while slips in the remainder would undoubtedly have been corrected. But the work is one which cannot fail to make the reader think. And those of us who knew him will feel in reading the book that they are meeting once more Battye with his cheery temperament and all he stood for.

F.C.M.

MAGAZINES.

RIVISTA DI ARTIGLIERIA E GENIO.

(*September*, 1936.)—1. *Artiglieria Anno XIV.* By Colonel Marras.

A brief dissertation on the new Italian artillery to be brought into use in the Fascist year XIV :—

> A 20-mm. anti-aircraft gun has been distributed.
> A new 75/18 gun has been decided upon.
> A new 149-mm. howitzer is under consideration.
> A new 149/40 gun and a new 210 howitzer have taken shape.

2. *La telemetria per la manovra del fuoco.*

Colonel Balotta discusses the organization of fire manœuvre by divisional artillery in mobile warfare.

3. *Sbarramento d'arresto nella guerra di movimento.* By Lieut.-Colonel Ruta.

As a consequence of the motorization of modern armies, obstacles of the types used in former wars will no longer answer their purpose. In this article Lieut. Colonel Ruta describes the more suitable obstacles for mobile warfare under present-day conditions. Obstacles must be spread over a large area in depth, placed in position rapidly, and must not make too great a demand on the services of engineers. They must not be spread evenly over the area to be covered.

Amongst the tools recommended for use in placing obstacles are : drilling and boring tools, portable motor-saws, flame metal-cutters, pneumatic drills and windlasses.

Mines are effective obstacles and are easily concealed. They can be fired by a trip wire or similar device. Their moral effect is considerable. Mines should invariably be fitted with a safety catch of some kind, which should not be released until the last moment. Mines may, with advantage, be combined with abattis, a most effective obstacle, but clearly visible from aeroplanes.

Gas is very useful, especially if discharged over broken ground.

When laying mines, a sketch should be prepared showing the exact position of each, especially of every contact mine, so that, when no longer required, they may be taken up again.

Gaps must be left in the line of obstacles to admit of friendly troops passing through them. Engineers belonging to the unit that laid the mines should be posted as guides.

When obstacles laid by the enemy have to be crossed, and they cannot be circumvented, the safest method is to destroy them by artillery fire, though at times it will be necessary to employ sappers and men of the chemical service to remove them (always by day).

The article concludes with some suggestions for the training of personnel in erecting obstacles in mobile warfare.

4. *I materiali nuovi della nostra artiglieria d'armata.* (S.T.A.M.)

This article gives particulars and illustrations of the two latest additions to the army artillery, viz., the 210/22 howitzer, with a range of 15,000 metres, and the 149/40 gun, with a range of at least 20,000 metres.

5. *L'artiglieria nella guerra Italo-Etiopica.*

Brig.-General Garavelli describes the armament, organization and employment of the artillery on the Erithrean front in the Italo-Ethiopian campaign. The artillery operated in very difficult mountainous country, often devoid of any tracks and, on many occasions, the gunners had to construct their own roads.

6. *Lesioni che più frequentemente si manifestano ai fabbricati.* By Lieut.-Colonel Caravano.

Cracks in buildings may be due to any of the following causes:—

(*a*) Settlement of the building material.
(*b*) Settlement in the foundations.
(*c*) Crushing.
(*d*) Rotary movement.
(*e*) Sliding.

(*a*) May be due to thick mortar joints. Cracks should be watched for a period between a fortnight and two months, and, if they show no signs of increasing, they can be grouted with cement.

(*b*) May be due to a variety of causes, and each will have to be treated on its merits. The removal of the plaster over the crack, and the placing of one or more plaster "tell-tales" over each crack, are the first things to be done. The walls may have to be shored up or strengthened with iron stays.

(*c*) Is due to the use of soft or inferior materials, and may show itself by cracks in arches, bulging of walls, and other ways. Where the damage is serious, the defective masonry will have to be cut out and rebuilt.

(*d*) Is due to unilateral thrust. It may show itself in cracks between floors and walls or in more serious forms. The treatment varies, and in some cases a series of struts between the building and an adjacent one provides the necessary remedy.

(*e*) Is due, very often, to the building being founded on a stratum of water-bearing clay, and may show itself in the walls bulging near the foundations, or in the walls getting out of plumb. It usually occurs in hilly country, and the remedy is the provision of proper drainage.

7. *L'apertura dei varchi nello studio di una preparazione d'artiglieria.*

Lieut. Cocchi explains, by means of a graph, how gaps may be opened in a defence line during a preparatory artillery attack.

(*October–November*, 1936.)—1. *Preparazione del tiro nella guerra di movimento.* By Brig.-General Fautilli.

The official Artillery Fire Instructions were compiled with a view to mobile warfare, but with a comparatively slow advance. Nowadays, however, a rapid and decisive war is required, in which the time factor is paramount. The writer shows how he would modify the Fire Instructions to keep pace with the latest ideas.

2. *L'artiglieria nelle unità celeri e motorizzate.*

Major-General Trezzani describes the duties of artillery in mobile and motorized units, and discusses the question whether there should be any change in the organization of divisional artillery, which at present consists of two groups of 75's and one of 105's, each of three batteries. One group of 75's is horse-drawn; the remainder are motorized.

3. *Controllo della taratura e dell' isoonda nelle stazioni radiocampali destinate alle minori unità.*

Captain Malebra discusses the systems adopted in radio work and wave-lengths in the smaller wireless signal units.

4. *Il problema delle slitte in montagna.*

A prize essay by Lieut.-Colonel Molinari, in which he describes various types of sledges, for the transport of guns and other military stores in the Alps, to be drawn by men or by mules, according to circumstances. The writer comes to the conclusion that there is no universal type of sledge suitable to all kinds of ground, and that the simpler the design the better service it will give.

5. *L'impiego dei pontieri nel forzamento di un corso d'acqua.* By Lieut. Zaccaria.

The duties of engineers in forcing a river passage is a subject that is often discussed in technical military journals. If this article does not tell us much that is new, it lays down the main points quite clearly.

Co-operation between the three arms—infantry, artillery and engineers—is essential to success. A commander should be able to reconcile operation requirements with technical ones. A preponderance of artillery is absolutely necessary.

The first operation in a river passage is the establishment of a bridge-head on the enemy bank. This is done by ferrying a sufficiently large force of infantry across to cover the bridging operations.

In these days of aerial observation, complete surprise is necessary. Bridging material is very conspicuous from the air; it should be brought up by night or under cover of fog. Artificial fog is useful, but it is likely to give away the attacker's intentions.

Sites for ferrying and for bridging should be selected beforehand, and the amount of material carefully calculated. Material for ferrying should not be counted upon as available for bridging, and there should be a reserve of material of 50 per cent. As regards personnel, a 30 per cent. reserve should be allowed for.

Bringing up the bridging material is a delicate operation. It will be brought up by mechanical transport to within a certain distance from the river, depending upon circumstances, but the sound of the motor engines must not be heard by the enemy. At a distance of two to three km. from the enemy bank the transport must be halted and unloaded. The material must be man-handled the rest of the way. If it can be carried down to the river in a night, so much the better; if not, the carriage will have to be done by stages.

The best form of boat for crossing is the large type capable of carrying 50 armed men. This is more manageable than a raft of boats carrying the same number. The ordinary pontoon carries 24 men.

Bridges must be built in the shortest time possible, and must be kept in repair at all costs.

6. *La polvere alla nitrocellulosa pura.* By Captain Cassetta.

An article on the manufacture of various types of nitro-cellulose powders.

The "*Technical Supplement*" (*October*, 1936) contains articles on the following subjects:—

(1) Rapid determination of the weight, the position of the baricentre and the moments of inertia of a projectile.
(2) Location by acoustics of invisible aircraft in flight.
(3) Sight vanes for plane-tables.
(4) Formulæ for internal ballistics.
(5) Circulation of air in anti-gas shelters.

A.S.H.

REVUE DU GÉNIE MILITAIRE.

(*September–October*, 1936.)—*Petit Guide pour les travaux de peinture.* By Captain Legrand. Conclusion of the article. A table of market prices of painters' materials is included.

Rouget de Lisle, officier du Génie. By Mme. Henry-Rosier. It is probably not generally known that the author of the Marseillaise was an Engineer officer. This sketch of his career is *à propos* of the recent celebration of the centenary of his death. Young Claude Joseph Rouget entered the École Militaire in April, 1776. He was not a diligent student, and had some difficulty in satisfying the examiners, but in 1782 he succeeded in passing into the Military Engineering School at Mésières. Here he continued to qualify in the reports as honest but given to dissipation, and spent as much time on musical compositions as on studies of bastions and polygons. However, he was appointed 2nd-Lieutenant in April, 1784, and posted to Grenoble. He spent four years enjoying the pleasant life of a young officer received in the best local families, where his musical and poetical talents ensured him a generous welcome. In 1792 he was promoted Captain. When the revolutionary wars broke out, he composed a "war song for the Army of the Rhine," breathing the patriotic sentiments of the time; down with the foreigner, the *émigrés* and the sovereigns allied against France. But when the National Assembly deposed the King, and sent their Commissioners round the armies to obtain the adherence of the officers to the Nationalist Government, Rouget de Lisle refused to declare his adhesion, and was suspended from his duties. A little later he was temporarily reinstated and served at Namur. Subsequently he took part in Hoche's operations at Quiberon. He was never fully reinstated, and in 1797 he finally resigned, and devoted the rest of his life to politics, music and literature. He died in 1836.

