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CONTENTS.

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THE LATEST METHODS OF ROAD CONSTRUCTION FOR HEAVY MOTOR TRAFFIC.

A Lecture delivered at the S.M.E. on 25th October, 1923.

By BRIG.-GENERAL LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., C.I.M.E., A.I.C.E., Memb. Inst. of Transport.

THERE are various aspects of roads on which I could speak to-night. There are those which concern the financial and the engineering points of view, while there is also the commercial, the political and the national value of roads to be considered. In addition to these there is the military aspect, which specially concerns you. But I must confine myself to the subject of this lecture, although a few general remarks by way of preface and conclusion, however, are permissible.

The origin of roads dates back to the earliest times, when, thousands of years ago, the paths used by man followed the tracks beaten flat by wild beasts through dense undergrowth in temperate climes, and the jungles in tropical countries. When the civilization of Rome was at its zenith, the road-maker was busy, as he is always where civilization is most progressive and of a high order. But it is remarkable that from these Roman times to the days of Napoleon, Macadam and Telford, a period of about 1800 years, the world boasted no famous road-makers. Most of the roads made by the Romans degenerated in a century or two into uneven trackways, fit only for riding or for pack animals, and it was not till the end of the 18th century and the beginning of the 19th that the increase and demands of wheeled traffic compelled more attention to roads. The military needs of European wars between 1800 and 1815 and General Wade's campaigns in Scotland led to a revival in road-making in order to increase the mobility of troops and facilitate their supplies. It is an interesting fact that all the great road systems in Europe and Asia, and, in fact, all over the world, had their origin in wars, or invasions by armed forces.

The change which has taken place in our system of transport and design of roads since 1900, when motor-cars and lorries first began to be used considerably on our roads, is in reality and not only in name, a revolution. Twenty-five years ago the only mechanical vehicles allowed were traction engines moving at four miles an hour and preceded by a man with a red flag. Axle loads in these days did not exceed six to seven tons, and long periods elapsed between the passage along a road of one mechanically-propelled vehicle and the next. Now we have lorries with axle-weights up to 10 tons moving at comparatively high speeds in their tens of thousands in every direction. In addition, the speed of the ordinary motor-car has commonly risen to about 30 m.p.h., and these conditions have altered the problems with which the road-maker has to deal to such an extent that, in my opinion, new methods are needed to withstand the traffic of to-day and of the near future. The two methods by which this can be done are, firstly, by the gradual reconstruction of some of our roads, and, secondly, by the building of new trunk roads designed from the beginning to carry the heaviest and fastest traffic.

The structure of a modern road outside urban areas may be defined in general terms as a triple-section pavement laid on mother earth. First of all there are the foundations which are all important. Secondly, upon them is built the lower section of the crust—the sub-crust, as it is called. And, thirdly, on the surface we are now placing a layer of some sort called a "carpet" made of various materials such as asphalt, tarred granite chippings, bitumen and sand, or of some other semi-plastic and water-proofing material. The chief cause of the destruction of any road is the passage over it of heavy weights moving at fast speeds, and the blows delivered and the impact caused by the bumping of heavily-loaded wheels against any obstruction, however slight, on the surface of the road or on the further side of a pothole. If a road could be made so that it would remain absolutely smooth the wear would be small. Then there are other destructive agents such as great heat or cold, heavy continuous rains or movement of subsoil. Sometimes the temperature of the surface may be as high as 160° Fahr. under a midsummer sun and as low as zero in winter. Nine-tenths of the actual destruction is not caused by surface wear, as is the popular impression, but by the movement of the individual stones in the bed, or sub-crust of the road underneath the carpet. It is quite a common experience when pulling up a modern road for repairs to find the stones on the surface in their original positions, and only slightly worn, the natural broken angles being still quite sharp. But the stones below will be found worn and rounded like water-worn pebbles in a river-bed or on the seashore. This process of internal wear is called inter-attrition. Some years ago, on the London and Exeter–Southampton road, near Staines reservoir, a new layer of red granite was placed on the existing worn gray granite beneath. In course of time, when this road began to bear heavy traffic, the mud on the surface was gray in colour, though the surface material was red, showing clearly that the wear taking place was in the sub-crust of the road, a proof of the truth that it is inter-attrition and not surface wear which chiefly destroys a road.

In regard to heavy mechanical vehicles, the maximum axle weights allowed by law and the regulations made under it, have been increased recently from 8 to 10 tons. Heavy motor vehicles are also allowed to draw two trailers (at a reduced speed), and the combined loads sometimes run into considerable weights. The power vehicle weighs, say, with its load, 10 tons, and two trailers 5 tons each, or 20 tons in all. Sometimes, at a slower speed, a traction engine weighing at least 16 tons can be seen drawing three trailers each of 8 tons weight, making a total weight in the four vehicles of 40 tons. With loads such as these our highways, bridges and culverts, in addition to public service mains conveying water, gas, etc., have to bear stresses for which they were never designed when built say 15 to 20 years ago. And the cracked culverts, walls and ceilings in villages situated on much-used roads testify to the shocks caused by this new heavy traffic on the road structure.

To appreciate what these weights mean, especially the axle weights, I would ask you to remember that to-day, in railway locomotive practice, the axle weights of the heaviest express passenger types—such as the latest Great Northern type—and of the heaviest goods locomotive, do not exceed 21 tons per axle, while the majority of locomotives do not reach 20 tons load per axle. As traction engines have often an axle load—quite illegal—of 12 tons, and ordinary motor vehicles 10 tons per axle, you will see that we are asking the road to-day to bear, in some cases, more than 50 per cent. of the weight borne by steel rails weighing 100 lbs. or over to the yard. It is clear, therefore, that a revolution in the system of road-making will have to take place if roads are to stand such great weights without constant and costly remaking and strengthening. Perhaps we shall have even to return to plateways, where heavy traffic is continuous, as the most economical form of road, though the first cost is heavy. In addition to this, the ordinary speed at which the average commercial vehicle is driven far exceeds the legal maximum of 12 m.p.h. In daily practice on the open road commercial motor vehicles up to 10 tons total weight, without trailers, exceed 25 m.p.h.—20 m.p.h. being a very usual speed—and with trailers, 15 to 18 m.p.h. If the smallest amount of corrugation exists on the road surface, the bumping action set up by such vehicles at such speeds is most destructive to the surface and especially to the sub-crust and even in the foundations.

The diagram illustrating impact which is shown in Fig. 1 on page 540, indicates how quickly the force of the blow delivered increases with speed.

Road engineers have been searching for some years for the type of road which will not disintegrate under heavy fast-moving loads, and for the perfect surface, or at any rate, the surface which will not corrugate. The real cause of corrugation is still unknown, scientifically speaking, whether on roads or rails. It is natural,

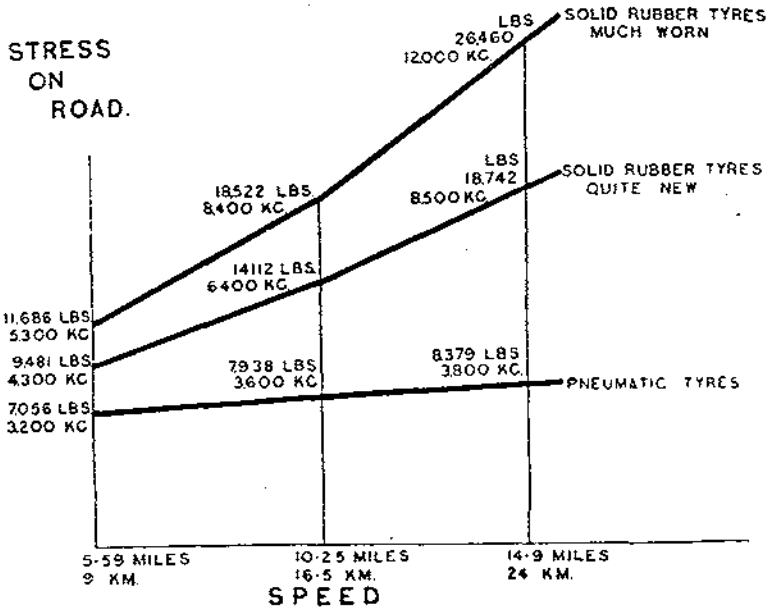


FIG. 1.

therefore, that a great deal of attention should recently have been concentrated on concrete roads, either carpeted or not, for concrete to a large extent seems to resist corrugation. In the U.S.A. to-day there are over 10,000 miles of such roads, most of which have borne their loads fairly well so far. But from my own observation of such roads there, here, and in other countries, I am not sure that our present system of laying concrete is ideal for anything connected with surfaces. As a foundation, however, or as a super-foundation or sub-crust upon breeze, broken stone or chalk, concrete, reinforced or not, presents many advantages. But the effects of heat and cold in the contraction and expansion of concrete are difficult to provide for. If we leave joints, either longitudinal or transverse, the edges of these joints are soon damaged by the traffic, and if the joints are filled with bitumen and sand or some other filler, when the concrete expands in summer this mixture is squeezed out, producing disagreeable results to boots and wheels. Again, every winter gaps reappear, and when they are refilled, the same process of extrusion takes place the next summer. So far as our experience in this country is concerned, although it is more expensive, it seems better to put a carpet on a concrete road, either in one or two layings, and the joints or cracks then look after themselves or are not so serious. In the diagram, FIG. 2, you will see the system as at present in use on the Winchester–Southampton road, which will shortly be bearing traffic amounting to nearly 5,000 tons a day. There are also instances of similar construction in Middlesex, where there are

TWO-COAT BITUMINOUS ROAD SURFACE AS LAID ON SOME MAIN ROADS IN THE COUNTY OF HAMPSHIRE.

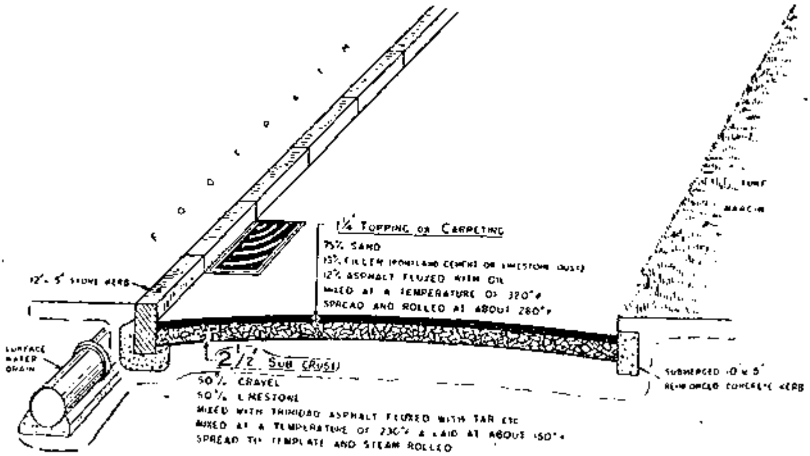


Fig. 2.

now roads with 9 in. of plain concrete and 2 in. asphalt carpet, costing altogether about 15s. per square yard. On the well-known Bath road east of Colnbrook, there is a stretch of road made on the two-coat carpet plan which has been down for ten years and has required very little maintenance, and in this case there appears to be several years' life still left in the surface.

Taking a number of roads which are known to me, I should say that, with a traffic of about 5,000 tons a day, a two-coat bituminous carpet, laid on a solid foundation of tarred or grouted macadam or concrete, should last at least 15 years. For the first five years the cost of maintenance should be negligible. During the next five years the cost should not exceed 3½d. per super yard, and 6d. to 7d. should cover the cost of patching and partial renewal from the 10th to the 15th year. Even then the surface should have some useful life left. Therefore, in my opinion, which, I am glad to say, is confirmed by competent county surveyors, though we have not been able to obtain any absolutely accurate data (because the system has not been in existence long enough) I think I may say that a well-made road on this principle, even with a heavy and fast traffic of 5,000 tons a day, should stand for 15 and possibly 20 years without entirely resurfacing. In the case of the Northern & Western Motorway, with which I am associated, on the 226 miles' stretch of road between Uxbridge and Liverpool, we hope to make various tests with regard to different surfacing and foundations, and the present plans are to use 9 in. of concrete, possibly reinforced, and on a portion, at any rate, of the road we hope to try both concrete carpeted and uncarpeted.

Besides the concrete road there is the grouted road, of which there are many good examples. This is made of hard stone rolled in with some bituminous substance such as the "Invicta" fluid. Owing to the homogeneous character and wear-resisting qualities of this form of construction, and owing to the sub-crust being amalgamated thoroughly with the foundation and carpet, combined with a certain amount of internal resilience, the grouted road promises to last at least as well as any other method of road-making and it resists corrugation very well. There is a piece of such road laid five years ago running through Epping Forest, and another stretch on the Great North Road near Potter's Bar, both in good order. Another instance of this may be seen near St. Albans on the Holyhead road, where a road made on this principle was laid nearly ten years ago, and even now presents a very fair surface, though it is slightly uneven in places. The average traffic at this point, as shown by a recent census, is about 3,500 tons per day. The cost of a grouted road is about two-thirds, or even less, compared with a road built with concrete and carpeted.

The third, and, in my opinion, the only other type of road (outside urban areas) which will bear continuous heavy and fast traffic with any degree of success, is that made of stone setts. Types of this road may be seen in many parts of Lancashire, in some of the streets of London, and in the ancient and modern *pavé* of France. This type of roadway, though expensive to build, costs very little to maintain if properly constructed, that is, with the setts laid in sand and jointed with bitumen or tar. In fact, the wear-resisting qualities of such a road are probably superior to that of any other type. But against this must be put the disadvantage of increased noise and a certain roughness of surface, the former being a nuisance to the frontagers and ordinary users of the road, while the roughness produces a jarring effect tending to intensify the wear and tear of mechanical vehicles passing over it. I am unable to deal here with other roads of the town type, such as those made with wood blocks or specially-laid asphalt.

I now sum up the types of road suitable for ordinary modern traffic on our trunk roads in order of their resistance to wear, as follows :—

(1) Stone setts ; (2) concrete with a two-coat bituminous carpet ; (3) macadam grouted with bitumen.

Nos. 2 and 3 may, in the opinion of some road engineers, be reversed, and I admit that experience so far shows little between them, but grouted roads are more difficult to build up properly. As to our old-fashioned water-bound roads made with hard stone or gravel and rolled in with water and mud, these are useless when traffic is at all heavy, and the annual repair bill is so high that at the end of ten years or less it would have been cheaper to scarify the upper crust of the road and make a new waterproofed surface on any of the three systems I have outlined above.

As to the cost of the three types of road, stone setts may be taken as costing somewhere about 35s. to 40s., reinforced or ordinary concrete with a two-coat bituminous carpet about 15s. to 17s., and grouted macadam about 8s. to 10s. per super yard.

In regard to the repair and maintenance of all types of road, the watchword should always be: "Patch in time." Once potholes begin to develop, every wheel, even those lightly loaded, intensifies the damage, and in a very short time, especially in wet weather, the surface is worn through and the sub-crust becomes exposed. Water then may get through to the foundations of the road, leading to serious disintegration when the first frost and thaw occurs, for the road, being sodden, will then expand and contract, and the area round the pothole will prove a sore not easily healed.

There is another type of road which is now in an experimental stage but has many points of interest. Rubber blocks keyed on to an asphaltic base and to expanded metal are being laid on concrete. Such a system is to be seen laid three years ago in St. George's Road, Southwark, and more recently in Whitehall. The cost of such a road is about three times that of wood-paving, namely 85s. to 90s. per super yard. In Southwark the cost was 90s. and in Whitehall, which was laid about two months ago, I am told the cost was 80s. to 85s. Such extra expense can only be justified on the ground of such a surface outlasting other methods, or being superior in some respects. I am all in favour of this experiment with rubber being carried further, but I should doubt whether, at the present moment, the wisdom of laying any of the principal main roads of this country on a large scale with rubber blocks is proved either from an engineering or financial point of view.

The cost of maintaining roads compared with tonnage conveyed is showing a tendency to fall, owing to stronger methods of construction. In the year 1890, in the neighbourhood of Glasgow, it cost ·36d. to carry 1 ton 1 mile, and this figure fell to ·28d. in 1910, rising slightly in 1922 to ·31d.; these are cheering figures, even though the gain in economy to the ratepayer is relative and not actual.

If heavy and fast traffic is a serious matter on Class 1 or main roads, with a grant of 50 per cent. of the costs from the Road Fund annually, it is clear that on second class and unclassified roads construction and repair are a greater problem. These unclassified roads include something like 80 per cent. of the total mileage of roads in this country. Where second class or unclassified roads have not been strengthened recently, the heavy traffic has already done considerable damage, and the expense to local ratepayers of road-making and mending is bound to increase. Even supposing the Class 2 roads can stand, with the grant of 25 per cent. from the Ministry of Transport, the strain of modern traffic, there remains still the serious problem as to how the expense of maintaining the unclassified (or, as they used to be called, 3rd class) rural roads of this country is to be met in future. It is obviously unfair to ask the local ratepayers, already highly rated, and often local tradesmen, to help in keeping up to a standard not required locally a road over which rivals from a neighbouring town bring goods to compete with them in heavy motor vehicles. In the country districts, also, the principal local ratepayers in general, such as farmers, do not see why they should contribute nearly the whole cost of 3rd class roads over which perhaps 75 per cent. of the traffic nowadays is of non-local character. Without going further into this controversial subject, you will understand from these remarks that the problem of who is to pay for the new heavy and fast traffic on our roads, especially the 3rd class roads, is by no means easy to solve. In fact, I may say that, difficult as are the engineering problems of the road-maker to-day, they are easy compared with the financial problems and the settlement of the proportion to be paid by the user, the ratepayer and the taxpayer, and that is the State.