La Réception du Général Faucher dans l'École Polytechnique de Prague. The first officer to be admitted as *doctor honoris causa* by the Polytechnical School of Prague is the French General Faucher, an Engineer officer. He is the head of the French Military Mission in Czecho-Slovakia. His address to the assembly on the occasion of his election, June 20th, 1936, is extensively quoted.

Supplement to the September–October number of this Revue. A pamphlet on *Les Obstacles dans la Guerre Moderne*, based on translations or analyses of several recent articles in the German military Press.

The Germans now include in the word "Sperren" all demolitions, obstacles, inundations or land mines. The pamphlet begins with a short account of strategical obstacles, with reference to the Great War. The French made a mistake in 1914 in carrying out so few demolitions in their retreat. This was chiefly due to their desire to have the means of moving forward again later, but it is now recognized that it is a mistake to leave all the facilities to the enemy who will benefit by them during his advance, and will most certainly destroy them in his own retreat, after making full use of them.

Many of the articles made use of in this pamphlet have already been reviewed in *The R.E. Journal*, and the subject has been dealt with in General Buckland's articles on the Fifth Army Demolitions, 1918, as well as in other articles in the *Journal*.

W.H.K.

REVUE MILITAIRE FRANÇAISE.

(October, 1936.)—*Une Étude de Guerre de Montagne. La Frontière des Alpes en 1752.* By General Dentz. An analysis of a book by M. Duhamel on an inspectional tour of the frontiers of the Alps made in 1752 by the Marquis de Paulmy, who was commissioned by the Minister of War to make a series of inspections of the French frontiers. The Treaty of Utrecht had pushed back the French frontier on the Alps, and the Treaty of Aix-la-Chapelle had not redressed the grievance. M. de Paulmy was therefore instructed to examine the strategical defence of that frontier, and he took with him, amongst others, the Inspectors of Cavalry and Infantry.

The strategical importance of France's south-eastern frontier is undiminished to-day; and the author of the article claims that this account of de Paulmy's journey is not without interest in spite of its date. The inspection was thorough, and the details show that, even in those days, there were men of strong faith in the importance of close study of the ground.

La Défensive devant la Mécanisation. By Lieut.-Colonel Lançon. A long and well-written article by a writer whose name is familiar to readers of this review. So much has been written already on this subject that the author attempts no more than to summarize and classify the ideas already well known. The continually increasing number of mechanical armoured vehicles in all armies makes it certain that their use in the next war will open up possibilities at present only guessed at.

After describing briefly the development of the defence during the Great War, and reminding us of the fact that the tanks of those days had primarily one mission only —to accompany the infantry, and to facilitate their passage over the fortified zone, the author goes on to discuss the present-day problem. It is assuredly quite different. The power and speed of the new machines and their increasing numbers will be exploited to the full, and if, in peace time, budgets limit the quantity of the machines, it is certain that the arrangements made beforehand for rapid output as soon as war breaks out will very soon reach their maximum effect. Masses of rapid tanks will come into action in waves, submerging the whole defensive position, while infantry, also in armoured vehicles, will follow at the same speed, and complete the destruction of the defenders.

To combat this power, it is necessary to attack the weaknesses of the mechanized arm. These weaknesses are: its dependence on supplies of oil and petrol, expert mechanics, workshops, repair shops and spare parts; on the field of battle, its cumbrousness, and its feeble vision. It is the two latter defects which the defence can deal with. A modern mechanized division comprises several hundred motor vehicles and a thousand motor-cycles; the roads would be encumbered with the clumsy columns, to a depth of 80 kilometres for a single division. It will be impossible to camouflage such a multitude of vehicles, and they must assemble in visible masses before they can rush into action. With air bombardment and long-range artillery fire directed by air observation, these masses will suffer severely. A quantity of damaged tanks on the roads will seriously impede all other vehicles. Smoke and camouflage will add to the difficulty of vision inherent in the tank.

Other defensive measures may be adopted against the motor-power of tanks, their armour, or their speed. The author agrees that it is not impossible that science may discover a ray which will put engines out of action, or some corrosive gas which will choke up the air intake. Speed may be opposed with obstacles, land mines, ditches, etc. The author also deals with the counter-attack by tanks, the organization of a position, and concludes that the new threat from the multiplicity of motorized weapons must be met by constant activity in the evolution of counter-measures

L'Armée Allemande: son histoire, son organisation, sa tactique. By Commandant Carrias. Continued from last month. This instalment describes the development of the German Army from 1871 to 1918. A chapter is devoted to the changes in the army during the Great War. At the beginning of 1918, Germany had 241 divisions; the highest figure reached. During the same year, she had to disband 28 of them. The details given have been compiled from various well-known sources.

(*November*, 1936.)—*Les Petites Places des Ardennes en Août* 1914. By Lieut.-Colonel Darde. A short, interesting account of the part played by the minor forts of Longwy, Montmédy, Les Ayvelles and Charlemont, in 1914. All these forts were hopelessly out of date; three of them dated from Vauban, while Les Ayvelles was built in 1878. They were garrisoned chiefly by Territorial troops, amounting in all to 10,500 men with 120 guns. To "declass" them would require the consent of both Chambers of the French Parliament, and whatever the opinion was as to the desirability of doing this, the forts remained manned, and were included in the scheme of defence. They were directly under the orders of the Commander-in-Chief. Longwy and Charlemont each had garrisons of 3,500 men. Montmédy, Les Ayvelles and Charlemont were to be part of the advanced position of *couverture*; but Longwy, at the corner of Luxembourg and Lorraine, stood some 15 to 20 kilometres in front of the general system.

In general, these forts, or rather, little fortresses, offered much greater resistance than was expected of them. The defence of Longwy was particularly courageous. On August 8th the garrison fired their first cannon shot; on the 9th the isolation of the fortress was complete, and communication could only be kept up by pigeon post. The outposts were driven in on the 20th, and on the 21st the German bombardment began in earnest. An attempt was made on the 22nd by the French Third Army to relieve the garrison, but it was unsuccessful. Bombardment continued with increased intensity for the next three days, and on the 26th, the fortress had to capitulate. The garrison had 500 killed or wounded.

The garrison of Montmédy, after seeing the retreat of the 2nd Corps and Colonial Corps, found themselves completely cut off; the German Fourth and Fifth Armies passed them by, without detaching any troops to deal with them. The commander, Lieut.-Colonel Faures, telephoned to Verdun for authority to evacuate the fortress and to attempt to regain the French lines. Permission was granted, and after rendering his guns useless, burning his archives, and destroying munitions, the commander led out his column at 8 p.m. on the 27th August. They reached the heart of the Forest of Wöevre without encountering any Germans. Next day, they arrived at the edge of the forest, and found all the roads crowded with enemy columns. The gallant Faures decided to cut his way through. The Germans, taken by surprise, lost heavily in the first few minutes, but quickly recovered, and after a very costly fight, they captured the greater part of the little force. The French lost 16 officers killed, 11 wounded and 400 other ranks killed. The German losses are stated to have been about the same. This gallant little action had the effect of slowing down the German columns; a whole division was halted for several hours, and for some days afterwards the enemy acted with caution.

Les Ayvelles had a less distinguished record. Finding himself without French troops in sight, the commandant telegraphed to the Fourth Army for permission to evacuate the fort. A telegram ordering him to hold the fort was sent, but does not seem to have reached him. He marched out with his garrison the same night. Meanwhile, the 60th and 52nd Reserve Divisions had been ordered forward, and the 336th Regiment reoccupied the fort. The unfortunate commandant was ordered back and the garrison resumed their posts, but next day the general retreat was continued, and the 52nd Reserve Division retired, taking the garrison of Les Ayvelles with it.

Charlemont, like Longwy, withstood a siege. The garrison was commanded by Lieut.-Colonel Pailla, of the Engineers. On 24th August, the fort was isolated; on the 29th the Germans began to bombard it. For the next three days, the bombardment continued with increasing severity. A great deal of damage was done. On the 31st August, the commandant capitulated. The resistance of Charlemont had held back the German 24th Reserve Division from the battle of the Marne.

The author's chief conclusions are that it is a waste of men to attempt to hold such isolated forts; and that such works, if they are defended, must be an integral part of the line of battle.

Défense des Territoires d'Outre-mer, et forces d'Outre-mer. By Commandant Deleuze. A short article on the use of the air arm in the defence of overseas territories. The author refers to the British control of Irak and Palestine by air forces, and thinks that our experiments were not so successful as to justify the application of the system to French possessions. He says that our Air Force in Irak was there rather as a protection to our air route to India than a controlling force to hold the country. Air control cannot distinguish between friendlies and hostile tribesmen. In Palestine we had to revert to land forces in order to pacify the country.

L'Armée Allemande, son histoire, son organisation, sa tactique. By Commandant Carrias. This, the third instalment, deals with the period 1918–1936. The Republican Government collected a force of 350,000 men in March, 1919, and formed them into four Army Corps. The command was exercised by Soldiers' Councils. Various other bodies were also formed, under the guise of police or national guards. The Allies' peace terms cut the German Army down to seven infantry divisions and three cavalry divisions, totalling in all 100,000 men; but, as had happened in 1807–13, the Germans knew how to overcome this restriction, and there was a steady progression towards the reconstitution of the Army from 1919 to 1936, when Herr Hitler threw off the mask and tore up the military clauses of the Treaty of Versailles. The rest is well known. The whole nation is being re-armed, and German policy becomes more menacing as the military preparedness progresses. Every possible step is being taken to ensure rapidity in mobilizing the whole strength of the nation.

Fonctionnement d'un 2e Bureau. By Captain d'Esneval. A long article, well supported by maps, describing firstly, the information collected by the Intelligence Staff of the French Fourth Army during the period 18th to 22nd August, 1914, and secondly, the manner in which the information was misused.

The author describes the situation of the Fourth Army on 18th August, its mission, the intelligence gathered up to that date, the area of the operations, the means at the disposal of the *2e Bureau,* and then, in detail, the information collected during the five days referred to. Air reconnaissance was in its infancy, and the Army had to rely very largely on the older methods of obtaining information. The Cavalry Corps (Abonneau's) soon exhausted its powers. It seems that the intense strain thrown upon the French Cavalry by the immensity of the German invasion wore out both personnel and horses in a shorter time than could have been expected. The notions of cavalry reconnaissance handed down from 1870 gave no true indication of the much wider scope of the work to be done in August, 1914.

In discussing the misuse of the intelligence collected by the Fourth Army, the author ascribes it to two causes: the insufficient technical study of the information, and the faulty distribution of it. He gives clear examples under both headings. The difficulty of the task confronting an army intelligence section in contact with the enemy is well illustrated by this article. Every move of army headquarters must complicate the careful sifting of intelligence reports, but nothing is of greater importance than rapid and accurate intelligence.

The author has had the advantage of comparing guesses with facts, and he has given a most interesting account of the subject.

(*December,* 1936.)—This is the last appearance of the *Revue Militaire Française.* It is to be replaced immediately by the *Revue Militaire Générale,* published by the same firm, and edited by General Azan, formerly chief of the Army Historical Section of the General Staff. The articles will remain of the same character.

This number of the *Revue Militaire Française* has only two articles. The first concludes Commandant Carrias' *L'Armée Allemande, son histoire, son organisation, sa tactique.* This instalment describes the German tactical doctrine in a general outline from the Prussian victory over the Swedes at Fehrbellin, 18th June, 1675, to the present day. It traces the doctrine of rapid movement combined with iron discipline under Frederick the Great, the lapse back into incompetence after his death, the astonishing revival after Jena, the sliding back again after 1815, under the feeble guidance of Frederick William III, and the restoration of military prestige in 1866 and 1870. The aims of the German doctrine before the Great War were accuracy of reconnaissance, the development of initiative, rapidity of deployment, and suppleness in manœuvre. The author gives some examples from the Great War under each of these headings, showing how the German tactical views were carried into practice.

Finally, he gives us a view of present-day German tactics, based on concrete examples of exercises, taken from examinations, review articles, etc.

Essai de critique Militaire. By Captain Chaupot. An artilleryman's view of the tendencies of the French regulations for operations in the field. The author wrote before the issue of the new *Instruction sur l'Emploi tactique des Grandes Unités* which has just been published. He criticizes the present-day teaching as being too stiff, and illustrates the difficulty infantry divisions would have if they unexpectedly had to meet hostile motorized divisions. There are many conjectures, and the article is, perhaps, rather inconclusive, but it contains many interesting reflections on what may happen in mechanized warfare.

W.H.K.

REVUE MILITAIRE SUISSE.

(June, 1936.)—Premiers enseignements de la guerre d'Abyssinie. By General J. Rouquerol. A short summary of deductions from the Italo-Abyssinian campaign. The author emphasizes that all that the Italians did was most carefully and meticulously prepared. Although there was a considerable lull after the opening moves, it was due to the necessity for constructing the lorry road from Asmara to the front, and not to want of success in fighting the Abyssinians. Traffic on the road between Massowah and Asmara rapidly reached 1,200 vehicles a day in each direction. Up traffic had the road for 12 hours, down traffic the next 12 hours, thus avoiding blocking the road by opposing streams of vehicles. On the road from Quoram to Dessié every available man, including doctors and medical orderlies worked as navvies to open the track. For the final dash on Addis Ababa, a column of 25,000 men and 1,600 lorries were assembled at Dessié. A hundred and fifty aeroplanes continuously reconnoitred the route during the advance, and large numbers of aeroplanes were used for dropping supplies by small parachutes.

The Abyssinians were astounded to find that the rains did not stop the operations. The campaign will evidently furnish more material for study than was at first expected; and the two recent books by Marshals de Bono and Badoglio should attract many readers.

Le Prince Eugène: Un homme et un siècle. A short editorial review of a book by Paul Frischauer. It gives a brief summary of Eugène's career.

Le Jalonnement, simple problème de liaison. By Captain Schlegel. An article on the location of ground troops by aerial reconnaissance. Two examples are quoted from recent Swiss manœuvres, both on a small scale. It is one thing to ask of the aviators to discover the whereabouts of troops of their own side, but quite another to ensure that those troops, hiding themselves immediately on the approach of airmen, whether hostile or friendly, shall make it possible for the reconnaissance to recognize them. Troops on the ground must have some means of signalling their position to the aviators. The aeroplanes have simple means of communicating with the ground: radio, dropped messages, or rocket signals, but the troops on the ground are not so easily equipped. Only headquarters staffs have radio apparatus. The troops must use some simple panels or ground strips. For identification of the front line, plain sheets of waxed canvas, about 24 in. x 16 in., are used. For identification of units, similar canvas signs cut into various geometrical shapes are employed; while for short-coded messages various devices and arrangements of canvas strips can be displayed.

Whatever the system employed, full knowledge and experience of it on the part of the troops and the aviators is essential.

Notes sur l'organisation des Compagnies mitrailleuses de bataillon. By Captain Zweifel. No definite decision has yet been made in the Swiss Army as to whether a machine-gun section should have three guns or four. The French have four and the Germans three. The Swiss have a paucity of trained N.C.O's, and so they are not yet prepared to settle the point. They no longer have any separate regulations for the employment of machine-guns.

(July, 1936.)—*L'Instruction du tir dans l'Infanterie française il y a un demi-siècle.* By Lieut.-Colonel Mayer. The musketry reminiscences of an old French officer who joined the army in August, 1870. He took part in the battle of Buzenval (January, 1871) without being able so much as to aim the rifle. He describes the long indifference to proper musketry training. In 1885 he became an instructor of musketry at the training camp at Rachant. He mentions the fact that Colonel Lebel, whose name was given to the famous magazine rifle of 1886, hated innovations, and had actually nothing to do with the invention of this weapon. He was no technician and understood nothing about mechanics.

Les Aéronautiques militaires de nos voisins. By Captain Schlegel. A summary of an article from the *Journal Militaire Suisse.* It gives a short review of the air services of France, Italy, Germany and Belgium up to the year 1935. It puts the numbers of effective machines at: France, 4,000; Italy, 2,000; Belgium, 300. The German total is not specified, and is probably not known within 500, outside the Intelligence services.

Un maître oublié: Le Général-Major Warnery. By Lieut. Stelling-Michaud. A forgotten veteran of Swiss birth (born in 1720), who served under Eugène and Frederick the Great in most of the campaigns of his day, and became famous as a military writer. He studied every form of the military art and read every military author. As a result he himself wrote the *Remarques sur César et autres auteurs militaires anciens et modernes* (1782), *Campagnes de Frédéric II*, and several other works, long since forgotten. He died in 1786.

La Presse et la défense nationale. By Captain Paquier. A short article, striking the note of warning that too great a freedom of the Press, even in peace time, may do harm to the State.

Chronique Allemande: La nouvelle Armée Allemande. By Colonel von Xylander. A short account of the new German Army, the gist of which has already appeared in other military reviews. Written by a German correspondent for the *Revue Militaire Suisse.*

(August, 1936.)—*Troupes du Génie.* By Colonel Lecomte. A discussion of the proportion of engineer troops to other arms in the Swiss Army. The author thinks that the present Swiss distribution is faulty; they have altogether too few engineer units. The present allotment is as follows:—

Infantry regiment: None.
Infantry division (8 regts.): 1 battalion of sappers (4 companies each of 150 men) and 1 company of pontoneers.
Cavalry brigade: None.
Infantry brigade: None.
Army corps: None.
Army: 6 (*landwehr*) battalions of sappers (of 3 companies each); 3 battalions of pontoneers (of 2 companies each) and 1 battalion of miners (4 companies).