Of course, the ideal to aim at, at any rate in the main roads of this country—we will call them national trunk roads—is that a road should be built like a sound building of any kind, to last more or less for ever. Nor is there any engineering reason why this should not be done. It is a question of the first expense of sufficiently good foundations, the discovery and application of the perfect surface and the cure of corrugation.

Flat roads or plateways, without camber, have been suggested. I need hardly tell an audience of Royal Engineers that it is far more scientific, at any rate in theory, to continue to make roads on the principle of the flattened arch, varying the camber from 1 in 66, or even less in the case of very wide roads, to 1 in 33, or even more on roads less wide, with inferior foundations. Recently I have heard of experiments with a type of road laid like a floor, with sleeper walls of concrete or steel joists, and slabs of concrete or steel placed upon them. I do not say that such a road may not eventually be devised which will show unusual wearing qualities and retain its shape. But I fear that a flat construction will tend to sag in the centre, or unevenly, and, in addition, there is always the problem of drainage, which, without camber, would mean a central drain if not transverse gratings or drains as well.

In conclusion I will mention the general principles which the progressive road engineer should bear in mind. Primarily, he should think of roads as being made suitable for the traffic rather than the traffic made to suit the roads. This axiom must not, however, be pushed too far. Everything has its limits of strain, including roads, and co-operation is essential between the designer and user of the vehicle, and the road-maker. Much can be done by proper design, by the resiliency of springs and tyres, and the reasonable limitation of speed and weight

Roads are great national institutions and transport is the life-blood of the nation, ebbing and flowing through its arteries and veins. Cheap and rapid transport, moreover, is essential to our commercial prosperity, more now than at any former time in our history. Railways, which some thought twenty-five years ago were the final and best method of transport, we see now have limited uses, and are unable, except in few cases, to deliver from the place of origin to the destination. And as, in this country, no important manufacturing district is more than 120 miles from a seaport—for instance, Birmingham to London Docks—unlike America, where manufacturing districts are sometimes a thousand miles from the seaboard, it follows that a form of transport in which many handlings can be avoided is one which, in the long run, must gain in popularity in these days of the high cost of labour. Except in cases of the most heavy and cumbersome goods, for which the railway is the best carrier, transport without intermediate handling from the factory door to the shop or to the ship's side should be the ideal for commerce.

But road transport, though it costs more for power per ton mile than rail trausport, may yet be cheaper. It may be asked why this should be so. You will recall the calculation that it needs a 15-lb. pull to move a ton carried on a clean steel wheel running on a clean steel rail. Even on the average smooth carpeted road it takes about 40 lbs. to move a ton on a rubber-shod wheel, or nearly three times as great an exertion of power. This disparity is considerable, but it has been calculated that each average handling in connection with goods sent by railway transport is equal in cost to about 11 miles of actual moving by rail. It will be easily comprehended, therefore, that handling has become more important and more costly than the extra power required per ton to move an equal load. Power, in fact, in recent years, has become cheaper and labour dearer, till the advantage of the lesser consumption of power has disappeared. That, in my opinion, is the real scientific reason underlying the growth of road transport. We are now at the commencement of a new era of road transport and we must prepare for it. For the purposes of peace and war alike we must realize that nowadays roads must convey heavier loads at high speeds.

From the military point of view, in which you are particularly concerned, in the British Army to-day over 75 per cent. of the tonnage in wars in countries with roads will be conveyed at some period in mechanical road vehicles, and for a successful campaign, therefore, designers and constructors of roads, and armies of road-makers, will be needed. That is where you come in. The lesson taught everywhere in the Great War—in France, India, Italy and Palestine, was that good roads, military mobility, and rapid and easy transport, are the necessary preludes to the successful issue of any campaign. Cæsar and Napoleon, in their times, grasped this fact—the immense value of " road power " in war.

Twenty years ago Rudyard Kipling said that " Transportation was civilization." I can go further than the new Rector of St. Andrews to-day and say, " Good roads make a nation." There is no more interesting, wonderful and inspiring profession than that of Road-maker—he who smooths Earth's rugged bosom for the service of man.

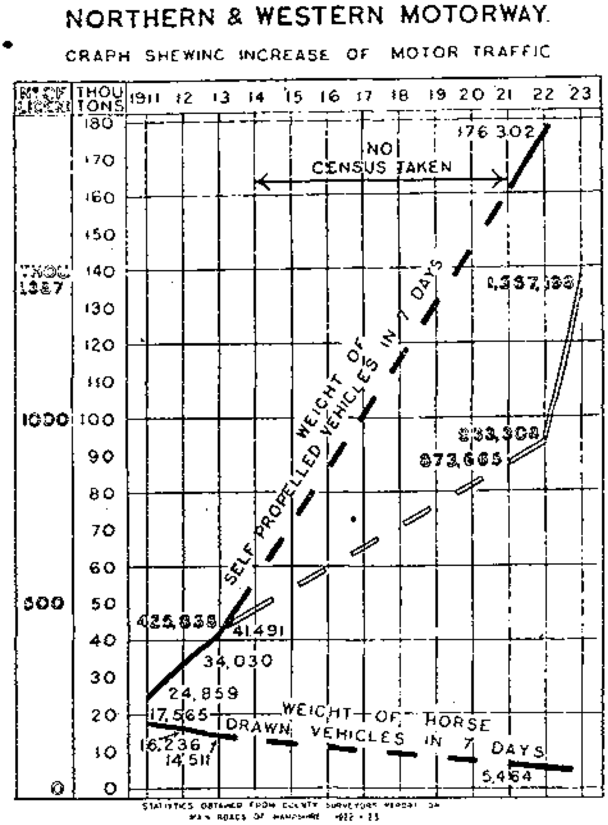


FIG. 3.

The author desires to express his acknowledgments to Mr. W. J. Taylor, County Surveyor of Hampshire, for the use of the diagrams.

THE DISMANTLING OF HELIGOLAND.

By Colonel J. C. Matheson.

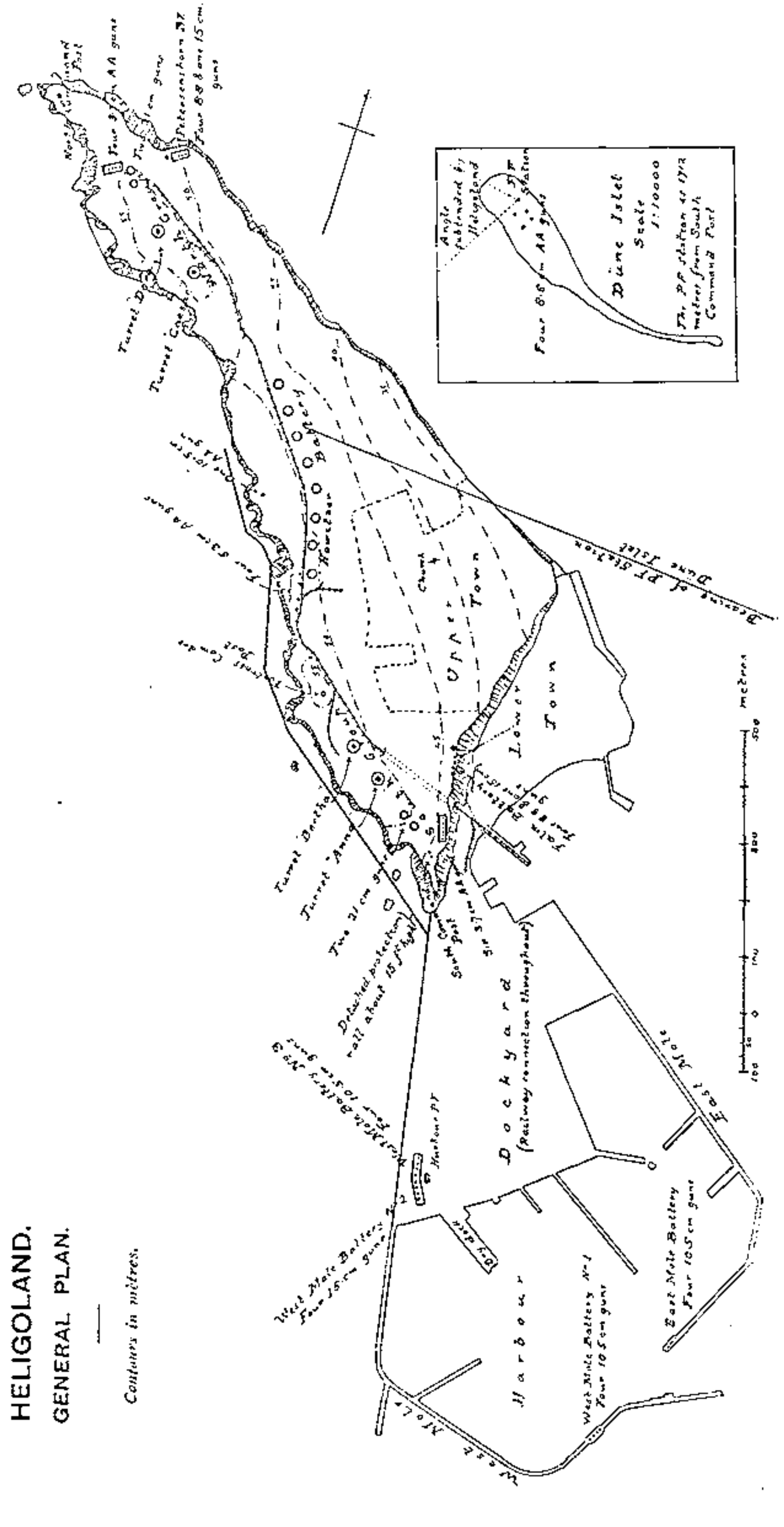
The inhabitants of Heligoland can hardly have welcomed the results of their transfer from the sovereignty of Great Britain to that of Germany in 1890, as it has entailed so many changes in their minute island. It was a pity for them that "self-determination" had not been invented then, as they were not asked their opinion on the subject. Within a year of the island's coming under the sway of the Kaiser changes began which greatly altered even the physical features, and the process continued until the Great War broke out.

To the south of the rock a large war harbour was created for destroyers, submarines and sea-planes, with repairing shops and stores. The Unterland, that short strip of beach at the south of the island, certainly remained much as it had been, but the Oberland suffered many changes. It is at best but a very circumscribed area, a triangle some 1600 yards long with a 600 yards base. Outside the little town it had consisted of potato fields. These had to be curtailed severely. Room had to be found for large barracks, while the fortifications took a heavy toll. The very contours of the table-land were altered greatly when the North Group of guns was installed on a miniature mountain, fashioned out of the material blasted out of the rock in forming the maze of subterranean stores and war shelters. (*See Plan*).

After all this was done the area left for potatoes was very small, but the "Kartoffel Allee" remained to preserve their tradition.

Then the Great War came and Heligoland has felt its results, more, perhaps, in proportion to its area than any other place within what one may call the "radius of rupture." At the beginning of the war those Heligolanders who had retained their British nationality were imprisoned, and the remainder were all removed to Blankenese, near Hamburg. The close of the war and the Versailles treaty brought fresh changes, since Heligoland as a base had to be dismantled.

An interesting article in *Smith's Dock Monthly* for June, 1923, by Admiral Sir Edward Charlton, K.C.B., the head of the Naval Inter-Allied Commission of Control, gives an account of the actual dismantling. If any of the inhabitants of Hamburg, who used to flock to Heligoland for their summer holiday, have been in doubt as to who won the war, their next visit will answer the question.


HELIGOLAND.
GENERAL PLAN.
Contours in metres.
Upper Town
Lower Town
Dockyard
(Railway connection throughout)
Harbour
West Mole
East Mole
Düne Islet
Scale
1:10000
Four 8·8 cm AA guns
Bearing of PF Station Düne Islet
Detached protection wall about 15 ft high
Turret "Anna"
Turret "Bertha"
Turret "Caesar"
Turret "Dora"
East Mole Battery
Four 10·5 cm guns
West Mole Battery No 1
Four 10·5 cm guns
West Mole Battery No 2
Four 15 cm guns
Battery
Church
metres

The war harbour no longer exists, its remains now constitute a rocky shoal which shelters the old anchorage from the westerly gales. The fortifications are demolished and the underground works filled in and the potatoes are triumphant.

The Heligoland Sub-Commission, of which the writer was for some time a member, arrived at the island on H.M.S. *Coventry* in February, 1920, to superintend the business of demolition. Two days after arrival they met the German Commission and arranged procedure. Naturally, the meeting was not characterized by its cordiality, but no exception could be taken as to the correctness of behaviour on both sides. The work of demolition was carried out by some 500 to 600 Germans under the supervision of the Sub-Commission, and the men worked well and gave little trouble.

At first some German mine-sweeping vessels used the harbour as a base and their crews showed obvious disapproval of our presence. This was manifested by assembling outside the hotel which served as quarters, singing "Deutschland über Alles" and throwing a few stones at the building. However, this was quickly stopped and an apology was tendered by the O.C. Mine-sweepers. It is rather interesting that the author of that Teutonic-soul-stirring effusion composed it at Heligoland years ago, whilst he was sojourning there under the British flag. The singing referred to above took place round a statue of the author which has been erected there.

Admiral Charlton mentions three points of special interest in the work of demolition:—

(i) *The War Harbour.*—The German Commission included the engineer who had constructed this and now he had to assist in its destruction, surely a unique record. The sides of the dry dock (which projected into the harbour) were blown up, the moles had their foundations destroyed by explosives, and the winter gales, always heavy, soon made them a mass of ruins. The reclaimed ground, on which stood the dockyard buildings, had openings made in its retaining walls and the sea sucked out the millions of tons of sand brought from the Elbe for its formation. Thus the whole place has been wrecked in such a way that no new harbour could be constructed on the site.

(ii) *The Fortification Works.*—The engineer officer on the German side of the Commission had been "C.R.E." of Heligoland for some time during the war, and he, like the harbour engineer, must have found it a unique experience to "hand over" to a Royal Engineer officer and conduct the latter through all the intricacies of the Kaiser's "Holy of Holies." His distasteful task was, however, carried out with dignity.

The fortress, as Admiral Charlton remarks, resembled a huge unsinkable battleship, the guns being in turrets and most of the works were underground. These were demolished systematically.

Party walls were removed, a few pillars being left. These were then blown up and the roofs fell in. (*See* Photo of South Group taken before demolition of the supporting pillars. The wire-netting was to prevent the projection of pieces of concrete, etc. The Photo shows the two-metre roof of ferro-concrete.) The resulting spaces were then filled in and planted over.

(iii) *The Destruction of Metal Structures.*—Most of the guns were in turrets or cupolas and the control stations and P.F. cells were also armoured, so that there was a vast mass of metal to be cut up and removed. To effect this, the oxy-hydrogen or oxy-acetylene flame was used for steel and the pure oxygen process for cast-iron.

The guns and turret armour were all cut up by one of the first two processes, the gases being contained in cylinders at a pressure of 150 atmospheres. To one who had not seen much of the process previously it was intensely interesting to see the 16-in. steel armour of the turrets being cut up in this simple manner.

The armour round the turret beds was chilled cast-iron (the French technical term for it being "*avant-cuirasse*"). It was of the usual section of a curved mark of exclamation. To cut this up the pure-oxygen process was employed. The gas, contained in cylinders at a pressure of some 115 atmospheres, was led to the point of application by flexible tubing ending in a long length of steel tube, about ½-in. external diameter and five-sixteenths inch internal.

To start the process, the end of the steel tube was first heated to redness and the oxygen turned on through it. The gas combines with the steel at the heated end and the combustion, once commenced, continues, the steel tube being quickly burned away as the metal operated on is melted. The process is based on the fact that the heat produced by the combustion of steel and oxygen is much higher than that required to melt cast-iron.

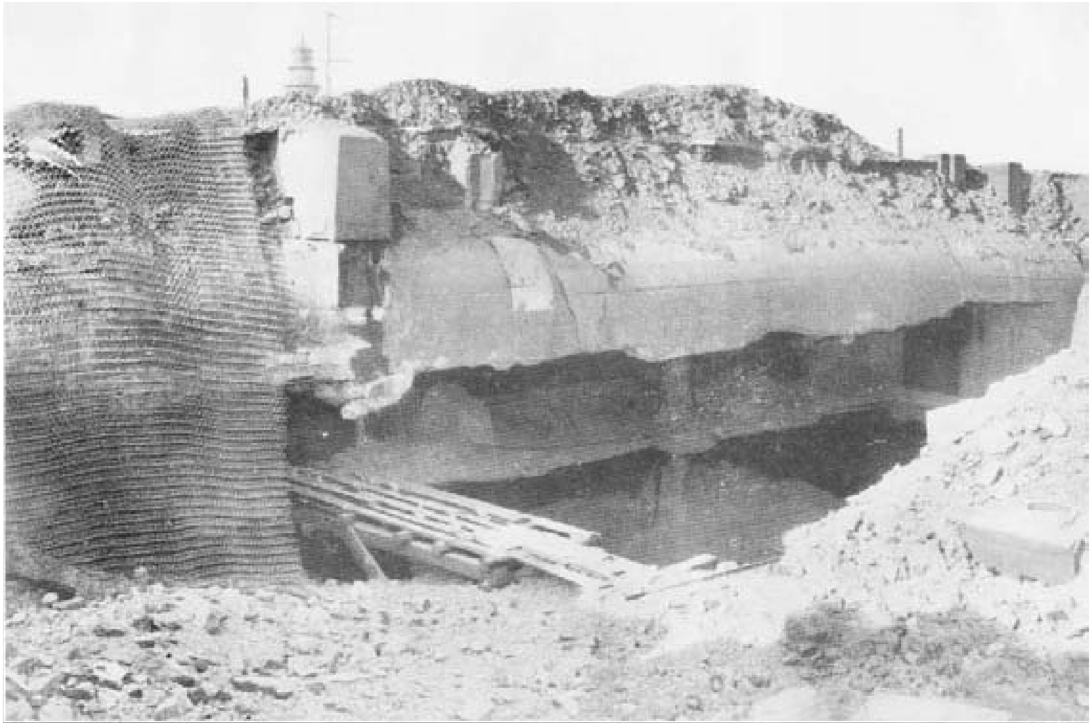
The average length of steel tubing required per lineal foot of 3-in. hole burned into the armour was 20 ft., and the time taken just half an hour. The holes thus made were charged with explosive and the metal was broken up, about 1½ lbs. of explosive being required per ton of metal operated on.