Thus if the divisional commander distributes engineer sections to his regiments or brigades, he would have practically nothing left in reserve; and his corps commander, having none, could not assist him. All engineer employment beyond a company would require the intervention of the army staff.

Although, in theory, the army with its 28 companies of engineers could reinforce any corps or division, in practice there would be so much demand for these units for work under the army staff that it is improbable that there would be any left over. The six *landwehr* battalions of sappers, although good labour units, are scarcely mobile, and are only moderately trained and equipped, and a great deal could not be expected from them at the outset of a campaign.

The author recommends the following :—

To an infantry regiment : a strong section of sappers forming a company with the telephone detachment.

To each special brigade : a specialized company corresponding to the probable missions of the brigade ; *e.g.*, for a mountain brigade, a company of "teleferists" ; for light troops, some motorized sappers and pontoneers, etc.

To a division : a battalion of sappers (of 2 to 4 companies).

The author explains that, after he had written his article, a new project for the organization of the Swiss troops was drawn up and is now being considered by the Federal Government. This scheme satisfies part of his proposals, but still leaves undesirable gaps. It provides :—

To a division : 1 battalion of sappers (of 3 companies).

To a mountain division : 1 battalion of mountain engineers (of 2 companies).

To a mountain brigade : 1 or 2 companies of mountain engineers.

To a light brigade : 1 company of motorized sappers.

To an army corps : 1 battalion of pontoneers (of 3 companies).

To an army : 1 battalion of miners (of 4 companies) and 4 battalions of sappers.

Colonel Lecomte's objections to this are :—

There are still no sappers to an infantry regiment.

No bridging material in the divisions.

No special equipment for mountain work.

Insufficient reserves at the disposal of the army.

He would like to see the divisional battalion equipped with light bridge material, and to retain the present divisional bridging company.

Le tir à la Mitrailleuse contre avions. By Captain Daniel. An article explaining in simple terms the problem of rifle or machine-gun fire against aeroplanes. Aerial attacks against an ill-disciplined or demoralized unit will have disastrous effects ; but against steady, well-trained troops the damages can be considerably diminished. *Sang-froid*, decision and rapidity of fire are necessary conditions for protection against air-attack. The article is to be continued.

Nos récentes manœuvres aériennes. By Captain Schlegel. The brief manœuvres carried out from June 15th to 17th, 1936, were the first real air exercises on a large scale undertaken by the Swiss air arm. The attacking Reds had favourable conditions on two of the three days, and were able to navigate above a cloud-layer which covered the whole Swiss plateau at a height of between 2,000 and 3,000 metres. The defending Blues, however, had a good service of listening posts and spotters, and the route followed by the enemy raiders was accurately reported. The manœuvres confirmed the general opinion that the defence requires considerably greater means at its disposal than the offence. Greater fire-power can, of course, be developed by the ground defence, but the three-dimensioned element in which the attack can operate gives the latter the advantage.

About 100 machines took part, and only two minor accidents occurred, involving no injuries to personnel. The results are said to have been entirely satisfactory.

Chronique Suisse. Some recent appointments to high offices are announced and notes on the careers of the new occupants are given.

(*September*, 1936.)—*A l'École des Orphelins Militaires.* By Lieut.-Colonel Mayer. A brief description of the origin of the school founded in Paris by Fleuris Paulet.

L'Aviation en Afrique Orientale. By P. Gentizon. An interesting account of the Italian air operations in Abyssinia, with much more detail than in the article in the June number of this review. The author remarks that at the beginning of the campaign most military critics thought that, owing to the absence of large towns, industrial centres, factories, or even important lines of communication, the Italian Air Force would have no objectives to speak of. The Abyssinians would scatter with the greatest of ease, and conceal themselves on the approach of danger. There were, moreover, no suitable landing-grounds. The very important part played by the Italian airmen in the campaign came, therefore, as a great surprise. When the campaign began, there were many regions of Abyssinia still completely unknown to the Italians. The aeroplanes became the flying cavalry, examining the ground, reporting obstacles, making sketches, taking photographs and enabling maps to be produced. The reconnaissance would remain for hours over a suspected region. Distant tribes were visited and propaganda leaflets dropped which, by proclaiming the great power and novel means of warfare possessed by the Italians, played an important part in bringing about the submission of large numbers of chiefs. There were objectives in plenty. Fords, tracks, mountain passes, watering-places, especially on the Somali front, were all obligatory meeting-places for the Abyssinians, and these were continually bombarded. So also were the numerous supply caravans. On one occasion, a convoy of 200 camels was discovered, the beasts grazing in the open plain. Small bombs were dropped just behind the herd, which took fright and made off in the direction in which the airmen intended; until the whole 200 camels eventually arrived in the Italian lines, having been literally captured by the air squadron.

Further examples of the ubiquitous use of aeroplanes in this campaign are given, one of the most noteworthy being the transfer by air of the whole of Marshal Badoglio's headquarters, including all services, personnel, archives, telephone and telegraph plant, from Makalle to Dessié, a distance of 300 kilometres, in an hour and a half. The feeding of the troops by air was also carried out on a large and practical scale; even live animals were dropped by parachute. Between April 4th and 22nd, 400,000 kilograms (nearly 400 tons) of foodstuffs and stores were dropped.

Relays of squadrons were used so that the reconnaissance service could be continuous. In the pursuit of demoralized troops the aeroplanes were of far greater value than cavalry, for they kept up their harassing fire much longer, and by continual relays they allowed no respite for their foes, who were unable to rally.

Of course, the Italian airmen had no opponents to hinder them, but they had physical difficulties to contend with, such as the rarer atmosphere of the high altitudes, and the absence of landing-grounds. Two hundred and fifty-nine machines were hit by rifle or anti-aircraft gun-fire, but only eight were brought down.

It is clear that it was the air arm alone which enabled the Italian forces to win the campaign in such a remarkably short time and in such a complete and overwhelming fashion. The demoralizing effect on the unfortunate tribesmen was disastrous to them, and even the help they expected from the rainy season proved of no avail against the vast modern equipment of the Italians.

There is much to be learnt from the air work in this campaign, and great possibilities in future warfare are opening up.

Le tir à la mitrailleuse contre avions. By Captain Daniel. The concluding instalment of the previous month's article. Contains a short account of the problems of anti-aircraft fire as regards machine-gun defence, and, coming after the article on the work of the Italian air force in Abyssinia, is of interest.

(October, 1936.)—*L'Emploi des réserves*. By General Rouquerol. The pre-war schools taught that reinforcements and reserves should be thrown into the battle as rapidly as possible; and the author cites the battle of Charleroi (22nd/23rd August, 1914) as a case in which reserves were frittered away on both sides without any useful result whatever. The big Allied attacks of 1915 petered out for want of reserves on the spot, and at that time the Germans had nothing much in the way of second and third lines behind the breach. In 1918, General Foch built up his reserves with great care, and only parcelled out his divisions with a niggardly hand; but he was

conserving his strength for a definite purpose, and was employing reserves in a broad strategical sense. This is not the same thing as the employment of reserves on the actual battlefield. If, instead of massing large cavalry forces with the intention of exploiting the gaps made by the infantry in the 1915 battles, the Allies had adopted Foch's system of successive blows, it is possible that greater success might have been attained. It must be remembered, however, that in 1918 Foch was dealing with an enemy who had shot his last bolt and failed.

The author's conclusions are that reserves must form a considerable proportion of the force engaged, and they must be in the hands of a master.

La réforme de notre haut commandement. By Colonel Lecomte. The Swiss Higher Command is in process of reorganization; and the author has some outspoken criticisms of the new proposals. The matter has been before the Federal Chambers, but it has not received the attention which its importance deserves.

The military organization of 1874 has prevailed almost to the present time, and it seems that the Swiss have been loath to nominate any particular individual as Commander-in-Chief designate. In the 1874 system there were no corps commanders. The eight divisional commanders met only once a year in conference.

A strong case for reform was made out in 1919 by General Wille, and the author quotes largely from this officer's report. Nothing, however, came of this report, and the system appears to be still out of date. The editor of the *Revue* promises a further discussion of this subject.

Troupes légères et ravitaillement en vivres. By Captain Buxcel. A supply problem arising out of the development of light, rapidly-moving columns.

Opinions italiennes: la tactiques des routes et la liberté de manœuvre. A reprint from *La France Militaire* of 2nd September, 1936; *à propos* of the Italian road-construction feats in Abyssinia. Written in very general terms, and containing no technical matter.

(*November*, 1936.)—"*Tu seras citoyen!*" By Colonel Frey. Deals with the obligations of youth to the State.

Emploi des Cuirassements Mobiles dans les fortifications sur territoire suisse. By Colonel Lecomte. This is a revival of an article published nearly fifty years ago by Captain Julius Meyer, and the resurrection is due to the recent interest in Swiss frontier fortification. Meyer was an infantryman to start with, but he died in 1927 as a Colonel of Engineers and chief of the military section of the Federal Polytechnic. He advocated a system of mobile armoured cupolas as opposed to large, fixed concrete fortifications. In his day, of course, the difficulty of combining mobility with armour was not yet overcome, and only a few samples of his contrivances were made. The Germans used a few armoured cupolas for machine-guns and observation posts during the Great War; a specimen was to be seen in the debris of the village of Tilloy, near Arras, in May, 1917.

Meyer envisaged the use of armoured turrets for 120-mm. guns. The heaviest tanks used in the Great War mounted the French 75-mm., but the tank was essentially an offensive weapon, and required to combine speed with protection. Meyer's conception was concerned with defence, and less mobility was needed. The writer of the present article believes that the day of extensive heavy permanent fortifications is over, and that the future will see a few very strongly-fortified points with the intervals guarded by mobile armoured machines. Invisibility and solidity of construction are antagonistic, and the Swiss are experiencing the same difficulties in their fortification as other nations. Complete protection against modern air attack is practically impossible on account of the expense of construction. The newer ideas of mobile armoured defence allow the defender to effect a certain degree of surprise. On these grounds, therefore, the old idea of Meyer in 1891 is worth re-study. He proposed to get his turrets into position by rail and road, special ramps and off-loading platforms being prepared beforehand. He had, of course, more time available for preparation than would be the case to-day. But we have the greater advantages of concrete roads and improved methods of traction to compensate us.

Troupes légères et ravitaillement en vivres. By Captain Buxcel. This concludes last month's article.

Majorque. La sanglante émeute de Palme (Mars 1810). An historical episode *àpropos* of interest in the Balearic Islands to-day.

Chronique de l'air. By Captain Schlegel. Describes a new biplane adopted by the Swiss service.

(December, 1936.)—*L'importance des liaisons.* By General Rouquerol. Emphasizes the necessity for complete liaison, especially laterally, between all units of a force. Mentions one or two instances during the Great War of false information being sent back to headquarters from apparently quite authentic sources. The author draws a sharp distinction between liaison and signal service.

La répression de l'espionnage militaire. By Captain Thilo. Switzerland, during the Great War, was a regular hornets' nest of spies and military agents. The present disturbed state of Europe has increased the activities of all secret services, and the author describes a recent case in which two Italians had illegally secured the services of three Swiss in espionage work. The Swiss laws dealing with the case are explained.

La service de renseignement d'artillerie, et les compagnies d'observation d'artillerie dans notre armée. By Captain Kuenzy. Describes the origin and growth of what we may call the Artillery Survey companies of the Swiss Army, and gives a short account of their duties in the field.

Chronique Suisse: l'Armée suisse en 1937. A considerable reorganization of the Swiss Army has been in preparation for some time, and in 1938 the new organization will come into full operation. Both in frontier fortification and in preparation for speedier mobilization improvements have been made. Details are not given in this number, but it is announced that each of the three Army Corps are to have an up-to-date light motorized brigade, composed of all arms.

W.H.K.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(November, 1936.)—*Pages d'histoire sur l'Armée Belge au Cours de la Guerre 1914–18.* This month's instalment describes the experiences of the 102nd Battery (75 mm.) during the period September 5th–October 21st, 1918, by its former commander, Lieut.-Colonel Baron Terlinden.

Thèmes Tactiques. Major Wanty continues his series of tactical studies, and adds two exercises; one dealing with the attack on an incompletely-organized position, and the other with lateral liaison during a fight. To follow the exercises, reference to the sketch-map with last month's instalment is necessary.

Quelques idées générales sur la balistique intérieure. By Lieut. de Moor. A purely technical article for artillerymen.—*To be continued.*

Tir réduit contre-avions. By Major Georlette. The author points out that the paucity of anti-aircraft weapons necessitates the perfection of the training of the infantry in anti-aircraft fire with their own weapons. Air attack on troops will be directed against their material rather than their personnel, unless, of course, the airmen find such targets as troops in bivouac, on the march, in defile, etc. Attack against infantry in the field will be made by special attack formations in squadrons or groups of squadrons. If the infantry is caught in column of route, the airmen will work in groups of three machines, flying over the column in succession throughout its length.

The anti-air defence has very little time in which to act. It is therefore imperative that troops should be trained to take immediate action. Observers must be constantly on the watch, for only a few seconds' warning is likely Rapid estimation of the range and direction of the attack is essential. The article describes a method of instruction of the soldier in using his rifle against aircraft, and photographs are given of a device for a miniature air target which can be used in a barrack alley.

Le Problème de la direction de la Guerre dans les Coalitions. By Lieut.-Colonel Dendal. The fourth instalment opens with a short account of the Calais Conference of 26th/27th February, 1917, at which an attempt was made by Mr. Lloyd George to place the British Armies in France under the command of General Nivelle for the coming operations. There were obvious objections to this method of achieving unity of command, as its author would have realized if he had not deliberately refrained from discussing it beforehand with Sir Douglas Haig and the Chief of the General Staff. The Belgians also made it clear that their army fought under the orders of their King and nobody else. It is probable that the clumsy attempt at Calais deferred the achievement of the understanding which later took place when Foch was appointed Generalissimo.

The next step was the British proposal (November, 1917) for the establishment of an Inter-Allied Secretariat with a military staff, for the purpose of advising on a combined Allied policy. This was the beginning of the Supreme War Council. It was a genuine attempt at obtaining a common plan of campaign. It was to be a Council, and not a body of Command, quite a different thing.

The Italian disaster at Caporetto hastened the development; and the Conference at Rapallo on November 7th, 1917, created the Supreme War Council and its permanent military staff. The Council had no executive powers; decisions remained with the various governments.

There were imperfections in this solution; Belgium was not represented on the Council; and it appeared to do little more than to centralize the Conferences which had already been held on numerous occasions. But it assured a more common exposition of plans, and established a permanent Inter-Allied Staff.

The author quotes M. Clemenceau's reminder on December 12th, 1917, that Mr. Lloyd George had shortly before, in the House of Commons, expressed himself as absolutely opposed to unity of command.

While the Supreme War Council was getting into operation, Haig and Pétain made mutual arrangements for their own support. Then followed the proposal for an Inter-Allied General Reserve, to be managed by an Executive Military Committee with Foch as President. The failure of this step is well known, and the German offensive of March, 1918, broke out before any definite step towards the unified command was taken. The Conference at Doullens, on 26th March, summoned at Sir Douglas Haig's instigation, was the first real stage. The arrangements for mutual support between Haig and Pétain were not working. The Doullens agreement charged Foch with "co-ordinating" the French and British operations.

The next stage was the Conference at Beauvais on 3rd April, at which Foch was charged with the strategical direction of the operations of the British, French and American Armies. Finally, on 1st May, Foch became Commander-in-Chief of all the Allied armies in France.

In all these agreements the Belgian Army had no part. The King of the Belgians preserved his constitutional right and refused to place his army under any foreign authority. But he loyally co-operated to the full.

The article sums up clearly each step in the direction of the unified command. The account is to be continued.

(*December, 1936*)– *Pages d'histoire de l'Armée Belge au cours de la Guerre 1914–18.* The experiences of the 102nd Battery in the Flanders offensive of 1918 are continued by Lieut.-Colonel Terlinden. The period covered is from 1st to 21st October.

Le Chef. By Lieut.-General Tasnier. A lecture given by the Director of the

Belgian "Centre des hautes études militaires" to Colonels of all arms. The author stressed the more elevated plane upon which the modern commander must be placed. He is, first of all, a moral force. He must have character, will-power, and grandeur of soul. Marshal Lyautey detested the old-fangled adages: the rolling stone gathers no moss; a bird in the hand, etc. He called them the philosophy of mediocrities. He who will conquer must have always before him an ideal; he will love action for action's sake. He is a physical force; his attitude towards his own chief must be that of "intellectual discipline"; towards his comrades, generosity; and towards his staff, authority, prestige and confidence.

Thèmes Tactiques. By Major Wanty. Fifth exercise: the conduct of the offensive battle. Sixth exercise: defence on a front of average extent. This latter expression refers, for the purposes of the exercise, to the front of one regiment.

The exercises are worked out with detailed orders.

Quelques idées générales sur la Balistique Intérieure. By Lieut. de Moor. A continuation of last month's article.

W.H.K.

MILITÄRWISSENSCHAFTLICHE MITTEILUNGEN.

(*October*, 1936.)—1. *The Fortifications of the Austro-Hungarian Monarchy at the Time of Conrad von Hötzendorf.* By Major-Generals v. Steinitz and v. Aarenau.