All the cut-up metal was removed to Germany and sold for the benefit of the Allies.

The Germans originally stated that the dismantling would take seven years to complete, but by bringing pressure to bear on them and by altering a few plans the work was completed by the 1st June, 1922, the last item being the destruction of the inclined tunnel from the Unterland to the Oberland.

Then Heligoland was left to take up its old life as a summer resort only. Under the new conditions none of its inhabitants remain British citizens, all are now German. They are an interesting people, some 2,500 in number, Scandinavian in appearance, pleasant

THE DISMANTLING OF HELIGOLAND



Turret of South Group, showing Underground Decks before Destruction.

uced from block lent by the DIRECTOR OF NAVAL INTELLIGENCE, *by permission of the Controller, H.M. Stationery Office.*

and courteous in manner and devoted to their island home. Admiral Charlton mentions that Heligolanders, when asked what they did in the winter, replied that they counted the money which they had made in the summer. He says that they well sustained their reputation for grasping which all islanders are said to possess (not excepting ourselves !).

They show little sign of dying out, judging from the number of children. In fact, one wonders whether Mr. Mellin, who was a Heligolander and invented a well-known food for children, had been inspired by the sight of the little streets of his native land when school was being dismissed. The children, like their elders, were most friendly to the small British detachment. One small maiden gave one of the officers of the Commission as hard a task as he had had for many a year by coming up and demanding that he should start her whipping-top for her.

One of the first inhabitants to meet the Commission was a pensioner of the Royal Navy, a fine specimen of a man. He had been unable to receive his pension for some years and was anxious to see about it.

The visible remains of British rule are not many, the outstanding ones being the little Government House and a bronze tablet on the church tower, with an English inscription commemorating its erection. Search in the churchyard revealed only one tombstone with English wording, erected in memory of a drowned sailor.

Admiral Charlton adds that the fortifications and harbour had cost Germany 35 million pounds and that the garrison during the war was 4,300 strong. He also reveals the fact that during the winter of 1916–17, when the German rivers were frozen over, 66 submarines used Heligoland as a base, and mentions that during the two months of the frost 30 million pounds' worth of damage was done to allied shipping.

Even allowing for the proportion of the loss to us caused by the existence of the Heligoland base one cannot but wonder if most of the money spent on the island could not have been used in some manner more useful to Germany.

With the departure of the Commission in 1922 it would seem that British interest in Heligoland can now be only sentimental and historical.

THE TECHNICAL EDUCATION OF THE SOLDIER.

By MAJOR G. C. GOWLLAND, R.E.

IN Part I of *Educational Training* it is stated that "the aims of educational training are to continue the general education of the soldier in order to improve him as a subject for military training" and "that every means must be taken to ensure that the same attention is paid to strengthening the mental capacity of a soldier as is devoted to ensuring that he is at all times physically capable of enduring the strain of active service. The certainty of constant new inventions in warfare tends to make the success of operations depend more and more on the intelligent initiative of junior N.C.O.'s and men."

It is clear from this that those shaping the educational policy of the army realize that men must be mentally well grounded before they can assimilate mechanical facts, and that the better educated the man the easier it will be to instruct him in the intricacies of modern machines.

One aim of the Army Educational Corps is, therefore, so to train the mind of the soldier that he will be easily able to assimilate the technical knowledge that his particular Corps considers necessary.

In order to mark a man's progress in general knowledge, the Army Educational Corps have devised the certificate system. Each certificate gained means that a man has passed one milestone on the road of general knowledge. The passing of the first milestone, *i.e.*, the obtaining of a Third Class Certificate of Education is compulsory; men are ordered to school and learning is thrust on them.

Having obtained a Third Class Certificate, men are encouraged and given every facility to gain the Second and First Class as well.

In technical units there is another side to a man's education, *viz.*, his Trade Education.

In every trade there are three classes, each class gained meaning that a certain trade proficiency has been reached. In 1920 the system of grading a soldier's trade proficiency was standardized; that is to say, there was an Army system of grading, certain fixed tests for every Army trade being laid down, together with the standard of excellence required for each and every class; those responsible for framing these tests, at any rate as far as the R.E.

are concerned, having arranged such tests roughly on the following system :—

A Class III man must have a knowledge of his trade, but need only be moderately skilled at it. He is only expected to do bench work.

A Class II man must be a first-class man at his trade as far as bench work is concerned, but in addition must have certain more general knowledge of things which do not come into the range of experience of all men of his trade.

A Class I man must, in addition to being a first-class bench hand, have still more general knowledge.

What it amounts to is that a second-class man, however good with his hands at bench work, can never attain first-class trade pay, as to gain this rate of pay he must have theoretical knowledge of his own and allied trades.

Take the trade of fitter as a concrete example :—

A Class III man does simple bench fitting jobs, and must be able to use, grind and sharpen all ordinary fitters' tools.

A Class II man must be able to produce work accurate to 2/1000 of an inch, in fact, be a rather more skilled man with his hands than Class III, and in addition must be able to dismantle, overhaul and re-assemble one type of service prime-mover (I.C., or steam), and must have a knowledge of the principles of construction and action of all types in use in his Corps.

A Class I man must, in addition, be able to overhaul, test, and prepare for test any machine used by his Corps—a pretty large order. To be capable of overhauling and re-assembling an engine, a fitter must know how such an engine works. Before he knows how an engine works he must have some knowledge of the theory of steam or internal combustion engines. Before he can test an engine he must know how to take its brake horse-power, and he must also be capable of taking and reading ordinary indicator diagrams.

A man with no theory cannot, according to the recognized trade tests, rise above Class III in his trade. The question arises, when and where is the man to learn such theory? Where is the Class III fitter to learn to take indicator diagrams and test engines? Where is the Class III mechanical draughtsman to acquire a good knowledge of the elements of internal combustion, hydraulic, electrical and steam practice? Where does the Class III painter learn to have a good knowledge of the principles of paint-spraying, stove-enamelling and dipping methods?

These questions are being asked by various disgruntled soldier tradesmen who, though first-class men as bench workers, lack knowledge of theory, and consequently fail to pass their trade tests when examined by Area Trade Testing Boards. The function of the

Army Educational Corps is to prepare men's minds so that they will more easily absorb technical knowledge. It does train, to a limited extent, "handy men" at Vocational Training Centres, but the Class III tradesman has got beyond this; besides, a "handy man" cannot pass a Class II test.

No courses are run for training sappers in the theory of their trades, and yet the Army demands that tradesmen should have such knowledge. It is true that pioneers, *i.e.*, men below Class III, can obtain a six-month's trade course, at the end of which they blossom into Class III tradesmen, but here, unless they be exceptional men, their trade career will end.

It is also recognized that a limited number of men receive training as fitter-drivers at Gosport.

There seems to be some flaw in the educational system as applied to technical units.

A sapper enlists at, say, 19 years of age, is mustered as a Class III tradesman, and obtains his Third Class Certificate of Education. He is ambitious, and he, therefore, works on till he gets his First Class Certificate of Education; this, given he has application, he can get without much trouble. He is provided with books, with an instructor and with a place in which to work.

Suppose his ambition is to be a first-class tradesman, what encouragement does he get? He must have book knowledge, but the Army is not always in a position to provide the necessary books. He must have technical knowledge, but the Army provides no instruction. He frequently cannot even practise the manual side of his trade.

It is fairly obvious from experience gained in trade-testing men for the Class II and Class I rates that the technical education of the rank and file is being overlooked by company and other officers. It is clear that many such officers still have the idea that a man skilled with his hands can get Class I trade rate, otherwise sappers totally ignorant of many parts of their trade test would not be sent up to the Area Trade Testing Boards.

The company or section officer spends much time in teaching his men to shoot, dig, tie knots and turn smartly to the right or left. A sapper who has not been given preliminary musketry drill is not allowed on the ranges, yet men are sent up for trade tests without even knowing what sort of test they are supposed to pass.

It is clearly an advantage to the Corps to have as many Class I tradesmen as possible, yet no system seems to exist for helping men to improve in their trade. Such assistance should presumably be given by the company or section commanders, but apparently this assistance is not being given. An officer may not go up for his promotion examination without a certificate stating that he is in every way fit to undergo the test. A sapper, having failed in his trade test, may do six months in the cook-house and yet be allowed to go up and have another try for a higher rate of pay—usually a perfectly hopeless proposition.

It is true that in A.C.I. 789/20, para. 7, it is laid down that "The O.C. units will forward to the President of the Command Testing Board the names of men whom they recommend for test, stating that they consider them sufficiently qualified to be tested."

Every man comes up for Trial of Trade, therefore, with a certificate stating that he is qualified to be tested. This certificate is frequently valueless.

How many C.O.'s signing this form have really taken the trouble to find out if their men are really fit to be tested?

The writer has in mind a candidate for test as bricklayer who arrived armed with his C.O.'s certificate of proficiency, but who could not build a plain 9-in. brick wall in simple English bond, much less take on a Class III bricklayer's test; yet this man was solemnly stated to be qualified to do any test set him.

Something further than a list of names with an officer's signature at the bottom is required. An actual statement that a candidate has been informed what is required of him, and has been found proficient therein by the actual officer signing his proficiency certificate, might wake up company commanders to the fact that they must take a lively interest in their men's trade training, and might be the beginning of some organization within the Corps whereby the missing links of the sappers' technical training are forged.

Corps Memo., Part II, para. 24, lays down that O.C., R.E. units, will take all possible steps to improve the trade skill of the men in their units. Presumably this means that men are to be trained within their units so as to be able to qualify for higher rates of pay. This entails the running of courses, etc., by units whereby sappers could be trained in the theory as well as in the practice of their trades.

In how many R.E. units do such courses exist, or are even contemplated, and in how many R.E. units are the full practical trade-training facilities of the district fully realized? *E.g.*, a field company is in a district where there are first-class engine rooms working pumping plants, etc. In how many instances are sapper tradesmen encouraged to work in such places with a view to bettering their trade skill in the case of engine-drivers, or enlarging their sphere of usefulness in the case of the fitter? Men of the latter trade, encouraged to work with engines, will soon blossom into the fitter-driver—a trade in which there is a Corps shortage.

The Field Company commander will probably justly protest that he and his men have no time for such things, but for all that, though the practical side of trade training may present difficulties, owing to lack of time, the organization of theoretical training within units should be easy.

All R.E. officers are capable of giving their men lectures that would assist them in the technical side of their trades. Incidentally, this would keep the officer up to date, besides helping the men.

Trades roughly divide themselves into the sub-heads of metal-workers and the building trades.

In every R.E. company there are at least two subalterns. The business of the one would be to take on the coaching of the metal, and of the other the building trades. This could be done in the winter. The mere attempt to teach men on these lines would impress on the officer what is required of his men by the Trade Testing Boards. It would, in time, become a point of honour to get men through their trade tests, and ways would be found whereby sappers could be helped in the practical as well as the theoretical side of their trades. Men are proud to be in the best shooting section of a company. Why should not men be proud of being in the best trade section?

Nine times out of ten it will be more beneficial to the Corps to have a section of first-class tradesmen than a section of first-class shots. There is no reason why the shooting should not be learnt during the summer and the trades during the winter. It is merely a matter of keeping up the summer training pressure all the year round.

There are other advantages. The officer in a field unit tends to lose touch with the technical side of his profession. If he has to deliver a series of lectures during the winter on, say, the theory of steam and heat engines, he must perforce read up his subject, and by so doing will keep himself up-to-date. At the same time, the fact that the officer takes a keen interest in the man's trade proficiency will tend to foster the good feeling between officer and man.

A strenuous programme, perhaps, soldiering all the summer, engineering, etc., during the winter, but, unless some effort is made, the technical efficiency of the Corps must drop. Few really good tradesmen enlist; the ordinary recruit is young, of low trade skill, and has very little experience outside his own particular rut, for civil practice tends to keep trades in water-tight compartments.

The Corps wants men of more general knowledge, and must accordingly train them, as they cannot be got by direct enlistment.

SOME NOTES ON THE DESIGN AND CONSTRUCTION OF A POST ON THE NORTH-WEST FRONTIER OF INDIA.

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

I.—HISTORY.

THE North-West Frontier of India is guarded by a mass of hills and desolate country, the only paths through which are provided by sundry river valleys.

Roads have, from time to time, been built for varying distances up these valleys, and are held by bodies of regular troops or militia of various strength, located in posts or forts situated every 12 miles or so along the roads.

The international boundary between Afghanistan and British India is the Durand line, which lies in the midst of the hills. Going east, the first natural boundary is the River Indus.

Our frontier policy varies from time to time, and depends on the prevalence of the views of either the "forward" school (the hold-up-to-the-Durand-line school) or the back-to-the-Indus brigade. As occurs with so many problems in India, the *via media* is followed, and we find ourselves, in Waziristan, for the most part in river valleys held up to points between 30 and 60 miles from the Durand line.

The garrisoning policy has, of late years, consisted of an outpost line of militia who are controlled by the civil authorities, supported at some 20- to 60-mile distance by regular troops. In 1919 the Afghan Army advanced on British India between the Tochi and Kurram valleys. Regular troops were not available in sufficient numbers to support the outlying militia posts and the withdrawal of their garrisons was ordered. Datta Khel, at the head of the Tochi valley, was such a post, and its garrison was withdrawn to Miranshah, some 23 miles east.

On evacuation, the post was burnt and its further destruction was assisted by local Wazirs, who became hostile to us on the approach of the Afghan troops. In November, 1921, a mixed force re-occupied Datta Khel and the Resident in Waziristan made known to the local tribes the terms under which the "blockade" of the upper Tochi valley would be removed.

A temporary post was erected 100 yards from the site of the old post wherein a militia garrison of some 300 sepoys was located, and the regular troops withdrew in April, 1922, to Dardoni.

II. PRELIMINARY RECONNAISSANCE.

As it was certain that Datta Khel would be permanently occupied, although there were no definite orders for the building of a new post, it was incumbent on the engineer to make a very complete reconnaissance of what remained of the post and of local conditions, *e.g.*, water supply, building stone, limestone, fuel, clay suitable for burnt bricks, timber supplies, possibility of obtaining unskilled labour from the local tribes.

There was no trace of timber or metal in the remains of the post, though some 60 per cent. of the walls were standing. Had, however, the original lay-out been followed, a further 10 per cent. would have had to be demolished.

Water supply was found within 100 yards of the post from an old *karez* or underground (artificial) stream, giving some 700 gallons per hour. A well, much damaged, and filled with débris (including a searchlight) existed inside the post. Failing these supplies, the Tochi river was distant two miles below the post.

There was no suitable building stone available nearer than four miles.

Limestone boulders for burning to lime were to be found in the small *nala* beds within 1½ miles.

Fuel was not within sight, save rough bushes, but arrangements to buy locally up to about three tons a day could be made, at a price.

Clay, suitable for burning to bricks, was available near the water supply.

So far, construction appeared to be possible on the site, whatever the temper of the local tribes.

Timber, however, comes from the forests on the hill slopes to the south and west, and great rough-hewn logs come daily on camels down the Tochi valley.

It was, however, expected that these might be held-up or diverted by the local tribes. A " peculiar " feature of the local wood trade is the fact that the people prefer to carry logs an additional 60 miles and get a few annas increased price than to sell at Datta Khel and take a slightly smaller price.

Time seldom enters into the calculations of the Oriental.

The possibilities of obtaining, and the advisability of using, local unskilled (there is no skilled) labour was doubtful, and dependent on too many factors to be decided immediately. On demand a rough approximate estimate for rebuilding the post according to the original design was put in for Rs. 150,000.

III. Requirements.

The original post consisted of a civil portion built on to a militia portion.

The civil post contained a double-storied section wherein were all the British Officers' quarters and the Political Agent's rooms, and it also provided accommodation for the civil staff charged with the administration of the tribes in the Upper Tochi.

The militia garrison, who are under the orders of the Political Agent as far as employment strategically is concerned, were housed in a self-contained post, considerably larger than, and immediately adjoining, the civil post.

In considering the design of these frontier posts, which invariably contain both civil staff and militia, a decision has to be come to as to which portion shall be looked upon as the "keep."

It is hard to find an all-sufficient answer, because :—

1. The militia garrison may mutiny ;
2. The militia post (containing many rifles) may be rushed, as occurred at Tut Narai post.
3. The civil post has to keep more or less open house to all manner of local "badmashes" who may wish to "confer" (always at tremendous and illogical length) with the civil power, and consequently is liable to be overpowered or rushed more easily than the militia post.

It is, therefore, hard to decide which post shall command which.

The militia consider their men trustworthy, whilst the civil are usually casual to a fault about letting large crowds of locals into their portion.

The decision here was compromised by the fact that the civil portion could be rebuilt, and required no enlargement, and had previously contained the B.O.'s quarters.

Later practice at Spinwam post placed the B.O.'s quarters and the Political Agent's private rooms in the militia post on the party wall with the civil post, but on the first floor again.