After a brief historical sketch, the writers describe the programme laid down for the fortification of the dual monarchy from November, 1906, onwards, when Field-Marshal Conrad von Hötzendorf first took up the post of Chief of the General Staff. The problem that Conrad was faced with was the fortification of a frontier 3,600 km. long. The budget allotments for fortification, which included fort armament, were absurdly small, a mere fraction of what Italy was spending on her very much shorter frontier.

In this first instalment the fortification of the Russian front in Galicia is described. Here the two main fortresses were Cracow and Przemysl, whilst there were a series of fortified towns such as Lemberg, Jaroslav and others.

In the World War, Przemysl played a part that was second only to that played by Verdun on the Western Front. After-events showed that it would have been better if Przemysl had been evacuated at the start. The relief of the fortress was not one of the main objects of the supreme command, and it capitulated to the Russians on the 22nd March, 1915.

2. *The Training of Officers in Austria.*—(*Continued.*)

Major-General Kainz describes the supply and training of officers during the earlier part of the World War. Little difficulty was experienced in maintaining the supply of reserve officers, but difficulty was experienced in keeping up the supply of regular officers to replace the heavy casualties incurred, and to keep pace with the expansion of the army. It was decided not to recruit officers from a lower stratum of society than had previously been the custom. Prior to the war, candidates for commissions were trained for four years at a cadet school and for three years at a military academy. These periods were reduced in length with the proviso that officers should complete their course of training when the war was over.

3. *The Straits Conference at Montreux.*

Lieut. Sokol gives details of the Conference held at Montreux by delegates of eight countries, as well as those of Turkey, to replace the Treaty of Lausanne by admitting the claims of Turkey to re-militarize the Dardanelles and to certain other privileges.

The writer considers it a matter for regret that Germany and Italy were not among the signatories to the agreement.

4. *The New Distribution of Troops in Switzerland.*

Lieut. Field-Marshal Schäfer describes the new organization and distribution of the Swiss Army. The six divisions of which the Swiss Army now consists are to be replaced within the next few years by nine divisions and four mountain brigades, of which one will form part of the 9th Division: the other three will be independent. The air force is to be doubled, 100 anti-aircraft batteries are to be provided, and many units are to be mechanized.

5. *Prize Essays.* There are essays on: *Armies with Weak Artillery* and *Mechanical Vehicles marching under Difficult Conditions.*

6. *The New Italian 75/18 Gun for Mountain, Horsed and Mechanically-propelled Batteries.* By Major-General Rieder.

A description of the new Italian 75/18 piece with four illustrations, showing (1) the 75/18 M34 howitzer in its firing position, elevated to its maximum angle of 65°, (2) the same howitzer in travelling position, with tractor attached, (3) the 75/18 M35 howitzer in firing position, (4) the same howitzer towed by a tractor.

The howitzer can be drawn by two horses in tandem in mountainous country.

(*November*, 1936).—1. *The Fortifications of the Austro-Hungarian Monarchy at the Time of Conrad von Hötzendorf.—(Continued.)* By Major-Generals von Steinitz and von Aarenau.

In this instalment the writers deal first with the fortified line of the Danube, on which the main points were Linz, Vienna, Budapest and Peterwardein.

Next comes the most important fortified front, that on the Italian boundary. This front was divided into five sectors, from the Tyrol to the Adriatic. The attitude of Italy, even when she was a member of the Triple Alliance, was doubtful; the possibility of her becoming hostile became apparent in 1914. At that time it became obvious that the blockhouses constructed prior to 1873 were useless, the forts constructed during the 'eighties could only resist the Italian siege guns for a short time, and the forts constructed at the end of the century could not hold out indefinitely. Only a few works could last out a continuous bombardment.

During the war some of the forts were too far behind the front line to play any part at all; some played an important part and formed rallying points even after they had been pounded to pieces.

2. *The Training of Officers in Austria.—(Continued.)* By Major-General Kainz.

In the third year of the war the supply of officers presented a graver problem than ever. More than half the number of regular officers in the army were either wounded, prisoners, or sick. One-eighth had been killed. During 1916 it was found possible to shorten the course of instruction for cavalry and infantry officers, but not in the case of officers of artillery and technical troops. In July, 1916, there was a shortage of 1,500 subalterns, which could only partially be made good.

The year 1917 was worse still as regards the supply of officers, and it became very difficult to find suitable instructors for cadets. But by the end of the year the military situation in Austria had greatly improved.

In 1918 the supply of officers was kept going by still further shortening the course of instruction, but they were below standard, both in intellect and physique. Arrangements had been made to carry on in 1919, had the war continued.

3. *Riding and Training in Equitation.*

General Berndt discusses the question of riding instructions for cavalry, and how the old practice should be modified to suit the short term of service of to-day.

4. *Prize Essay. The Employment of (1) Multiple-wheel, (2) Composite, (3) Caterpillar-track Vehicles in the Army.*

In this essay Major Schmilauer describes types of the three different kinds of motor vehicles adopted in various armies, and the uses to which they can be put.

The first group resemble the commercial lorries in ordinary use, and include all vehicles with six or more wheels, of which at least four are driven.

The second, or composite variety, have ordinary front wheels, that can be replaced by runners in snow; caterpillar tracks take the place of back wheels. The steering is done with the front wheels.

The third system, *i.e.*, with caterpillar tracks only, sometimes interchangeable with wheels, can be used on a large number of vehicles, from the smallest type to medium tanks. The Swedish Landsverk tank is an outstanding example.

(*December*, 1936.)—1. *The Fortifications of the Austro-Hungarian Monarchy at the time of Conrad von Hötzendorf.—(Continued.)* By Major-Generals von Steinitz and von Aarenau.

In this instalment the writers describe the defences on the Adriatic coast up to the outbreak of the World War. Ever since 1850 Pola had been the main naval harbour of the Austro-Hungarian monarchy. Its defences were overhauled by Conrad in 1912. At the extreme southern end of the Dalmatian coast lay the Bocche di Cattaro, a land-locked harbour from which operations against Montenegro could be undertaken. In the intervening stretch of coastline there were no very suitable naval harbours nor strong fortifications.

When Italy declared war on Austria, the Italian Admiralty planned the annihilation of the Austrian Fleet, the destruction of its harbours, and the support of the land army by naval operations against Trieste. These plans compelled the Austrian fleet to restrict itself to a strategic defensive.

The rest of the article describes the naval operations during the earlier part of the war. The Italians did not succeed in annihilating the Austrian Fleet. No very serious attack was ever made on Pola, and, after some successful attacks by Austrian submarines, the naval operations of the Allied powers were greatly restricted in their scope.

2. *Prize Essay. The Light Machine-gun is the Main Weapon of Scouts.*

In this essay Lieut. Ehler expresses his conviction that, in spite of mechanization, infantry is still the most important arm, and that the light machine-gun will, in future wars, be the ideal weapon for infantry scouts. In comparing the light, air-cooled Austrian machine-gun with certain others, he considers that the Austrian Army has the best weapon of its kind.

3. *The Civil War in Spain.*

General Wiesinger describes the events that led up to the Civil War in Spain. Neutral countries suffered almost as much from the effects of the World War as did the defeated combatants. In Spain the trouble took various forms, and it led to attacks on the monarchy and the church by the so-called "popular front," to which gathered the poorer classes who were largely the victims of misgovernment. As a reaction against the popular front, the national party was formed under the leadership of General Franco.

The main events of the revolution are described under the following heads:—(1) the operations on the north front under General Mola, (2) the operations on the south front, (3) the fighting round Oviedo on the north front, (4) the fighting for Madrid.

The next objective of the military party is likely to be Catalonia. Spain without Catalonia is unthinkable from an industrial point of view, and Spain alongside of a Soviet Catalonia would not be fit to live in.

A.S.H.

VIERTELJAHRESHEFTE FÜR PIONIERE.

(*November*, 1936.)—1. *Pioneer Battalions and Infantry Pioneers.*

In 1914 the German Army found its organization of Pioneers (Engineers) insufficient, and in the course of the war a pioneer battalion of two companies was allotted to each division. In addition to these, many infantry regiments formed special pioneer detachments of varying strength for their own particular requirements. Under the Versailles Treaty such specialist units have been banned. It has been suggested that in a future war of movement there will be no necessity for infantry pioneers. The writer, however, maintains that in future there will be such an extensive use made of obstacles that infantry regiments will not be able to avail themselves of the services of engineers, and will require their own detachments of pioneers.

In this article a series of problems have been worked out, based on an ordnance map, showing that extensive use can be made both of pioneer battalions (engineers) and infantry pioneers.

2. *Tasks for Engineers in the Defence of a River Sector.*

Major Knesch insists on the importance of giving as early notice as possible of the task to be set to engineers, so that the engineer commander may know by what means and with what materials he can assist the other arms.

He takes as an example the defence of a river sector, and explains what can be done by engineers (i) in the area on the enemy's side of the river, (ii) in and around the river itself, (iii) in the defender's position and in rear of it.