The Chief Commissioner of the N.W.F. Province in December, 1921, laid down the militia garrison as 250 rifles and 30 horses—the original garrison had only been 70 rifles and 19 horses.

This was all the "higher" direction necessary, and it was then possible to approach the two persons directly concerned—the Political Agent and the Commandant of the Militia, and ascertain their detailed requirements.

India is a land of "followers," and one man never seems able to hold down a job without five others—servants, sweepers, bhistis, sowars, orderlies,—to help him.

Consequently, the Political Agent's requirements comprise: All the civil officials and their servants; the Post Office and Postmaster and the telegraph linemen; the civil hospital and all the attendants; quarters for a Public Works subordinate and store; a lock-up for recalcitrant locals; water supply and latrines and cook-houses.

The militia, too, have to be self-contained, and, apart from sepoys, need tailors, bootmakers, a sweet-seller, quartermaster's store, garages for lorries and cars, wireless telegraphy rooms, magazines, armouries, all of whom or which have to be separately housed, either from caste prejudices or other considerations. An allowance of 40 sq. ft. per man is made in these posts.

With the above requirements obtained, the quickest and most satisfactory system to proceed on is to decide on a suitable span or width for the barracks and rooms which can be followed throughout.

This permits of uniform treatment for roofing and flooring throughout.

A rough ground plan showing the arrangement of all barracks and quarters is then got out, and this, together with accommodation statements, is discussed with the two persons respectively concerned.

At this juncture, too, all defensive requirements of the post are decided—the position of the gateways, towers, keeps, loopholes, magazines, guard-rooms, wells, reservoirs and capacity, and similar matters, on which the militia commandant has opinions. Owing to the fact that the garrison is largely used for "ghust" purposes (*i.e.*, a strong offensive patrol is often being sent out) it is essential that the militia post shall be defensible, during the absence of the patrol, by a minimum garrison. The perimeter, therefore, of the post must be reduced as much as possible, which means, usually, that the post will be double-storied.

The other determining factor in the size is the number of buildings, such as horse standings, bathing places, which of necessity fill the quadrangle.

It is then possible to get out a more detailed ground and first-floor plan. All these documents are signed as approved, to avoid later controversy or change of opinion with change of command.

The money for a post of this size has to be granted by the Government of India, and it is essential, before any specification is decided upon, that the Government should say how much they are willing to spend on the project. A rough idea of the probable cost is arrived at by the plinth area method for any given specification, but conditions have changed so much of late years that few reliable data are available on which to arrive at a plinth area rate for such a post in potentially hostile country.

DATTA KHEL POST

General View.

Exterior. Civil Post.
Before re-building.

Interior. Civil Post.
Before re-building.

IV. Specification, Design, Estimate, etc.

The post is sited on hard gravelly ground, and foundation trenches were only taken down one foot (4½ ft. wide) and filled with lime concrete.

A plinth protection of 3 ft. of rammed shingle was allowed, tapering from 6 in. to ½ in.

The walls of such a post may be of a variety of natures :—

1. Stone in lime and/or mud.
2. Burnt brick in lime and/or mud.
3. Sun-dried brick in mud.
4. A combination of burnt and sun-dried brick in two skins.

The lower storey may be *pucca, i.e.*, either stone or burnt brick, with the upper *kachcha, i.e.*, sun-dried brick.

Apart from the diversity in the initial cost of these, consideration has to be given to the maintenance costs which the various designs incur. Generalizing, of course, the higher the initial, the smaller the recurring costs.

Official India tends to low initial cost, regardless of maintenance charges.

In this case stone is prohibitive, owing to the long carry. Burnt brick can be used but sparingly, because fuel is dear. It is not, therefore, difficult to arrive at sun-dried brick as the medium for the bulk of the work. External walls were 3 ft. thick with protected walls 1½ ft. thick. Protected walls were built with B.B. in mud ; pillars at 8-ft. centres to support roof joists.

Burnt brick in lime was given for :—

> Fireplaces, chimney stacks above roof level, 4 courses at top of walls, 2 courses below bedplates.

All verandah pillars were B.B. in mud, lime pointed. Walls are finished mud plastered and leeped.

Roofing :—The cheapest form of roof is double matting on *bullies*, supported by wooden joists. It is also the coolest. In this instance, rolled steel joists supporting R.S. battens, to which were clipped 24-gauge corrugated-iron sheets, were used.

An instructive point arises here. The contractor is paid a percentage over certain standard schedule rates for his work. There is a schedule rate for mat-roofing on *bullies* and wooden beams, which means he is paid a percentage on the materials which he supplies as they are all included in the rate. On a rate, the bulk of which is made up of material, and the lesser portion labour, the flat percentage tendered for all rates in the schedule may become a source of loss on a certain rate. The labour rate for fixing R.S. joists is hardly more than for timber work. All the steel work and corrugated iron is purchased by the department, and no percentage, therefore, is paid on it. This, coupled with the low cost of steel joists at the time, made this specification advantageous.

As a protection from the sun, 4 in. of rammed earth with 1 in. of mud plaster was allowed over the corrugated iron. This arrangement of mud on C.I. sheet is sound so long as parapet walls are provided. Without these the rains wash off the mud very soon and high maintenance charges are incurred.

A roof slope of 1 in 30 is allowed. The necessity for standard spans for the buildings is here apparent, as all the steelwork was drilled in Karachi, on plans submitted, ready for erection, and a multitude of spans would have made erection and sorting a lengthy process. The parapet wall had, of course, to be defensible, and in this case a castellated wall was preferred to the loophole. The loophole has a bad moral effect on men, and the field of fire, unless it is a costly ball-and-socket type loophole, is very limited. Reinforced-concrete loopholes for the kneeling position were allowed at 25-ft. intervals along the parapet wall. On the inside face a parados wall was built, also castellated. All bedplates for R.S. joists were 3-in. cement concrete cast in position.

Roof drainage is by means of down-takes at 25-ft. intervals. These have to be very open as they have been used before to-day as a means of scaling the wall into the post.

Floors for all save European and superior quarters on ground-level were rammed earth. These are maintained and leeped weekly, or as wear occurs, by the occupants. Upper-storey floors were of 1½-in. *chir* wood planks. Windows of barracks, to save wastage in glass and ensure ventilation, were all 3 ft. by 3 ft. battened clerestory type.

The guardrooms, lock-up, magazine and rifle *kōts* are all built in B.B. in lime to a height of 6 ft. above ground-level.

The magazine and rifle *kōts* are wholly-detached buildings within the post, commanded by a "keep" tower. The reason for this is that attack is occasionally made on the magazine by tunnelling.

Perhaps it should be mentioned that a round of S.A.A. sells for eightpence on the Frontier, and the short Lee-Enfield rifle goes for about £50 in the Khost bazaars.

The guardroom is placed next the main gate of the militia post and the gates of the two posts are sited together. To save the cost of bullet-proof steel doors, two brick screen walls are built out from the posts at suitable angles to protect the wooden gates from rifle fire and also to make the actual entrance way circuitous and less easily rushed.

Further, one sentry can supervise the two entrances.

The keep tower, which is sited at one corner of the militia post, furthest from the entrance gate, possesses a hinged iron ladder access to the first floor, and no entrance at ground level. It contains a supply of water and S.A.A. and, as already mentioned, commands the magazine, and the whole interior courtyard. The ladder being hinged, it can be pulled up in case of emergency. The keep tower is always garrisoned by a sentry group.

Surface drainage within the post is by means of standard gutters of three sizes, designed to present no danger to horses or obstacle to motor or wheeled traffic.

Water supply consists of two 4-ft. diameter wells, one in each post, steined with B.B. in lime, some 70 ft. deep. They are fitted with Boulton water elevators worked by hand-power, delivering 500 gallons per hour. This type of elevator is peculiarly suited to India. It is practically totally enclosed, it has no valve leathers or buckets to dry up, and the belt can be lengthened should the water-level drop. It is easily fixed at the top of the well. The elevator in the militia post delivers into a reserve storage tank built on ground-level storing 6,000 gallons, which is very ample with a potential reservoir within the post in the shape of the well itself.

For safety, and to ensure a reserve being always maintained, two draw-off cocks are fitted on the reservoir at different levels. The lower one is locked and can only be opened with the concurrence of the post commander, thus conserving some 2,000 gallons.

Bathing places, night latrines, cook-houses, stables, are included within the post, with incinerators and day latrines outside the post.

The estimate is prepared in the following sections :—

1. References to correspondence.
2. Report giving the cost and estimated time to complete.
3. Accommodation statements.
4. Abstract of costs.
5. Special conditions of contract.
6. Schedule of rates for all classes of work to be done.
7. Details showing how any special or unusual rates have been arrived at.
8. Calculations for all roof members, etc.
9. Specifications—separate for each class of building.
10. Detailed measurements for all buildings by classes.
11. Abstracted costs for each of the above.
12. Carriage charges.
13. Cost of kilns and plant, etc.
14. Cost of labourers' camps.
15. Payments to local *maliks*.
16. Stock charges and deductions from the contractor.

The drawings should show ground and first-floor plans and elevations and all details of particular construction.

V. ADMINISTRATIVE DETAILS.

The system by which work is done on the Frontier hinges on a standard schedule of rates for each locality. This schedule covers all classes of work likely to be met with in ordinary construction. The contractor tenders at a percentage above or below the schedule.

The letting of tenders for a post in potentially hostile country, 60 miles from the narrow-gauge railway, of which only 40 miles is motor road, and the last 20 barely protected, is a somewhat precarious business. A poor contractor is useless because he may fail, and he may be unable or unwilling to "placate" the local head men or *maliks*.

This leads us to the political aspect. The local tribes were havering, our hold on them was small; we were about to start a 40-mile heavy M.T. road into the heart of Waziristan with no military protection, we could not afford to incur disaffection for this project costing 4·3 million rupees as against only 0·2 million for the post.

The local *maliks* naturally wanted to be their own contractors for the post—contractors in name, employing some scurrilous Hindu to do the work. We had not the troops to raise a siege of Datta Khel, should the tribes around rise and invest it, as all available troops were being concentrated for the occupation of Razmak, as soon as the road was built to support them.

Could the *maliks* be bought off by giving them a percentage on the contractor's payments, or by buying the timber from them, or by giving them a contract for unskilled labour? The last two sops cramp the unwilling contractor's style, and are not popular.

As usual, all the native political advisers were pessimistic, and for some weeks, full of "conferences" with filthy *Wazirs* in flowing robes, the question of whether the technical would be prostituted for political hung in the balance. Eventually the *maliks* agreed on a percentage and a reputable contractor was appointed—in this case there was no tendering, as the locality was regarded as too precarious.

The contractor imposed all manner of conditions contained in Section 5 of the estimate. These are many and wonderful.

We find that the Government will:—

1. Provide protection for labourers' camps, working parties, and and convoys of material.
2. Pay compensation for abduction of labour or animals and damage to the work resulting from enemy action, or neglect by the "protection."
3. Provide labour camps and wired staging camps on the road up—will clean and water them.
4. Guarantee 500 gallons of water per hour from the Karez.
5. Erect kilns, provide tools.

It is truly hard to call these men contractors.

The protection is all arranged with the Political Agent, also the days on which the road shall be open for convoys and its protection on those days. The sites of camps along the road and the main camp at Datta Khel are agreed on with the Militia Commandant, who refuses to allow the contractor *all* the water, or to house local labour in his camp, etc.

It is possibly understandable that work does not run on ball-bearings for a day or so. Somehow, one day, something happens and another frontier post comes into being.

DAM CONSTRUCTION IN TIDAL CREEKS.

By MAJOR E. ST. G. KIRKE, D.S.O., R.E.

WITH the object of freeing from civilian traffic the existing track over the Maplin Sands, which are used for military purposes, the W.D. is constructing a road overland to Foulness Island in South-East Essex. This road will have the additional advantage of giving access to the Island at all states of the tide, instead of for a few hours only each side of low water.

The "Broomway" (*Fig.* 1), as the track over the sands is called, owing to its position being defined by bundles of sticks stuck into the sand, has been in use from time immemorial and is mentioned in documents over 400 years old. It needs no attention apart from periodic renewal of the "brooms," and heavy agricultural steam-tractors and machinery weighing 15–20 tons can pass freely along it, except when an on-shore gale has deposited a layer of soft sand.

Between Havengore Island and Foulness lies another small island, New England, into which the sea broke 25 years ago. This island has never been reclaimed and is flooded every high tide. As the road had to pass over it, there appeared the alternatives of bridging it and the encircling creeks by a pile bridge, or of reclaiming the island and running the road on its surface.

The latter was decided upon, and this involved damming either the breaches in the sea walls of the island, or the creeks from which the breaches were flooded. By damming the creeks the maintenance of a long length of sea wall was eliminated, all bridging was dispensed with and the necessary arrangements for landing material for the construction of the dams could more easily be made on adjoining dry land. Further, the main breach in the sea wall had, in the course of years, become enlarged to a cross-section almost as large as that of the creeks, with a deep central scour over 10 ft. below its bed.

Originally it was proposed to construct four dams in the positions shown A, B, C, D′ on the attached *Plan*, but a more detailed examination of the conditions pointed to D′ being moved to its present site D (so that the road could be run over it) and the sea wall being raised or repaired on the portion between A and D, as being cheaper than the construction of the dam itself at A. It was of no advantage to move "C" dam to the line of the road, as this would have left the big breach at E still open to the sea, and the sea walls between the road and B had been practically destroyed.

The actual method of constructing the dams proved an interesting problem, and for the better understanding of this a word must be said about the peculiarities of the tides. It will naturally be assumed that the tide comes in from and goes out towards the sea, but except for one or two hours before and after high tide the reverse is the case. The tide comes in from the Crouch, *i.e.*, from the land side, flooding the creeks till it reaches the level of the Broomway, which is nothing more or less than a watershed on the sands. When the tide has topped the Broomway from the land side it has also reached a similar level from the open sea, and, there being no restriction to its flow from the latter direction, it pours into the creeks, reversing its direction therein.

This feature of the tides had a considerable bearing on the best order for tackling the dams. If "C" dam were built first, half the water coming and going in New England creek would fill the reservoir formed by New England Island, and not have to pass over the site of the dam at all. Also, it would protect the site of B from the enormous volume of water hitherto draining over it from the Broomway.

Another consideration was that the creek at "C" dam was very nearly dry for one or two hours at low tide. It was, therefore, possible to form open foundations across the creek by diverting the last of the ebb from one side to the other, as occasion demanded.

The beds of the creeks are covered with mud to a depth varying from one to five feet, under which is generally, but not always, found a blue clay capable of bearing about three-quarters of a ton per square foot.

At one time it was proposed to drive a pile line across the creeks at the site of each dam, to keep the sea out while earthen dams were constructed behind them, but this scheme, while not impossible of fulfilment, presented very serious practical difficulties.

For one thing, the reversal of the tidal flow, referred to above, meant that each pile line would have to resist pressure from both directions unless the dams at each end of the creek were closed simultaneously, but the more serious difficulty lay in the volume of water to be controlled.

The creek at "B" dam, for instance, is 420 ft. across, and has a tide range of nearly 18 ft. on high spring tides, *i.e.*, from $-5{\cdot}5$ ft. to $+12{\cdot}3$ ft. O.D., with exceptional rises to $+14{\cdot}3$ ft. O.D., without wave-lap.

It has been found that, when the channel is restricted to more than half its normal area, serious scour takes place, unless the bed is protected by heavy and expensive stone or chalk pitching. The corollary of this is that provision must be made for closing nearly 200 ft. of waterway on one tide.

To drive a sufficient number of piles for this purpose on one tide is, of course, impossible, and it was proposed to drive a lower line of piles, a few feet only above the bed of the creek as a preliminary. On to this lower line was to be fishplated an upper line of piles to give the necessary height. This upper line of piles could only have been closed on one tide by assembling them into shutters, laying them handy on the bed of the creek, and raising them into position by means of an aerial cableway, without interlocking the ends of adjacent shutters.

The difficulty, however, of driving the lower line of piles accurately to line and level was found to be almost insuperable, owing to the extraordinary resistance offered by accumulated oyster shells; and the two hours allowed by the tide for placing the shutters would have allowed no more than a few minutes each. When it is remembered that failure to place the last two or three shutters would have led to a destructive wash-out, and that two dams had to be closed at the same time, the probability of there being a better and cheaper method of tackling the problem became apparent.

Owing to the creeks at C and D being nearly dry for two hours at low water it was possible, as explained above, to excavate the foundations for the dams in the open, and this rendered piling unnecessary for sealing these two dams against underscour or infiltration.

There then remained, as materials of which to construct the dams, earth or concrete. Either would have to be protected against the rush of tidal water, restricted more and more as the height of the dam rose, but there was the essential difference that if the concrete survived twenty-four to forty-eight hours, according to the time of year, it would be hard enough to resist further attack, and in any case a wash-out would not destroy more than a day or two's work at the worst, whereas earth, if its protection failed, might, and probably would, wash out right down to the bed of the creek.

Further, the amount of earth required would be about ten times that of concrete, owing to its low angle of repose, so there was not much difference in the question of cost.

For these reasons concrete was decided upon. As regards handling it, the quantities involved clearly pointed to machine mixers and Decauville tip wagons for running it out to site. Also, in view of the distance, and lift over the sea-wall, hand-pushing was out of the question, so 20-h.p. petrol tractors were obtained from Longmoor, being kindly loaned by the Commandant, Railway Training Centre.

The obvious aggregate was Thames ballast, which could be brought by barges alongside the steam cranes on the military pier at Shoebury for under 4s. per ton (about $\frac{3}{4}$ yd. cube). Between the pier and the site of work existed a railway for three miles, and this was extended, with material mostly on hand, to each dam in turn. Cement also

Fig. 3.

Fig. 4.

Fig. 5.

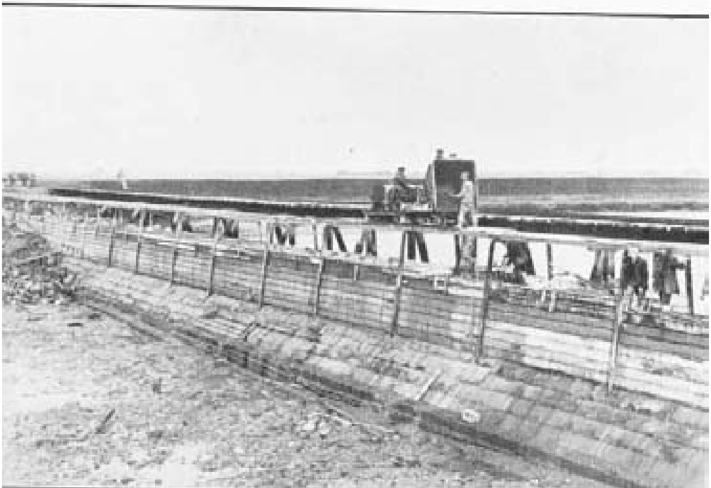


Fig. 6.

FIG 5 & 6

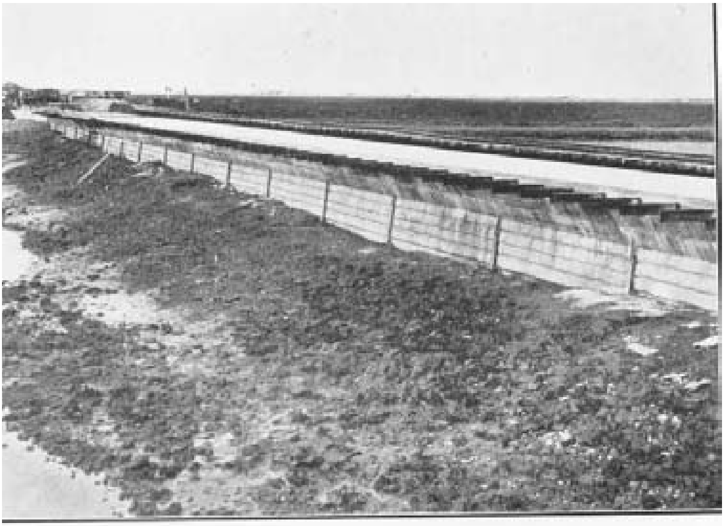


Fig. 7.

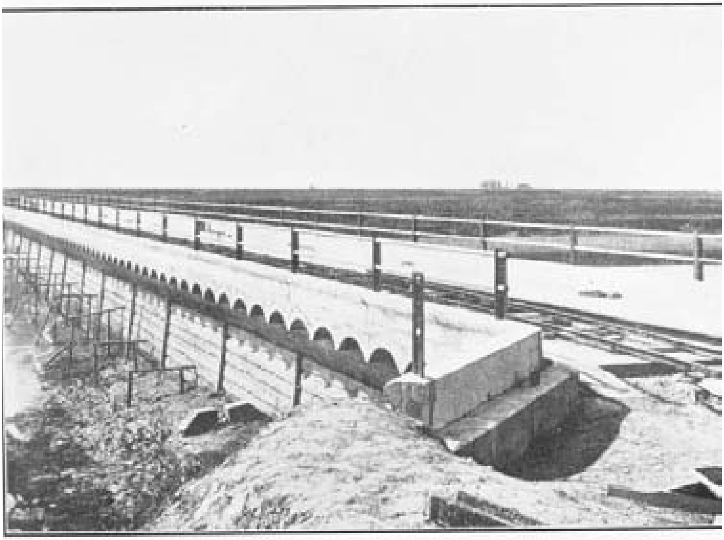
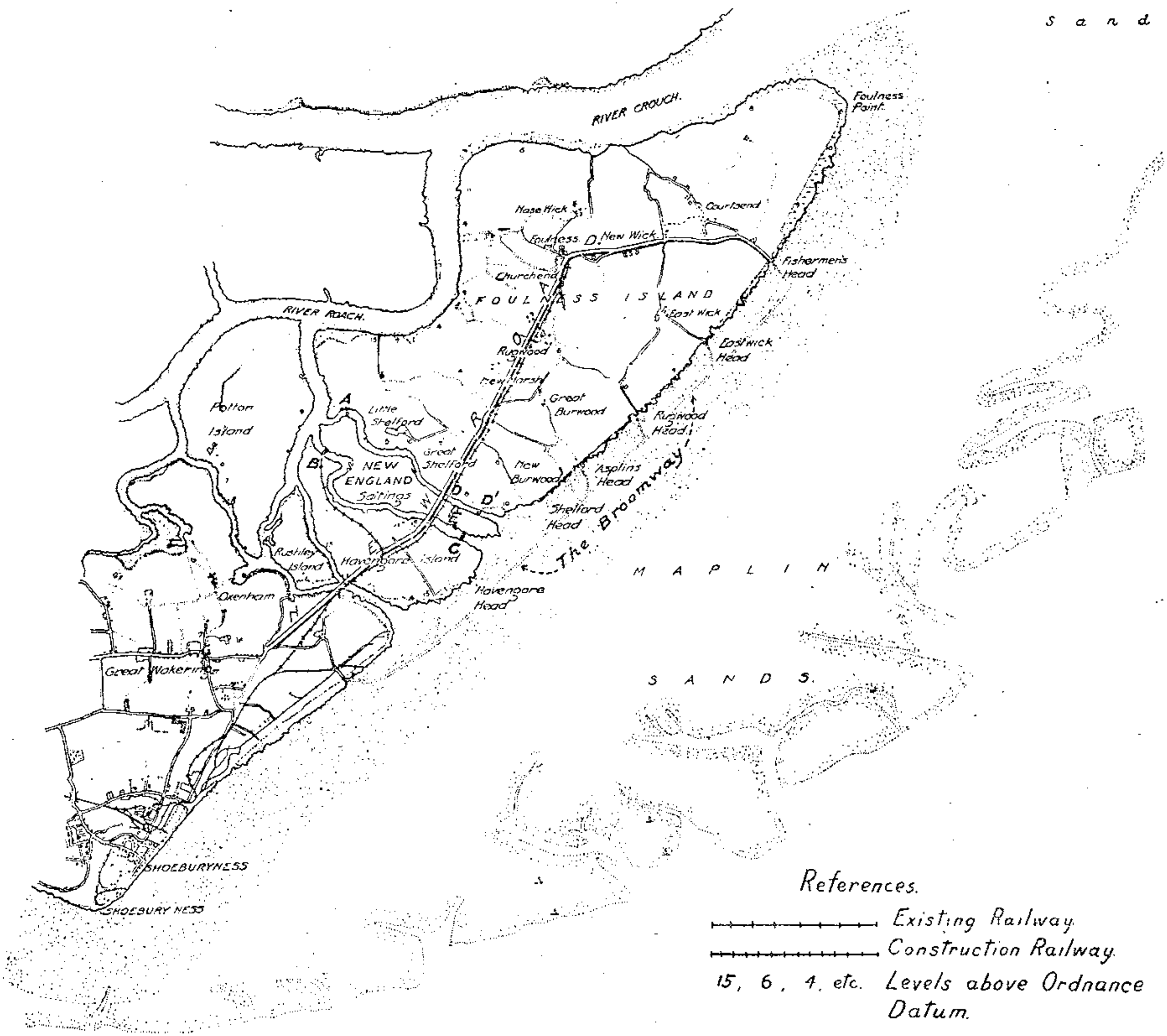


Fig. 8.

FIG 7 & 8

FIG 9



References.

Existing Railway.

Construction Railway.

15, 6, 4, etc. Levels above Ordnance Datum.

could be landed at site by the same means considerably under schedule prices. (Barging material direct to site was out of the question, as loaded barges could only pass over the Maplin Sands on high spring tides.) Last, but not least, workmen were conveyed to and from work, and saved a wearisome trudge morning and evening.

The dams as constructed, or being constructed, are each of a different character. "C" was the first to be built, and is a dam pure and simple, which will, when "B" is completed, be loaded on one side only. The length of the concrete portion is 240 ft.

"D," which is described below in some detail, is really only a causeway, as the tide rises and falls on each side of it. It was, however, designed as a dam in case "A" dam should ever be built. Its primary function is to carry the road, but it also serves to stop the tide-race up and down the creek, with consequent erosion of the banks and sea walls. The length of this is 350 ft., of which nearly 300 are concrete.

"B," the largest dam of all, is still under construction, and will be closed by dropping shutters down between reinforced concrete piers, founded on a concrete floor, enclosed between two low pile lines.

"D" Dam.

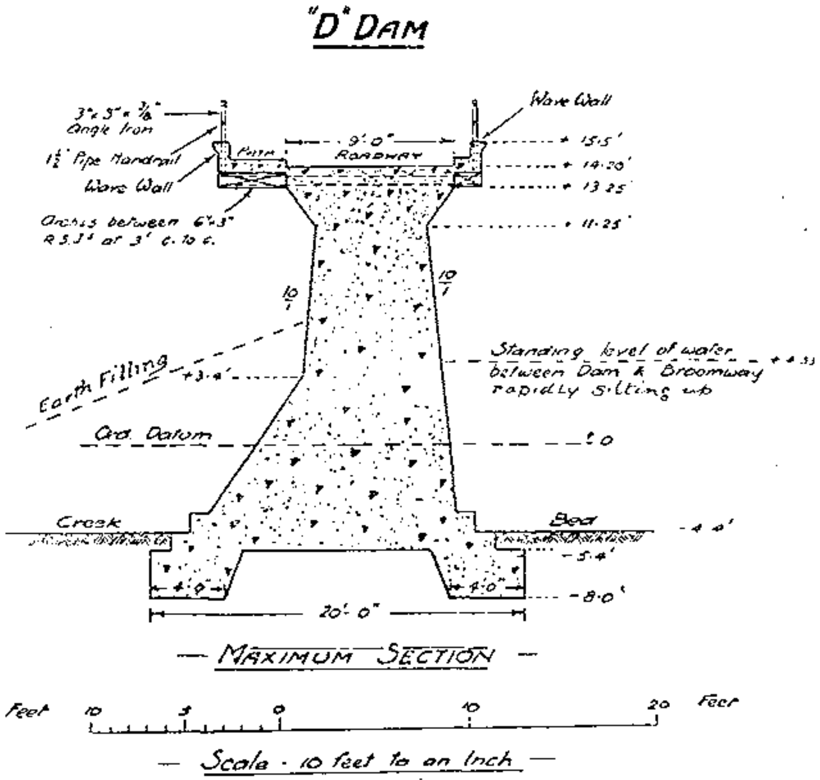
The lay-out of the mixer station was so arranged that the Thames ballast could be run in trucks alongside the mixers and shovelled direct into the hoppers. A full day's supply was six or seven 10-ton trucks. At the same time a turn-out was laid so that a truck of cement (one day's supply) could be placed at the side of the mixers. This reduced carrying to a minimum.

A Decauville line, with a loop in front of the mixers, took the concrete in tip-wagons to the site of the dams. The simplest way of carrying this line over the creek was to build piers of pre-cast concrete blocks, which could be placed in position at low tide upon small concrete foundations. It would not have been safe to build these piers to the full height of the dam, owing to the resulting weight on the mud, and the moral certainty of their being overturned if any slight scour occurred. They were accordingly made only six to eight feet high, and were incorporated in the dam, as the latter rose. Care had to be taken to remove seaweed clinging to these piers before concrete was placed round them.

Fig. 2 shows the Decauville supported across the creek, and how 45-lb. rails were clipped together with steel sleepers to form the track without the use of girders. One intermediate sleeper between each pier would have been sufficient, but two were used for subsequent convenience in forming a pathway between the metals.

Piers were placed alternately 14 and 16 ft. centre to centre, as this suited both the 30-ft. rails available, and also the 14-ft. and 16-ft. piles, which were used for casings to the concrete.

This *Fig.* also shows the toe-walls being excavated to conform to the section of the dam, and the concrete being tipped from the Decauville immediately after the excavation. This was necessary, as the sides fell in under the slightest provocation. Shoring of stakes and old corrugated iron was resorted to where necessary.



At the end of each day's work a sandbag wall was built. This kept the concrete clean, could easily be removed, and left a good broken surface for the next day's concrete to key on to. There was no question here of laying concrete in layers of specified thickness. This would only have resulted in each layer being covered with mud by the incoming tide, or in the sides falling in before each section was complete. By bringing the toe-wall at once up to the level of the creek bed, it could be covered up with sailcloth and weighted down with rails, piles, sandbags, etc., so that the tide passed harmlessly over it.

Fig. 3 shows the last section of the landward toe-wall being excavated and the concrete standing by on the Decauville, ready to be tipped as soon as required.

Between the toe-walls the mud was removed so as to expose the clay upon which to rest the body of the dam, and a levelling course was then constructed across the bed of the creek. As mentioned above, it was possible to divert the last of the ebb from one side of the creek to the other, so that one or two hours' concreting was generally possible before the tide returned. In neap tides, however, the tide sometimes did not recede far enough to permit of any work being done.

Fig. 4 shows the dam four courses above the levelling course, and the wooden profiles which were at first used to give the correct slopes. These profiles were really unsuitable as they were constantly being displaced by the tide. The same happened to wooden shuttering for the concrete, and it was found that no amount of weighting down with rails or piles would prevent this. As a result it was decided to use rails for the profiles, and steel piles for the shuttering, which could be wedged against the foot of the rail profiles, as shown in *Figs.* 4 and 6.

The piles were not stiff enough without one intermediate wiring to resist bulging under the weight of the concrete, but when so wired proved quite satisfactory.

Fig. 4 also shows the original Decauville and its piers protruding above the concrete, and how the rail profiles were used to form piers for the high-level line, when the lower one ceased to be useful.

At the level of the dam shown in this photo, the tide still ebbed over it from the Broomway even at low water, and the nearest bay to the camera of those over which water is flowing has been left at a lower level to form a spillway. This was sufficient for a short period on each tide to relieve all the other bays of water, and allowed them to be concreted dry.

The concreting of the spillways themselves took a certain amount of care. Shutters were placed on the water side and sacks of clay stuffed round them. By this means the rush of water was sufficiently checked to make the depositing of concrete possible. The difficulty of the water still flowing was got over, first by making the concrete 33 per cent. richer, and secondly by pushing the concrete forward from one side of the gap as each successive batch arrived from the mixer (at three-minute intervals), so that only one edge of it was subjected to the flow.

A certain amount of cement was of course lost, but no leaks were traceable to this cause. On only one occasion was there a failure to close a spillway at the first attempt, and this was caused by the tide returning an hour before it was due and catching the freshly-deposited concrete before it could be properly protected.

There is no doubt that by pushing concrete forward into water in this manner, instead of dropping it, the resulting mass can be made as satisfactory as if laid on dry land in the ordinary way.

The method of protecting newly-deposited concrete from the incoming tide, and the force of the latter, can be seen in *Fig.* 5. Sailcloths are spread over the concrete and weighted down in position by rails, piles and sandbags. To the ends of the sailcloths (under water) are attached rails to keep them from being lifted, and they were made of sizes to fit the work.

Fig. 6 shows the dam still further advanced and above the level of the Broomway, so that there is no water to interfere with construction for several hours a day.

There can also be seen the high-level Decauville resting on the rail profiles; the sheet piling being used as casing for concrete; the method of wedging it against the foot of the rails; and the vertical chocks to which were attached the intermediate wirings.

Fig. 7 shows the corbel for the roadway; the cross girders to carry the footpath; and the concrete road over the dam nearly finished. The mass of earth against the dam needs a word of explanation. The lake between the dam and the Broomway is at present over 8 ft. deep, and nearly a mile long, but every tide brings with it quantities of sand in suspension, which is deposited in the lake.

In time, probably under a year, if one may judge by a similar occurrence at "C" dam, this sand will rise to the level of the Broomway. There will then be, against the southern face of the dam, several feet of semi-liquid mud, in place of water, with a very much higher specific gravity.

It is to meet the extra thrust, which this mud will impose, that about 3,000 cubic yards of earth have been provided on the landward side.

Fig. 8 shows the work practically completed, with wave-walls and railings. The cost of this dam, exclusive of wear and tear of machinery, was £5,200, as compared with the estimate of £8,025 for the original piling scheme, without roadway.

The amount of concrete placed was 2,500 cubic yards, and of earth, 3,500 cubic yards, including 500 placed on the seaward side as additional protection against infiltration.

The average number of men employed was 20, though in the early stages, when only two or three hours a day could be worked at low tide, as many as 40 could be accommodated. For the remainder of the day they were transferred to the road on Foulness.

The dam took a year to construct, but of this period about two months were lost through inclement weather, and the necessity for pushing on with the road to facilitate a W.D. housing scheme on Foulness, which is Government land.

No contractor was employed, the work being carried out by direct labour.

The proportions of concrete used were one bag of cement to

$\frac{3}{4}$ cub. yd. of Thames ballast for ordinary work, equivalent to 1 : 7½ when allowance is made for the shrinkage of ballast concrete on setting, and one bag of cement to ½ yd. ballast, or 1 : 5 for foundations and closing spillways. The roadway is of 1 : 4 concrete.

It may here be mentioned that cement is weighed by the makers into sacks to the nearest pound, resulting in far greater accuracy than can be obtained by measuring boxes, and the use of the latter always means wastage, particularly when there is a wind blowing. To minimize loss by wind even from sacks, these were always emptied into the mixer-hopper when it was only a quarter full, so that its sides might act as a wind-screen.