3. *General-Fieldmarshal Count von Haeseler and the Engineers.*

An appreciation of the special interest taken by Count von Haeseler, a cavalry commander, in the Engineers under his orders, and of his wish to make them efficient by collaboration with the other arms.

4. *The Fortress of Metz.*

Colonel Heye concludes his article on Metz.

Dealing with the period 1900–1914, he shows how the defences of Metz kept pace with the development of modern artillery. New groups of forts were built of concrete and steel, extending the ring of forts to a greater distance from the main fortress.

The system of forts was practically complete when the war broke out in August, 1914. Metz had become, to all intents and purposes, the strongest fortress in the world, and was practically impregnable. It was, however, never attacked during the war.

The situation was as follows: Given a period of three weeks to arm the fortress according to plan, the enemy would have come up against an enclosed front, 55 km. long, of armour and concrete, defended by a war garrison of 85,000 men, with approximately 600 heavy guns, of which 100 were under armour.

A French general wrote: "If the fortress of Metz had been attacked in 1914 with the materials then available, it would probably have put up an insuperable resistance. Our 15·5 cm. guns and 22 cm. mortars were outranged by the fortress artillery, and could only have done little damage."

The writer concludes by expressing how great a pity it was that the fortress should eventually have been surrendered without fighting.

5. *Effects of Shells and Bombs on Concrete and Reinforced Concrete.* By Dr. Kraus.

The best way to determine the resisting capacity of a building material to dynamic force is, and always will be, practical trial. It is very difficult to determine the effect of a blow by mechanical laws, and especially in the case of a complex substance like reinforced concrete. The study of the properties of concrete, as determined by practical experience, and of the best method of distribution of steel bars, is a matter in which the fortress engineer should be deeply interested.

According to the law of conservation of energy, a flying shell or dropping bomb must, like every moving object, expend itself, on striking, in doing work, the magnitude of which varies with the energy of impact. The energy depends upon the weight and the velocity on impact, and is greater in the case of shells than of bombs. A bomb weighing 100 kg., dropped from a height of 4,000 metres, will develop a striking energy of 320 ton-metres; a 1,000 kg. bomb an energy of 3,200 tm.; a shell weighing 100 kg. will, after a flight of 20 km., develop 750 tm., a shell ten times as heavy, perhaps 13,000 tm. Much depends, of course, on the angle of impact of the projectile on the surface of the target, and the striking energy is a maximum when the angle is a right angle.

The blow of the projectile is taken up by the whole structure and its foundations, and is partly resisted by the compression of the material and partly by its elasticity. It has been maintained that with the type of construction used in modern forts a reinforced-concrete structure will react to impact entirely by its elasticity. The exact effect is difficult to determine, but no such substance as an entirely inelastic building material exists.

The article is illustrated with some sketches of sections showing the penetration of shells in concrete at Antwerp and Namur. In some cases a cone-shaped mass has been blown out from the top and bottom of a concrete slab, while the neutral axis has remained intact. There is a considerable difference between the effects of a shell on reinforced and unreinforced concrete. While it is difficult to establish rules for penetration into plain concrete, it is far more difficult to do so in the case of reinforced concrete. The specific sectional resistance of reinforced concrete is sometimes calculated at 1,500 to 2,200 kg. per sq. cm.

A great deal depends upon the binding capacity between concrete and steel; this is far less than is generally supposed, especially in the case of round rods. It is very important that the rods should be hooked round at the ends. Where the longitudinal and transverse rods cross one another, they should, if possible, be welded together.

It is true that concrete and steel have approximately the same coefficient of expansion, but this does not make for strength in the case of mass concrete, since the ratio of their respective heat conductivities is 1 to 100.

It is difficult to estimate the relative effect of impact and detonation. In the case of a bomb the weight of the explosive is half that of the projectile, in the case of a shell from 1/6th to 1/8th. The detonation acts in the line of least resistance, the impact in the line of flight of the projectile.

The greatest effect depends largely upon the time of explosion, and it works differently with bombs and shells. Some form of delay-action fuse is necessary, both too short and too long a delay reducing the damaging effect very considerably.

The article concludes with a description of the demolition of a reinforced-concrete silo by means of explosives. The experiment illustrates the value of cross walls in strengthening a building of this nature.

6. *The Trench Mortar. A Pioneer Weapon.*

Colonel Biermann concludes his article in this instalment.

At the beginning of the war the eight fortress engineer battalions detailed detachments to serve the heavy trench mortars, which were carried as special equipment with the siege train. Medium trench mortars formed part of the war equipment of the larger fortresses.

As the value of these weapons became more and more apparent in the course of stabilized warfare, it was found necessary to increase their range, their horizontal field of fire, and their mobility.

The Germans had the advantage of surprise in introducing the new weapon early in the war, but the Allies were not long in copying it, and, eventually, they had a larger number of trench mortars than the Germans.

But the writer maintains that the German weapon retained its superiority in range, accuracy of fire, and mobility throughout the whole war.

At the end of the war, the medium and light trench mortars became infantry weapons. The heavy trench mortar was forbidden by the Versailles Treaty, though it is now likely to come into its own again.

7. *The Road for the Modern Army.*

Captain Sckerl discusses the question of roads for the modern army from the German point of view.

Germany has spent milliards of marks on the construction of "auto-roads." The advantages of these roads are the heavy loads that they will carry and the speed of transport. Speed is chiefly attained by the absence of cross-roads; all crossings are either under- or over-crossings. The main disadvantages of "auto-roads" are their susceptibility to attack, owing to the large number of viaducts and bridges. It is also impossible to leave the road at will in the event of an air attack, and the straightness of the road makes it particularly liable to this form of attack, and also serves as a guide to aeroplanes.

The advance of a modern army depends upon a network of roads. In wartime much of the transport, especially in rear of the army, will consist of hired commercial vehicles. The tendency of civilian vehicles is towards lightness and speed, and these qualities will reduce their value for military purposes.

Only a small proportion of main roads is wide enough to carry traffic in both directions without difficulty. Broken-down vehicles must be got off the roads at once, and some form of railway traffic control is essential.

The capacity of roads will have to be increased; this can sometimes be done by metalling the fair-weather track alongside a main road. The question arises whether it is better to construct a road wide enough to carry traffic in both directions, or to construct two separate one-way-traffic roads. After considering pros and cons, the writer is in favour of the wide two-way road, as more economical in cost and labour.

Roads on the line of communications must be constructed to a standard as high as that of main roads, with solid soling and wearing coat. The question of stone ballast is considered, as well as quarries, transport by broad- and narrow-gauge railways, loading and unloading sidings, etc.

In past campaigns, ordinary metalled roads only were taken into consideration. Nowadays we have the concrete road. The use of ordinary Portland cement is out of the question, the hardening process is too slow. Even quick-setting cement does not come up to specification. Aluminous cement is the only variety that fulfils the requisite conditions, but, unfortunately, it is not produced in Germany, and its cost, for road work, is prohibitive. The question of finding material for manufacturing aluminous cement in the country is worth investigating. Shingle for concrete work is found nearly everywhere.

Minor approach roads to battery positions, etc., can be made, in sandy districts, by mixing an emulsion with the sand; in clay districts, by adding sand or gravel.

No army will, in future, be without railway troops. Road troops will be even more important.

8. *What must the Company Commander expect from his Subaltern in Charge of Recruits?*

A lecture by Major Obenaus.

A "recruit officer" should carry out the course of training laid down by his company commander, encourage and take part in sports, give instruction, and learn all about the character of his men.

A.S.H.

WEHRTECHNISCHE MONATSHEFTE.

(October, 1936.)—1. *A Consideration of the Principles of Manufacture of Military Stores.* By Dipl.-Ing. Schmidt.

The manufacture of arms, munitions and other military stores presents a very different problem now to what it did prior to 1914. Nowadays everything must be turned out on the mass-production principle.

The writer pleads for a closer collaboration between officer and constructional engineer. The officer knows the experience that the troops have gained. War material cannot be developed without feeling for the troops, and practical experience of its use.

2. *The Penetration of Projectiles into Solid Bodies.*

Dr. Heidinger mentions a series of dynamic formulæ for penetration, given by various authorities. He criticizes the static theory of Dr. Viesers as unsatisfactory, and then explains his own theory. He has worked out a series of tables giving the penetration of a 100-kg. explosive bomb, at varying velocities, into (1) concrete, (2) coarse loose shingle, (3) packed shingle, (4) fine sand.

3. *Infantry Howitzer and Trench Mortar.* By W. Brandt.

The writer compares two infantry arms of accompaniment: the 7·5-cm. howitzer and the 8·1-cm. trench mortar, both constructed by the Rheinmetall Company. He expresses a decided preference for the trench mortar, whose weight is only one-fifth of that of the howitzer, whereas its performance is very nearly as good.

4. *Calculations for Determining Mean Values and Dispersions.* By Dr. Horst Herrmann.

The writer describes Gauss' method of least squares, which is universally accepted as the best for determining mean values and dispersions.

5. *Solutions of Problem 3 in the August Number.*

(*November*, 1936.)—1. *Fortification of the Ground and Mastery of Space.* By Konrad Metzel.