Mixers were placed in pairs, one ½ yd. and one $\frac{3}{4}$ yd., so that each strength of concrete could readily be mixed, and each mixer served as a stand-by to the other in case of a break-down. This was found to be a very necessary precaution with the second-hand plant employed, although it is only fair to say that the almost invariable cause of stoppage was the magneto, and not any mechanical defect. Cheap sparking plugs were a false economy ; it is essential to have a kind which can easily be taken adrift for cleaning the porcelains.

It was found that elevating hoppers were unnecessary, when ballast was unloaded from trucks. They were even a disadvantage, as being liable to break down, and at the best taking time to function.

Quick-setting cement was tried for this dam, but experience proved that, unless it was used within about ten days of manufacture, its quick-setting properties disappeared, and it then set more slowly than ordinary cement. This is no reflection on the quality of the cement, which was far above standard in tensile strength, but was due to the absence of dry storage accommodation.

Cement of all kinds was purchased by the barge-load of 100 tons or more, and took a week after manufacture to arrive on site. It was not practicable to lay it all in the few days remaining during which the quick-setting properties survived.

As very satisfactory results were obtained from ordinary cement when protected by sailcloths (as described above), the expense of providing suitable storage was not justified.

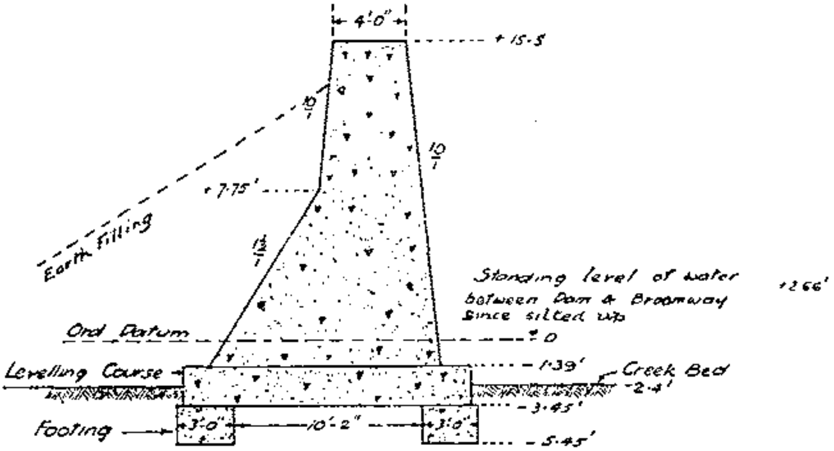
Salt water was used for concrete in this dam, and caused fifty per cent. slower setting, but on the other hand enabled work to be carried on regardless of frosts, during the winter months.

"C" Dam.

Fig. 9 shows "C" dam complete, except for the earth-backing. This dam was constructed on much the same principle as "D." The chief difference was that, in place of rail profiles, the correct slopes were given by setting pre-cast concrete blocks at 15-ft. centres on each face, and fixing the shuttering against them.

The blocks weighed 4 cwt. each, but were often displaced by the tides, and were not easy to handle under the Decauville. The latter was raised, course by course, 15 in., as the dam rose. Less trouble would have been experienced if the blocks had been made narrower in a direction at right angles to the face of the dam, so as to offer as little resistance as possible to the tide, but they had all been made before this necessity became apparent. In fact, their construction was the only work possible on this dam when the tide drove the men out of the creek; the road was not then available as an alternative occupation.

"C" DAM



— MAXIMUM SECTION —

The cost of this dam was approximately £3,200, including 1,730 cub. yds. of concrete, 3,000 cub. yds. of earth, and joining on to an adjacent earth dam over another branch of the creek. The concrete worked out at 32s. 6d., and the earthwork at 1s. 6d. per yd., but these figures do not include depreciation of machinery. The time taken, including the laying and dismantling of half a mile of broad-gauge railway to the site, and lay-out of the mixer arrangements, was four months' actual working time.

As in the case of "D" dam, all work was carried out by direct labour, which was at the outset unskilled in this class of construction.

The force of water rushing over these dams when partially completed invites consideration of the use of tides for the generation of power. The difficulty usually found is that turbines, however satisfactory they may be on a falling tide, can no longer function when the tide has turned and is rising against them.

In this connection a suggestion made by one of the many visitors to the dams, whose name the writer has unfortunately forgotten, seems well worth putting on record.

The scheme consists in the provision of :—

(*a*) A high-level lake, to feed the turbines, filled from the sea at high tide through automatic lock gates which close as the tide falls, and impound the water in the lake. These lock gates will be familiar to those who know the fen country, as they are to be seen on most of the important " drains."

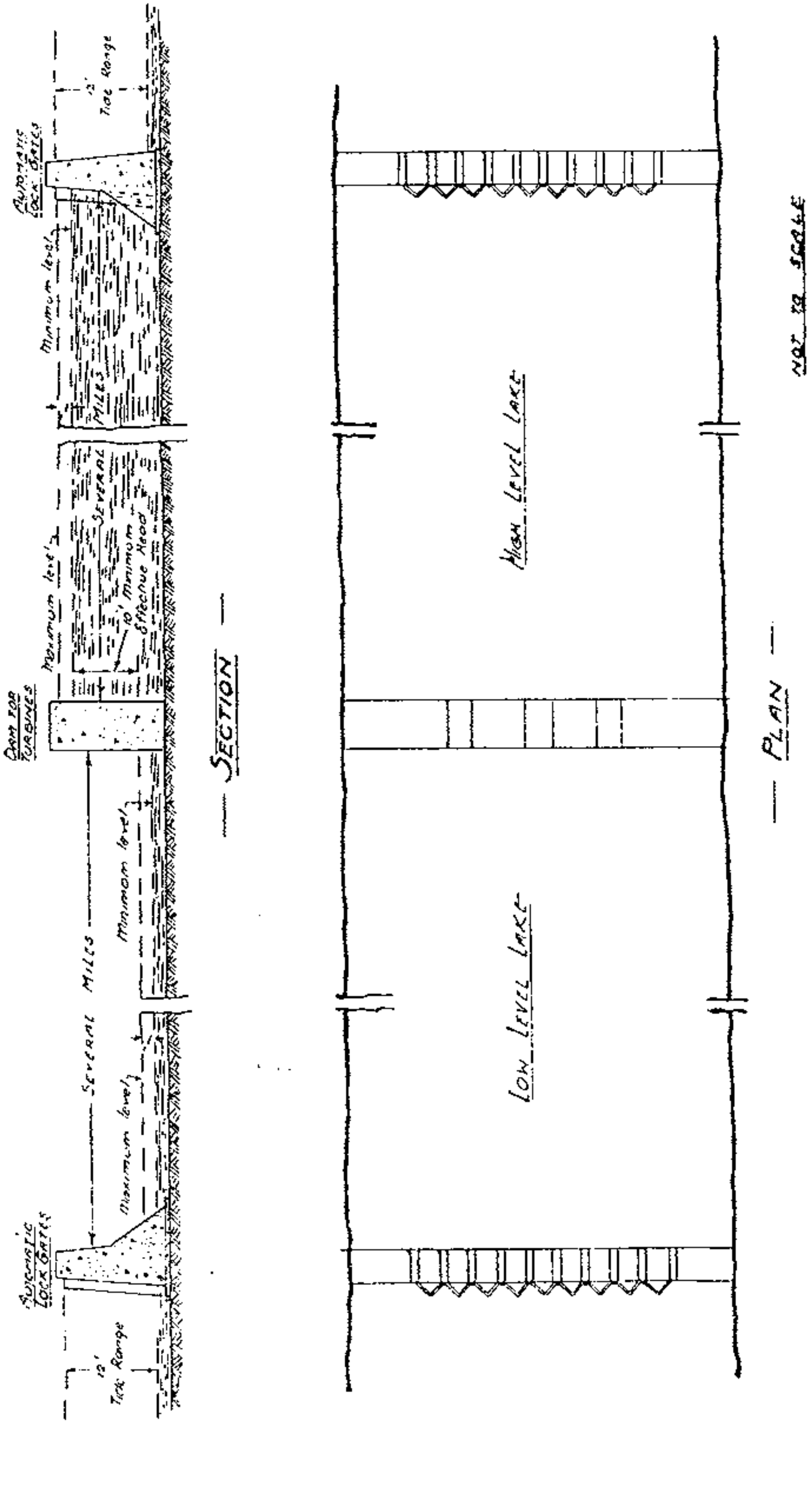
The lake must contain enough water to drive the turbines for over twelve hours between tide and tide, without its level dropping more than a foot or 18 inches.

(*b*) A low-level lake of sufficient size to receive the outfall from the turbines without its level rising more than a foot or so in the same period. This lake discharges into the sea every low tide through similar automatic lock gates at its lower end, and these close against the returning tide, leaving the lake once more at low-tide level.

The minimum head always available for driving the turbines would, under this scheme, be the difference between the lowest level of the upper lake and the highest level of the lower.

Both lakes must, of course, be measured in miles to be capable of serious power-station work, and it is essential to have separate connection with the sea for each lake. Both these conditions are admirably fulfilled by some of the oyster-bearing creeks of the East Coast, though it is doubtful if a minimum head of even 10 ft. could be ensured on neap tides.

Three dams would be required for each power station, the outer two to carry the line of lockgates, and the intermediate one to house the turbine. The two following diagrams will make this clear.


Automatic Lock Gates
12' Tide Range
Minimum level
Several Miles
Maximum level
10' Minimum Effective Head
Dam for Turbines
Minimum level
Several Miles
Maximum level
Automatic Lock Gates
12' Tide Range
Section
High Level Lake
Low Level Lake
Plan
Not to Scale

REPORT ON THE WORK CARRIED OUT IN R.A.O.C. WORKSHOPS ON THE REPAIR OF WORN COMPONENTS BY ELECTRO-DEPOSITION.

By CAPTAIN J. P. McLARE, B.SC., A.M.I.E.E., R.A.O.C.

THE principle of the electro-deposition of metals has been applied commercially for a very great number of years in such processes as electro-plating, " cold " galvanizing, electro-refining of metals and in electro-typing and copying. It was not, however, until during the war, when the difficulty of obtaining supplies of spare parts for the vast and widely differing collection of guns and carriages, aeroplane engines, M.T. vehicles, etc., became so very acute, that the idea was evolved (by, it is understood, the Royal Flying Corps) of utilizing this means for building up the worn parts and making them serviceable again.

Experiments were carried out in France, more or less simultaneously, in the Repair Shops of what was then the R.F.C., the R.A.S.C. and the R.A.O.C., and, though there was a great difference in the type of parts requiring treatment passing through the respective workshops of these three units, they all found that the process could be successfully and economically applied for the repairs of many parts hitherto scrapped on account of wear. Deposition plants were, therefore, gradually built up and, though they remained to a great extent in an experimental stage up to the cessation of hostilities, a great deal of work was done, and an enormous saving made by the number of parts put back into service.

It may be interesting here to record that the process being carried out in France became known at home, and an Electro-Metallurgical Committee was set up in connection with the Ministry of Munitions, mainly through the instrumentality of the Sheffield University, for further research into this and other subjects, and to improve the methods and apparatus in use. Amongst the experiments carried out under the auspices of this Committee was an endeavour to build up the " A " tube of a 12-in. howitzer which had been accidentally machined to too great a diameter. This experiment, which was performed at the Coventry Ordnance Works, was somewhat ambitious at this stage of development of the process, and was only partially successful. It sufficed to show, however, that repair by this method was quite a feasible proposition, even in the case of a large job of this description, and that success would come with further experience.

At the end of the war the deposition plants in France were dismantled when the workshops, with which they were associated, were broken up, and the personnel employed, which was never very great numerically, was dispersed. A good deal of knowledge and experience gained was therefore lost, as apparently no extensive records were made at the time of the procedure adopted by the different units concerned ; and later, when it was thought desirable to have a consolidated record of the process for use in possible future emergencies, it was necessary to collect information from various sources and to cover, by experiment, a good deal of old ground. Fortunately, some of the R.A.S.C. officers concerned have written a paper on their process and various experimenters have since published results of their researches which have assisted in advancing knowledge of this method of repair, and at least one firm (originated by members of the staff of the R.A.O.C. deposition plant at Havre) is applying the process commercially, so that it has by no means been allowed to die.

In the R.A.O.C. Workshop at Chilwell, a small plant has been arranged and efforts have been made from time to time to develop the process with the primary object of having in the Corps the necessary knowledge available in the event of war to lay down and work a plant in the field for the repair of various valuable gun and carriage parts. So far, owing to the comparatively small wear which occurs in Ordnance in peace time, and the number of new spare parts available to replace any which do become unserviceable, there has not been any scope for a deposition plant in anything more than an experimental way.

A few practical jobs, however, have been done of which descriptions are given later. It is proposed first of all to describe briefly the development of the process and indicate the stage to which it has now been brought.

DEVELOPMENT OF THE PROCESS.

It is understood that the R.F.C. initiated the process by depositing copper upon various engine parts to make up wear and to enable standard spares, such as ball and roller bearings, to be refitted to them. The deposition of this metal does not present any great difficulty, for, after cleaning the job and giving it a preliminary coating of copper in a cyanide solution, almost any desired thickness can be built up in an acid sulphate bath. The usefulness of copper, however, for this class of repair work is very limited, as it can hardly be applied to form an actual bearing surface, on account of its comparatively high coefficient of friction and its liability to "seize," and even when used only as a "packing" to restore parts to their original plan size, it is, on account of its comparative softness and ductility, liable to extrude, and looseness of fit soon redevelops.

Very hard electrolytic deposits of copper can, however, be obtained by employing suitable solutions and current densities, so that the problem of extrusion can be eliminated with due care, and therefore, considering the ease and rapidity with which copper can be deposited in comparison to iron and nickel, its usefulness in an emergency for certain classes of work is not to be ignored.

The process of repair by electro-deposition, having thus been initiated, the next step was to endeavour to deposit some other metal of more general utility than copper; a metal suitable for building up an actual rubbing bearing surface or ball race. It was known that practically all the elemental metals used for engineering purposes, and even some simple alloys such as brass, could be deposited electrolytically from solutions of their respective salts, but there is a wide divergence in the ease with which the different deposits can be obtained, and also in the nature and physical properties of the deposits. However, as the use of nickel for electro-plating purposes, and of iron for electro-typing, was universal, these two metals suggested themselves as being most likely to satisfy requirements. Development thus proceeded on these lines, iron being used chiefly by the R.F.C. and R.A.S.C. while the R.A.O.C. in addition accomplished great things with deposition of nickel.

In the early stages it was found impossible to obtain sound and adherent thick deposits of iron upon the basis metal (usually steel), as the preliminary cleaning process had not then been perfected. The cleaning so far was done on the lines of that usual in the electro-plating industry, and consisted of removal of grease or oil by petrol, boiling in caustic soda solution, scouring and finishing in an acid dip. Such preparatory treatment is suitable when very thin deposits only are required, as in providing articles with an ornamental or protective coating, but for the thick deposits now required it did not give a sufficiently high degree of adhesion, and as the deposition continued, it was unable to withstand the tension which is set up in an electrolytic deposit, and consequently "peeling off" ensued.

The practice was therefore adopted of giving the job, after cleaning, a preliminary coating of copper in a cyanide bath. The adhesion of this coating was fairly sound, as the cyanide solution itself has certain cleansing properties, being able to dissolve any slight films of oxide which may exist on the surface of the work, and in addition the evolution of gas at the cathode tends to drive off extraneous matter. Having received this coating of copper, which took only two or three minutes to effect, the job was washed, and without giving it time to dry and oxidize, was transferred to the iron depositing bath. In this it was found possible to put on a thickness of about ·003 inches without risk of peeling off of the deposit, and when sufficient time had elapsed to give this thickness, the job was removed, washed, and put back in the cyanide bath for a further deposit of copper. This "sandwich" system was repeated until the total thickness of deposit required for the repair had been put on.

This system of building up enabled a fairly thick deposit to be made, but the adhesion to the basis metal and between the various layers left much to be desired, and more often than not, the deposit stripped off while being machined, or if not then, shortly after the particular repaired fitting had been put back into use. There were the further disadvantages that these deposits varied considerably in hardness, and as they were not capable of being heat-treated, they were of little use in cases where a hardened surface was necessary.

In order to obtain a greater degree of adhesion and to eliminate the necessity for copper coatings, attention was directed towards improving the cleaning process, as it was recognized that the secret of success lay in this direction. The aim was to obtain an absolute "chemically clean" surface on the portion to be built up, upon which deposition could commence the moment the job was placed in the bath. It was discovered after a time that the substitution, for the acid dip, of an electrolytic acid bath in which the job was placed as anode, gave good results; further improvement was subsequently made by the introduction, in addition, of electrolytic alkaline baths, and after experiment had decided the compositions of the solutions of these baths for consistent results, the cleaning problem was more or less solved.

With this improved cleaning process it was found possible to put fairly thick deposits of iron direct on to the basis metal and the adhesion was so good that heat treatment could be given and articles case-hardened when required. Such heat treatment, so far from loosening the deposit or impairing the adhesion, greatly improved matters, as micro-examination revealed the fact that the deposit then became thoroughly merged into the basis metal and the previous clear dividing-line between the two disappeared.

From this point, development was sought in the direction of gaining knowledge of depositing solutions and their working, and this involved considerable experiment and research.

The most suitable substance from which to make the iron-depositing electrolyte proved to be ferrous ammonium sulphate. A dilute neutral solution was eventually adopted as being that which apparently gave the most reliable and consistent results, and in order to prevent pitting of the deposit by the clinging of hydrogen bubbles to the work, and to keep it in contact with electrolyte of uniform iron content, a very efficient system of agitation of the electrolyte was devised as follows:—

The anode was made of soft Swedish iron wire, in the form of a cylindrical cage of sufficient size for the particular work in hand, and which it surrounded. (*Fig.* 1.) Fitted to the inside of the cage were two or more celluloid rings slightly cone-shaped. The whole anode was suspended from a rocker arm, which, when set in motion, gave it a slow up-and-down movement, and thus, by the pumping action of the celluloid rings, the whole volume of liquid was kept in gentle motion.

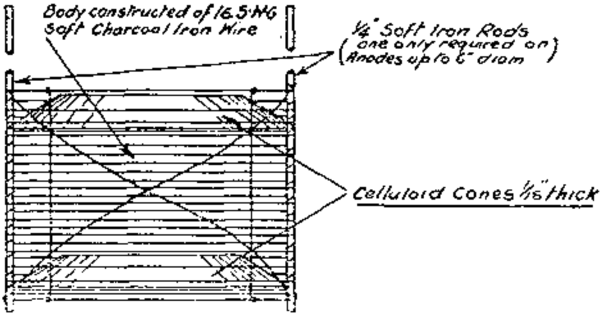


FIG. 1.

The employment of the dilute neutral electrolyte, while giving fairly good results in the shape of a finely crystalline and firmly adherent deposit of considerable hardness, had the disadvantage that it was only possible to use a current density of at most 5 amperes per sq. ft. of cathode surface, giving a rate of deposition of only ·00027 in. of thickness per hour, thus making the process a very slow one. For this reason, and also on account of the fact that very great care had to be exercised in the control and the manipulation of the ferrous ammonium sulphate electrolyte, by reason of its tendency to oxidize and form insoluble ferric salts which adversely affect deposition, the R.A.O.C. personnel engaged in this work decided to deal more particularly with the deposition of nickel. A concentrated solution of nickel salts could be employed in this case, making possible a rate of deposition of ·001 in. thickness per hour, and in addition the oxidization troubles did not arise.

The adhesion of the nickel to the basis metal was, provided that the preliminary cleaning process had been properly performed, all that could be desired; and as electrolytic deposits of this metal are extremely hard, it being possible to obtain those having Brinell hardness numbers of well over 400, it was argued that nickel would meet all requirements in connection with the repairs to be dealt with, with perhaps the exception of parts which required a hardened and tempered surface, or others which may be required to be subjected to high temperatures, as, for example, cylinders, pistons and gudgeon pins of internal-combustion engines. Nickel deposits, in addition to their hardness, possess the advantage of being rust-proof, and capable of taking a high degree of polish, forming an admirable wearing surface.

It was still thought necessary with the nickel solutions to employ means of agitation for the removal of hydrogen bubbles, and a system of rocking-arms was provided. In this case, however, the anode remained stationary in the bath while the article being treated was moved to and fro, and in some instances a form of brush was immersed in the solution which rubbed across the work as it moved, thus ensuring the removal of bubbles.

In the deposition of both iron and nickel, each job, except very small parts, which were dealt with in bulk, was treated in a separate bath which was made up according to the requirements of the particular work. Whenever possible, the whole job was put into the bath, those portions of it upon which no deposit was required having been previously "stopped off" by a suitable wax composition. In many cases, however, a comparatively small portion of an article too large to be put into a bath was required to be repaired, and then it became necessary to build up a containing vessel round the part. Such containing vessels were usually made of sheet-iron waxed inside for purposes of insulation, and after being arranged in position, were made water-tight by running more of the wax composition round the joints.

The aforegoing is a brief summary of the progress made from the initiation of the progress up to the end of the war. Much useful work had been done, even though a small percentage of failures occurred, many of which could be attributed to faulty cleaning or manipulation of the depositing baths, while others may have sprung from insufficient knowledge of the control required to keep the chemical compositions of the various electrolytes within the limit of their proportions for proper and efficient working.

The drawbacks to the process, evident at this stage, were :—

1. Its extreme slowness, especially in the case of deposition of iron.
2. The lack of consistency in the physical nature of the deposits.
3. The complications, introduced into the apparatus, required by the necessity for agitation of the electrolytes.
4. The great care necessary to ensure success, and the skilled personnel required to carry out the work.

On the other hand, it was the only known means of making a real repair of many a costly article, and the cost of the repair was trifling in proportion to that of a new one. In addition to this, salvage of worn parts in the field on an extensive scale would, in war time, lessen the strain in the industrial establishments at home, ease the traffic problem, and effect a saving in time, labour and material, in many directions; so that, in spite of the difficulties associated with it, the process was one which fully justified itself, and the field for further research opened up was one which gave every promise of providing the engineering world with a most useful and efficient "putting on" tool.

Outline of Process.

The various stages of the process as now carried out are :—

1. Removal of oil or grease, if present, from articles by petrol.
2. Cleaning in boiling alkaline electrolytic bath ; this also removes any rusting which may be present.
3. Washing in warm clean water.
4. "Stopping off" of such parts as may be necessary.
5. Cleaning in cold alkaline electrolytic bath.
6. Washing in cold clean water.
7. "Anodic" cleaning in acid bath.
8. Washing in cold clean water.
9. Deposition.

In many cases where the parts to be treated are not greasy, oily, or rusty, stages 1 to 3 may be omitted. Further modifications may also be necessary in cases where the bath has to be built round the work.

The lay-out of the plant should be so arranged that the work may pass through the various baths, etc., in progression. The secret of success, so far as good adhesion goes, lies in having the job in the necessary condition of absolute cleanliness, when it is placed in the depositing bath, and that deposition must commence immediately. To this end it is essential that no time should be lost in washing the work after leaving the acid cleaning bath, and transferring it to that for depositing. The washing must certainly be efficiently carried out, but the film of water covering the cleansed part must not be allowed to dry, for, should this occur, oxidization would take place—very slight, it is true, but sufficient to prevent good adhesion.

Alkaline Cleaning Bath, Hot.

The composition of the electrolyte in this bath is :—

Commercial caustic soda	1 lb.	per gallon of water.
,, washing soda	½ lb.	
,, sodium cyanide ...	1 oz.	

It is contained in a welded iron or mild steel tank of suitable size and shape for the type of articles to be dealt with. The temperature should be just under boiling point, and the heating can be effected either by the external application of heat to the tank by gas or oil stove, but more preferably, for reasons of control, by a steam coil inside the bottom of the tank. The coil would require an insulated joint in order to lessen the risk of short circuits and to obviate leakage and wastage of current, and for the same reason the tank itself should be mounted on a wooden stand or otherwise suitably insulated.

The metal of which the tank is made can be connected to the positive current supply and serve as anode. It is better, however, to have two iron plates suspended in the bath for this purpose, as the cleaning off of the sludge and scale which collects can then be more readily effected and, in addition, the distance between the work and the anodes can be adjusted to meet individual requirements.

The article to be cleaned is suspended in the bath as cathode, and a current density of about 100 amperes per sq. ft. of cathode surface is required. The time required for treatment is from 3 to 10 minutes, depending upon the state of greasiness or rustiness of the part to be cleaned. On removal, the article should present a dark grey appearance and will probably be coated with a slight powdery deposit, which, however, disappears in the subsequent washing operations.

This hot bath was not employed in the process in France, it being the practice then, instead, to boil the articles for several hours in a strong solution of caustic soda. It may be said, therefore, that a considerable improvement is effected by the introduction of this electrolytic method beside saving a great deal of time.

Stopping-Off.

After washing in warm water, the article is allowed to cool, but, while still slightly warm and dry, the "stopping-off" compound is applied to such parts as require to be insulated. The part upon which the deposit is required should be wetted with a clean damp cloth; this prevents the sticking of any overlapping portion of the compound, which, when "set," can be neatly trimmed up along its edges with a knife, and the surplus, being on a dampened surface, will peel off readily.

The stopping-off compound, which can be applied either by brush or by dipping, as may be most convenient, is usually a wax composition, and its preparation requires some care. It should set fairly hard, but not be brittle and liable to flake off. It should not be affected by the chemicals used on the process. Beeswax, for example, is slightly affected by strong alkali, but a small proportion of it mixed with other wax forms quite a good compound.

Compounds made up as follows have been found satisfactory:—

(*a*)	Paraffin wax	93%
	Carnauba wax	5%
	Boiled linseed oil	2%
(*b*)	Paraffin wax	80%
	Beeswax	20%
(*c*)	Bitumen	60%
	Paraffin wax	40%

A compound of guttapercha and paraffin wax has lately been evolved by another experimenter, and this appears to be a very good one indeed.

Alkaline Cleaning Bath, Cold.

This is made up and used in the same way as the hot bath, but it is used at a normal room temperature. Its function is to provide a means of removal of dirt and grease from the work after "stopping-off" has been done. This type of cleaning is, of course, carried out much more quickly and efficiently in the hot bath, but a stopping-off composition has not yet been evolved which will remain solid at the temperature required. If, however, the job has already passed through the hot bath and care has been taken subsequently to keep the surface clean and out of contact with anything from which it could pick up matter of an oily nature, (it should not, for instance, be handled) a few minutes in this cold bath will suffice; if not, it will be necessary to allow 20 minutes to half an hour to obtain the desired result.

Acid Cleaning Bath.

This is contained in a suitably-sized lead-lined vat, and the electrolyte made up in the following proportion:—

Concentrated commercial sulphuric acid ...	$2\frac{1}{4}$ lbs.
Water	1 gallon

It was customary, in the R.A.O.C. plant at Havre, to add a small proportion of copper sulphate in making up this bath, the theory being that it was necessary to have some salt present of a metal electro-positive to iron, to achieve the desired result. It is not, however, thought that this addition does materially affect the working of the bath, the main factor in successful cleaning being to obtain a vigorous evolution of gas by employment of a heavy current density of at least 200 amperes per sq. ft.

A suitable type of reversing switch is required in the circuit of this bath, one lead from it being attached to the lead lining of the tank, and the other to the bar from which the article to be cleaned is suspended in the electrolyte.

Operation.—The article should be well rinsed in clean cold water, after being through the cold alkaline bath, and be put into the acid bath without loss of time. The current should be switched on, making the article the anode. A black film forms on it immediately and very little gas is formed; in about 30 seconds or so, however, this film will be observed to break away, and a free evolution of oxygen takes place. Allow this gassing to continue for about 20 seconds and then quickly remove the article, the surface of which will be found to have a clean grey matt appearance. Wash off the acid as rapidly as possible and transfer at once to the depositing tank.

Ordinary mild steel will be found in most cases to respond to this cleaning treatment very readily, provided the necessary current density is applied. In some instances, however, and especially with the harder steels, it will be found that the black film does not break away as described, or does so only partially. The current in this event should be reversed for about a minute, making the article the cathode; an evolution of hydrogen then takes place which assists in disintegrating the clinging film, and on again changing over the switch the cleaning will be accomplished.

In order to prolong the "life" of the electrolyte, anodic cleaning should not be continued more than is necessary, as ferrous sulphate is gradually formed in the solution, and when this reaches a certain limit the bath becomes inoperative and must be renewed.

DEPOSITION OF IRON.

It has previously been mentioned that the process, as carried out in France, was very slow on account of the use of dilute solutions containing about 12 ozs. per gallon of ferrous ammonium sulphate and the consequent necessity for employing very low current densities. Experiments were therefore made, with a view to discovering, if possible, some means of using more concentrated solutions, the current densities being increased in proportion to the degree of concentration.

It was found that medium-strength solutions, containing from 1 lb. to 2¾ lbs. of the salt per gallon, whether used slightly alkaline, neutral or slightly acid, gave deposits which were very much pitted and had a sponge-like appearance; they were, too, very brittle and useless for all practical purposes. With strongly-concentrated solutions, however, containing from 3 to 3¾ lbs. per gallon it was found possible to obtain excellent deposits of any thickness, entirely free from pitting; and as a current density of 18 to 20 amperes per sq. ft. could be employed without any necessity for continuous agitation of the electrolyte, the rate of deposition was increased approximately fourfold.

The concentrated solution should be neutral, or only very slightly acid, to obtain deposits of reasonable hardness: excessive acidity makes the deposit hard and brittle, while alkalinity tends to produce pitting. Other points in connection with the working of the concentrated solution are:—

1. It is preferable to do as much work as possible in a large vat, for the following reasons:—

(a) The acidity and the iron content of the solution are apt to change continually, and periodic examination and rectification is necessary. With a large bulk of liquid the change is less rapid than in the case of a small quantity, and control can therefore be more efficiently exercised.

In this connection it may be mentioned that the type and quality of the anodes used have a great bearing on this point. Hard anodes tend to weaken the iron content, and increase acidity. The most satisfactory type were found to be those made from very soft Swedish iron wire, wound either into the form of a cylinder or flat grids, as may be most convenient. With these soft anodes the iron content was found to remain practically constant, but the solution gradually became neutral and even slightly alkaline. This matter, however, is easily remedied by the addition, from time to time, of small quantities of sulphuric acid.

(*b*) The larger bulk requires less frequent decantation to eliminate the insoluble products of oxidization.

(*c*) An occasional stirring is all that is required, whereas with a small quantity of liquid, a more or less continuous agitation is necessary to obtain good deposits.

2. When the use of a small quantity of electrolyte is unavoidable, as in the case where the containing vessel has to be built round the work, a careful control must be exercised as regards iron content and acidity, some form of agitation should be used if practicable, and it is advisable to use a lower current density than in the larger baths, not more than 15 amperes per sq. ft. at most.

3. When deposition is continued overnight and attendance is not available to administer the occasional stirring to the electrolyte, it is advisable to reduce the current density during these still hours to about 12 amperes per sq. ft. The reason for this is that the electrolyte in the lower portion of the bath becomes more dense than that above it, and consequently the deposit goes on unevenly, and the lower portion will probably be hard and brittle.

4. The temperature of the electrolyte has a considerable bearing on the quality of the deposit, those produced at a too low temperature being hard and brittle. It is, therefore, essential to keep the temperature of the room in which the deposition is being carried out fairly constant, the minimum being about 18° C.

5. The anodes should entirely surround the cathodes and have a total area, if possible, at least four times as great as the latter. They should be taken from the bath periodically and the black slime which settles on them removed by scrubbing and washing.

6. Loss of liquid by evaporation should be made up by the addition of distilled water. If the solution is allowed to become too concentrated, the salt will crystallize out on the sides of the vat and on the anodes.

7. The current should be maintained throughout the whole period of deposition, as interruptions tend to produce a deposit consisting of badly adherent layers.

DEPOSITION OF NICKEL.

This presents much less difficulty than that of iron, for, as has previously been mentioned, the formation of oxides does not occur in the electrolyte in the same troublesome manner. Further, the composition changes very slowly, if at all, as the bath, when properly arranged, has practically equal cathode and anode efficiencies and, therefore, control becomes a very simple matter, all that is required being the addition, from time to time, of distilled water to make up any loss due to evaporation. With a suitable nickel electrolyte it is sufficient to gauge the degree of acidity by means of litmus, whereas a much more accurate determination of the quantity of free acid is essential in the case of that for the deposition of iron to ensure good results. In the latter it is necessary to carry out periodical analysis of the electrolyte by titration with standard solutions.

There are many formulæ for the composition of nickel electrolytes, each having its own bearing on the quality and nature of the deposit produced; the particular one adopted would depend upon the purpose in view. For the thick deposits required in the case of building up worn parts, the following gives satisfactory results:—

Nickel sulphate	2 lbs.	per gallon of distilled water.
Nickel chloride	$3\frac{1}{4}$ ozs.	
Boric acid	$4\frac{3}{4}$ ozs.	

A current density of 20 amperes per sq. ft. of cathode surface can be employed at normal room temperatures, giving a rate of deposition of approximately ·001 inches of thickness per hour. As in the case of iron, good deposits, free from pitting, can be obtained without the necessity for agitation, when a sufficiently large bulk of liquid can be accommodated around the job.

TYPES OF WORK DONE.

Repair of Worn Axle of Railway Crane.

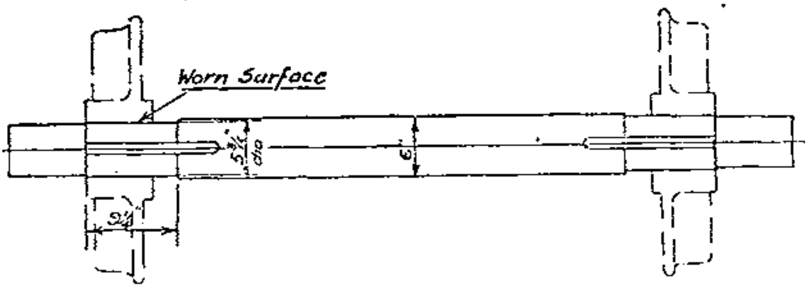


FIG. 2.

Continual jolting had caused one wheel to become loose in the axle, and it was found that approximately one-tenth of an inch of metal would have to be deposited on the diameter over this portion to enable it to be turned up to size again. It was decided to put on an iron deposit, but as the job was too large to be put into any of the vats available, a vessel was built around the part, as shown in *Fig.* 3, the base being of wood and the side a cylinder of soft iron sheet, the joints being made tight with paraffin wax.

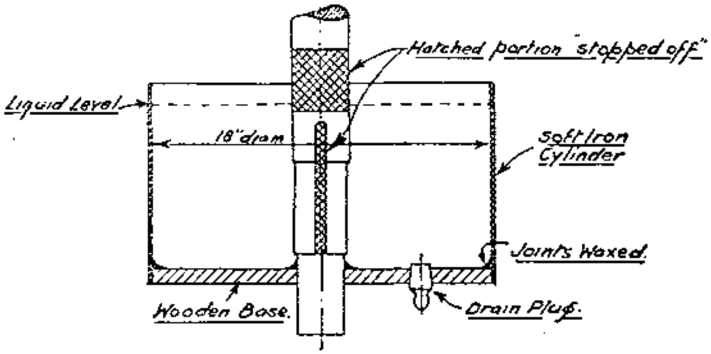


FIG. 3.