The writer expresses the opinion that the bogey of fortresses alarms only those who believe in it. The influence of a fortress lies far less in its real capacity for defence than in the value attributed to it by the enemy.

In the next war it will be preferable to destroy all stores and manufacturing plant rather than fight a great aerial battle, and to throw the whole production of arms and munitions out of gear rather than to commit oneself to big artillery actions.

Some of the main objects to be attained will be the destruction of railways and the cutting off of all raw material from the enemy. It will therefore be necessary for countries to defend, not only their frontiers, but all vulnerable points against attack.

Next to money and numbers, the time factor will play a quite undreamt-of part in the next war. Tanks will be a serious danger, and it remains a serious problem how to ward off a tank attack. Water is a great enemy of tanks. During the World War the Allies were able to take advantage of the possibilities of flooding the country in the north of France and in Flanders and hamper the Germans very considerably. The use of water in defence is a problem worth careful study.

The writer quotes, at some length, extracts from an article by Commandant Montigny, "Les systèmes fortifiés dans la défense de la France," that appeared in the *Revue Militaire Française* in 1935, and was reviewed in *The R.E. Journal* of December, 1935, and March, 1936.

2. *Gold and Total War.*

Dr. Ruprecht dwells on the importance of nations accumulating a large reserve of gold in peace-time to enable them to carry on in war. The greater part of the world's gold coinage is now held by the U.S.A., France and Great Britain. Japan has increased her gold reserves very considerably since the World War.

3. *The Engineer Officer.*

Major Engel describes the training that engineer officers receive in France. The majority of French artillery and engineer officers have, for the past 140 years, passed through the *École Polytechnique*, and of those who reached high rank in these corps nearly all were Polytechnique students. The French army administration lays great stress on the theoretical training of officers and on practical "refresher" courses, up to the rank of general.

After describing in detail the subjects in which the French engineer officer is instructed, Major Engel puts in a plea for a military technical college for German officers corresponding to the former military technical academy, as regards the first two courses, but extended to about 2½ years, which he considers long enough for an officer taken from regimental duty.

(*December*, 1936.) 1. *Effective Gun-Fire*. By Landrat Krommler.

When the artillery-man talks of effective fire (*Wirkungsschiessen*), he means that the fire has been so effective that the target has either been thoroughly destroyed or, at least, has been put out of action for some time. The writer explains how this high standard of shooting can be obtained.

2. *Military Technical Inventions and Secret Patents*.

Dipl.-Ing. Stott, referring to an article on this subject by Dr. Steinitz in the September number, relates his own experiences and offers some suggestions.

3. *Fuses for Anti-aircraft Shells*. By Lieut. Schmitt.

With the introduction of machine-guns (of 2 to 4 cm.) for fighting aerial targets with explosive shells provided with a sensitive percussion fuze, a new problem arose for the designer of fuzes. If the shell missed the target, it became a potential source of danger to the civil population and to friendly troops. It was therefore necessary to ensure that if the shell missed the target the fuze should, after a certain time of flight, say ten seconds, automatically cease to function.

The attempts made to solve this problem satisfactorily form the subject of this article.

In discussing the value of tracer shells, the writer expresses the opinion, borne out by the experience gained in the Italo-Abyssinian campaign, that a combination of tracer and ordinary shells affords the best solution.

4. *Two Theorems in the Propulsion of Rockets*. By Ing. Akimoff.

A study of the simplest form of this problem, in which the rocket moves horizontally with a constant velocity, the resistance being proportional to the square of the velocity, the mass of the rocket remaining constant.

5. *The Redistribution of Industry to Help the Manufacture of War Materials*. By Major Mende.

Centres of industry have been located in certain areas for definite reasons, such as the facility for obtaining raw materials, the presence of skilled labour, facilities for distribution, etc. Present-day conditions, however, require that a country should be, as far as possible, self-contained and independent of outside sources of supply, in case of war. This requires an organization comprising all civil industries and manufactories of war-like stores under one supreme control. It also requires, as far as may be feasible, the removal of some centres of industry to places as remote as possible from enemy attack.

The writer speculates how far these conflicting conditions can be realized.

6. *Modern Infantry Weapons and Ammunition*. By Dr. v. Buttlar-Elberberg.

A description of the rifles and ammunition of the leading European armies. The German rifle is looked upon as satisfactory; the Russian rifle, in spite of some defects, is one of the best; the British rifle and ammunition are described as, without exaggeration, the worst in the world.

A.S.H.

THE ENGINEERING JOURNAL (CANADA).

The issue for January, 1937, contains an article, "The Royal Engineers in British Columbia," which is a record of an address delivered by His Honour Judge F. W. Howay, LL.D., F.R.S.C., at the Western Professional Meeting in July, 1934. It is not even recorded in the *History of the Corps* and perhaps few R.E. officers know that in 1858, when gold had been discovered in British Columbia and a gold rush from California had ensued, a body of 150 Sappers, selected from volunteers as potential settlers, sailed from England, under Colonel H. C. Moody, to the west coast of Canada, and for five years formed the chief agency of opening up British Columbia and at the same time represented the armed forces of the Empire. The scope of their work was wide: they explored, they surveyed and issued maps, they founded the capital, they located the roads and constructed many of them, they erected buildings, they even designed the Colony's coat of arms and postage stamps. Above all, their presence was a guarantee that British Columbia developed by orderly methods and avoided the chaos which similar conditions had produced farther south. The company was disbanded in 1863; nearly all the rank and file remained in British Columbia—the last died in 1927.

The article describes all this in detail and very appreciatively. Though a minor incident in Corps history, it is one which contributed to great results and one of which the Corps has every reason to be proud; and it is good to know that our services to British Columbia are not forgotten there.

E.V.B.

THE INDIAN FORESTER.

(*October*, 1936.) By far the most interesting article, at least from the point of view of the layman, in this number is "Specimens for the Zoo," by A. F. Minchin, who describes the means to be taken for the safe transport of the smaller fauna by sea. For instance: "A friendly drink with the Captain will usually result in reptiles accompanying a passenger, travelling free of charge, and if objection is raised to carrying live snakes it can often be met with the suggestion that they should be stowed in one of the ship's lifeboats." The reviewer feels glad that the days of his voyages to and from India are over. Again, "In the Madras Presidency, one of the boldest snake-catchers of our time was Mr. H. A. Latham. A perhaps untrue but anyhow appreciated tradition of him runs thus: Deep peace and a hot weather afternoon. Mr. Latham, the Conservator, returning through the forest from inspection: in his right hand a butterfly net, and in his left, clasped at the correct spot, an incensed snake he had caught. A stout Range Officer (name unfortunately not discovered) completes the scene; meditative, yet keeping his distance from the reptile, following home his officer. Sudden transformation: Mr. Latham is away fifty yards after a butterfly! whilst the Ranger stands frozen with horror! In his hand the neck of the lively serpent that had been flung into his keeping before his mind had begun to work!"

Yon (*Anogeissus acuminata*) a Burmese wood, has been found very efficient for making tool handles, etc.

Major Edney's article on "Dowsing," in the June number of the *R.E. Journal*, is quoted at some length. An editorial note points out the value of the science of dowsing in forestry.

(*November*, 1936.) The number opens with an account of the Hailey National Park, for the preservation of wild life. The locality—in the U.P. at the point where the Ramganga debouches on to the plains—is ideal. The article is well illustrated with photos. The hope is expressed that a system of fair weather roads, now under construction, will open up the area to visitors in two or three years' time.

"The Punjab Erosion Conference" is worth reading, while "Irrigation Research" contains some interesting facts and theories on the subject. Experiments have been made in America to show that vegetation is not nearly as thirsty as was supposed; in certain counties in California, irrigation charges have been reduced from £7 10s. to £1 5s. per acre, with no loss of yield.

In a review of an American book *Erosion Control on Mountain Roads*, Mr. Gorrie mentions an experiment in "contour-wattling" on the newly raised embankment of the Jhelum railway bridge. "Contour-wattling"—very successfully employed in America—implies the staking down of grass or brushwood fascines at a V.I. of about a foot on slopes likely to be eroded, while the intermediate spaces are sown with suitable seed. The result, in which the stakes do their part by sprouting, is that erosion is very quickly prevented by a thick growth of vegetation. Another wrinkle concerns the making of roads on sidelong ground, where the spoil, instead of being hurled down the khud, is conserved in a framework of iron or reinforced-concrete, serving as part of the foundation, and thereby saving a large amount of excavation.

(*December*, 1936.) An article on "Charcoal burning in the South Pegu forest division" is reminiscent of the days when charcoal was the one and only disinfectant known in the Army, and illustrations of improvised kilns were to be found in field-works manuals.

We learn that in the cotton states of America, cotton fabric is being used in road construction, as a reinforcing membrane between the foundation and the bituminous surfacing. The idea seems too expensive for adoption except where cotton fabric is extremely cheap.

F.C.M.

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