The hot alkaline cleaning treatment was carried out in a large "Derusting" tank, and after applying the "stopping-off" composition to the keyway and other portions as required, the axle was fixed up vertically and the smaller vessel assembled in position.

The cold alkaline treatment was then carried out, the iron of the containing vessel being made the anode. The liquid was then run off, the job washed with cold water, and the vessel filled up with the acid solution. An attempt to carry out the acid cleaning by using the side of the vessel as cathode was not successful, so a sheet of lead, bent to shape, was introduced to serve this purpose, with fairly satisfactory results. As soon as this operation was effected, the acid was quickly run off, the job washed, and a concentrated solution of ferrous ammonium sulphate poured in, the accumulators for supplying the current being connected meanwhile so that deposition would commence at once, the iron of the containing cylinder being used as anode.

A current density of 15 amperes per sq. ft. was employed for 65 hours without agitation of the electrolyte beyond an occasional stirring. It was found necessary to make small additions of sulphuric acid about every 12 hours to maintain the required degree of acidity, but the iron content remained practically constant.

Result.—The deposit was of the required thickness, fairly hard and free from pitting, firmly adherent except at the lower edge. This slight defect was due probably to this portion being in contact with the sludge which settled at the bottom of the vessel, and could have been obviated by allowing more space for the settlement of this sludge.

The deposit was turned up on a lathe and the wheel refitted, and the axle was in daily use for 18 months without showing any signs of wear.

REPAIR OF PLANING MACHINE BLOCK.

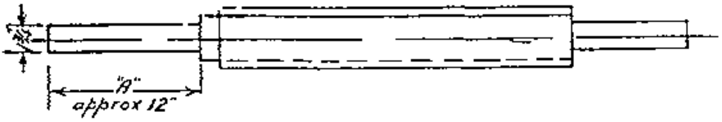


FIG. 4.

The portion of the cutter block shaft " A " upon which two ball-bearings fit had been turned down in error to ·1 in. under plan size diameter. An iron deposit was put on, in a large vat, and the job was quite successful, the deposit being hard and firmly adherent, and it ground up to a very fine smooth surface entirely free of pitting.

REPAIR OF WAGON AXLES.

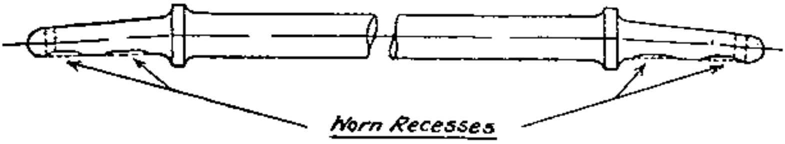


FIG. 5.

These axles are worn very deeply and unevenly at either end in two places, as shown in *Fig.* 5. It was decided to expedite the repair by filling up the deeper portion of the worn recesses by a copper deposit and then, after turning the whole to an even-tapered surface, to finish off with a nickel deposit of about ·05 in. in thickness.

The first layer of copper was deposited in a cyanide bath and the remainder in an acid copper sulphate bath at the rate of about ·0025 in. per hour.

The nickel was then applied, after turning up and repeating the cleaning process, and a fine smooth bearing-surface obtained. The nickel deposit is much harder than the original steel of the axle, so it is anticipated that the repair should give a considerably longer second life to the article.

Other small articles, such as gudgeon pins, tappet valves, etc., for I.C. engines, have been repaired by iron deposition, and it has been found that the wearing qualities of the deposit are excellent and that it remains firmly adherent even though it be subject to high temperatures during use.

DEPOSITION OF SILVER AND LEAD ON RUBBER RINGS FOR PACKINGS FOR GUN MOUNTINGS.

In addition to the work carried out by the R.A.O.C. at Chilwell on the repair of worn components by the deposition of iron and nickel, experiments were made with a view to evolving a resilient "metallic" packing to replace the textile packings at present used in the glands and stuffing boxes of buffers and recuperators of gun and howitzer mountings. The disadvantage of the present type of packing is that it tends to cause pitting of the finely-polished surfaces of the rods and cylinders, and when this occurs, the parts become unserviceable.

The idea was therefore conceived of enclosing rubber rings within a coating of metal of suitable thickness. Such a packing would be very resilient, forming a tight joint and yet would possess a metallic bearing-surface having no corrosive effect on the rods or cylinders. In addition, there would be less friction at the joint, less wear, and, consequently, less frequent renewals would be necessary.

In a packing of this description it would be necessary to completely enclose the rubber in order to protect it from the disintegrating action of the oil used in the buffers and recuperators, and it was thought, therefore, that the metallic coating could most conveniently be applied by electro-deposition. Silver and lead were selected as being the most suitable metals for the purpose, and suitable baths were therefore made for their deposition.

The first problem to be solved was that of obtaining a suitable conducting surface on the rubber; various expedients were adopted such as:—

1. Rubbing fine plumbago into the surface of the rubber.
2. Coating with a paint made up with plumbago.
3. Coating with a paint made up with bronze powder and amyl acetate.
4. Winding very thin copper tape on the rings to completely cover the surface.
5. Dipping in solutions of phosphorus in carbon bisulphide and silver nitrate in water.

None of these methods gave altogether satisfactory results, so the production of a film of silver sulphide (which is a fairly good conductor) on the surface of the rubber, was made by dipping the ring in a hot strong solution of silver nitrate and, when dry, treating it with sulphuretted hydrogen. This method achieved the desired result and good smooth deposits were made upon the conducting surface thus formed.

Having prepared the rubber in this manner, a piece of very fine copper wire was placed round the periphery of the ring, which was then suspended in the depositing bath. As soon as a film of lead had been formed over the whole surface, the ring was taken from the bath and the copper wire carefully removed. The ring was then replaced in the bath until the required thickness of deposit had been obtained, being suspended now by means of a wire hook, making a somewhat loose contact with the lead.

COMPOSITION OF LEAD BATH.

The electrolyte used was a fluoborate solution of the following composition :—

Basic lead carbonate	20 oz.	Per gallon of solution.
50% hydrofluoric acid	32 ,,	
Boric acid	16 ,,	

Small quantities of glue were added from time to time, as this was found to assist materially in the production of smooth deposits.

A current density of 20 amperes per sq. ft. was used and a rate of deposition of approximately ·003 in. per hour was obtained.

The thicknesses of the deposits given varied from a few thousandths of an inch up to ·1 in.

While it was not found that there was any distortion of the ring whilst undergoing deposition, it was noticed that in the case of the heavier deposits, the thickness was uneven in places. This matter, however, was easily remedied by a slight skimming up on a lathe, and the true circular shape required was thus obtained.

Some of the lead-coated rings, after being turned up, were silver-plated, this operation being carried out, after anodic cleaning in an acid bath, in a commercial cyanide electrolyte.

The packings when tested in an 18-pdr. gun-carriage were found to be extraordinarily resilient, and made a tight joint, as anticipated. The lead and silver coatings, however, invariably split on the sides circumferentially under pressure, allowing access of oil to the rubber, and further experiments are required to evolve a design of packing and supporting rings to overcome this trouble.

SOME THOUGHTS ON THE GROWTH OF MODERN FIELD DEFENCES.

By COLONEL G. C. WILLIAMS, C.M.G., D.S.O.

So keen are we to teach and maintain the offensive spirit that the study of defence is sometimes, even in these enlightened days, almost unpopular. Yet in every other game we know that we must learn both attack and defence before we can become proficient players.

Napoleon's opinion on the use of fieldworks was :—" Those who prescribe the use of defensive lines and the assistance which the science of the engineer can afford, deprive themselves gratuitously of an auxiliary, which is never injurious, almost always useful and often indispensable. It must be admitted at the same time, that the principles of field fortification require improvement."

The rôle to be played by field defences is to gain time, and to husband men, until the assumption of the offensive. And moreover, as the ultimate object is to attack, the defence must be able to develop the full possibilities for the counter-stroke. And so we have in the defence a most useful servant ; but one which needs knowing and which needs careful watching, or he will become the master of us. How easy a thing it is to become tied to trenches was only too apparent in the Great War. And this danger became such a bugbear to many a commander, that some distrusted trenches altogether and sought, not to learn their real uses, but for ever to avoid them. But, after all, the trenches are for the troops and not the troops for the trenches. Nor, of course, do mere trenches manned by troops constitute defence at all. Trenches and field defences, like armour, are an aid to an active defender ; and if used as such, they can never become a danger.

Since Napoleon wrote the maxim which I have just quoted, the art of field fortification has certainly improved. But I do not know that we can pride ourselves on having made all the improvements. They seem rather to have forced themselves upon us : and it has come about in this way.

The pre-war conception of a defensive position was clearly laid down as consisting of advanced troops to delay the enemy's advance, a main position to stop him and reserves behind whose duty was counter-attack.

In the Great War when the battle of the Marne became stabilized, the assaulting waves, as must happen on some part of the front in every big battle, found themselves dug in on a line closely watching the enemy. Then occurred a curiously inexplicable thing: as measures for defence were taken in hand, the pre-war conception was not practised; but so arresting were those front lines of fighters, that they assumed undue importance in the eyes of all. And the form of defence evolved was designed to maintain those sacred lines intact, to the exclusion of all other considerations. It may have been pride not to cede an inch of territory, or it may have been the desire not to give up anything that had cost so much to win. But there it was—the front lines became the main lines of resistance.

And what splendid and easy targets those front lines were! Naturally, every form of devilry was turned upon them. And every inventor thought that he only had to find something to destroy them in order to win the war; and so trench-mortars, "pigs," "babies," "pine-apples," hand-grenades, mines, took a heavy toll of those closely-packed and precious lines.

It was this very drastic treatment, intensified by a big increase in artillery, which could so quickly turn a spotless front-line trench into a pock-marked wilderness of broken timber, twisted iron and torn sandbags, that forced the stubborn opponents at last to live farther apart.

And so defence in depth made itself known.

So you see it was no sudden invention, no great brain-wave—this defence in depth.

Other things, too, were helping to evolve the modern system of defence as we know it now. The new power of automatic weapons was proving the value of the machine-gun to produce fire-power and to reduce man-power in defence. And so the defence in depth was laid out primarily as a machine-gun defence. Machine-guns were grouped to cover the main lines of approach, while the infantry concealed themselves in places from which they could best employ their most successful rôle, *viz.*, the counter-attack.

Then, while the machine-gun and the infantry were content with concealed positions, the growing importance and longer ranges of the big gun demanded good observation; and so observation, safe observation, became the keynote of the modern defensive position. Consider the advantages of Hill 70, Aubers Ridge, Vimy Ridge, Lorette Ridge, Chemin des Dames, Messines Ridge, Passchendaele Ridge, Mount Kemmel; and these were not all: it was always the high ground that was the bone of contention. Further inventions came to complicate the already intricate systems of defence. Increase in enemy artillery called for greater and greater depth, and further removal of the battle zone from the outposts. Aerial observation called for more complete concealment than had been needed against ground observation; and so the feminine art of camouflage and deception was called in to aid the field engineer.

The tank called for special obstacles as woods and water, whereas gas led to the avoidance of woods, villages and low-lying places.

The German attack of March, 1918, then came to round off the lessons in defence which the war was teaching. And that attack really taught us the difference between "depth" and "dispersion." Ask any formation or unit, big or small, in the 5th Army why it retired, and the answer is because its flanks were turned. In many cases it was true, and the tactics of infiltration used by the Germans lent colour to that answer.

The lesson was that the machine-guns and the infantry must needs be grouped in defence posts. Each defence post is self-contained and can present a reinforceable front in any direction. A proper combination of inter-supporting defence posts forms a defended locality, which is an area of ground organized for defence by a definite unit or formation from a company to a brigade. A defended locality has its own counter-attack troops to restore its own situation if needs be.

And furthermore, defended localities are inter-supporting, and by being so, form the framework of the whole defensive system.

An area, on the other hand, held in "dispersion" has no such plan in its construction, but is merely an area containing lines and groups of armed men. Such an area provided a complicated system of successive lines of trenches which give an excuse for retirement and which use up many men.

The true system must be composed of inter-supporting self-contained defended localities, and must be, at the same time, simple; and to achieve such a form of modern defence is in itself no simple matter.

THE CASE FOR LOW-PRESSURE HOT-WATER HEATING.

By CAPTAIN C. C. ADAMS, M.C., R.E.

IN the *R.E. Journal* of June, 1923, under the title of "Modern Forms of Central Heating," Brigadier-General W. Baker Brown, C.B., has given a description of a system of heating buildings which he believes should be of value to officers of the Corps. The article referred to does, however, leave an impression on the reader's mind that the pipeless system of central heating is the latest and best device, and that, while it is cheaper, both as regards first cost and running expenses, than other and more time-honoured methods, it is as economical and as effective as any of them. The present writer cannot claim any personal knowledge of pipeless heating, but he does feel that there is another side to the case. Heating by hot air without pipes is no new thing; it has certain inherent objections which have prevented its extensive use in the past, while, on the other hand heating small buildings by the circulation of hot water has advantages over other methods which should be carefully weighed before deciding to abandon such a well-tried and proved system.

There are many ways of keeping buildings warm in the winter months, and, naturally enough, advocates can be found for most, if not all of them. Under some circumstances, the open fire will give the best results, while, under other conditions, steam heating will be selected as the most economical system. An arrangement for heating a garage will not necessarily be effective for a church. Heating buildings is a science in which improvements are constantly being made in all branches; there are modern designs of open fires and stoves, and from time to time improvements in all forms of central heating are put on the market. It is really quite unfair to label a particular system "Modern Forms of Central Heating" and thus to imply that other methods are obsolescent. Such is by no means the case either in England or America and, although the pipeless system may have advantages, probably not even its most sanguine enthusiasts expect hot air to oust completely either water or steam as a vehicle for the transmission of heat from the furnace to the rooms.

The heating of buildings is an extensive branch of sanitary science, and it would be quite outside the scope of a short article to deal with all the methods in use. The writer, therefore, proposes to state the case more particularly for that branch of central heating which is generally accepted as most suitable for small buildings where expert supervision is not practicable, namely, low-pressure hot-water heating. In this system, the heat is conveyed to the rooms by the circulation of hot water through pipes and radiators, the pressure of the water being strictly limited owing to the pipes being open to the atmosphere at some part of the system. This method is in itself a large subject on which many books have been written, and it will be quite impossible to give any detailed description or calculations; the advantages and disadvantages will simply be compared with those of hot-air systems, and more particularly of the hot-air system known as pipeless heating, as described in the former article.

The utility of central heating would at first appear to be outside this discussion, as it is common ground on which both parties agree. It will not, however, be out of place to state the advantages usually claimed for it, as this will give us a basis on which to compare the two systems.

The main advantages of central heating are efficiency and economy. Efficiency is due to the use of one heat-producing unit instead of several, and to the fact that most of the heat from a central stove or furnace will be employed usefully, while in the case of open fires, some 50 per cent. or more of the heat produced usually escapes up the chimney without doing useful work. Economy of fuel is an important advantage, and there is further a considerable saving in labour—labour for carrying fuel, supervision and cleaning, the latter referring, not only to the cleaning of the grates themselves, but of the rooms, which soon become dirty with smoke and coal-dust from an open fire. A further advantage claimed for central heating is that not only living rooms, but all rooms, including halls and passages, can be given their measure of heat. In this way, draughts are avoided, and the whole building is raised to a comfortable temperature. Again, radiators can be so situated in rooms as to give the best circulation of warmed air, and in large rooms two or more radiators can be installed in different positions. With open fires, or stoves, such a distribution is not usually possible, owing to structural details and the positions of flues; consequently the temperature of a room heated in that way may not be evenly distributed. It is no uncommon thing to find one part of a room, heated by a grate, comfortably warm, or even too hot, while another part is quite cold. Or again, a man sitting in front of the fire may have his face and part of his body warmed, but at the same time feel decidedly cold down his back! Yet another advantage of central heating is that of rapid regulation. Radiators can be instantly turned on or off, and, with most systems, a partial turning of the valve handle will give a corresponding increase or decrease of heating power. The same applies to electric, gas or oil stoves, but not to a coal fire, which takes some time to "get going," and once it has been allowed to go out, must be re-laid before it can be re-lighted.

There are two disadvantages usually given for all forms of central heating, that it is not "cheerful," and that it does not promote ventilation. The latter point has been discussed by the author of the former article; the modern expert asserts that we get quite enough fresh air in our buildings without the use of open fires, and in any case, it is very doubtful whether the expense of installing them in all living rooms would be justified by the improved ventilation obtained. Here it might be pointed out that one argument given in favour of pipeless heating (p. 205) is that the same air is used over and over again, and so starts partially heated. The same argument applies to water in the case of hot-water heating. The question of "cheerfulness" is more important. An open hearth is certainly a cheerful thing in cold weather, and it is even doubtful whether the advocates of auto-suggestion would get the same satisfaction from sitting in front of a radiator as they would from an open fire. It has been stated that a house properly warmed by hot water has perpetual summer in it, and that the sight of a fire is not welcome or cheering on a summer day. This is an argument usually given by central-heating enthusiasts and may well appeal to some readers. The writer must, however, confess that it is an argument which does not overcome his English conservatism, and he will always vote for central heating with one or two open fires in addition in the principal living rooms.

Now let us see how far these advantages (and requirements) of a central heating system are met in the case of pipeless heating. Its efficiency compared with scattered heat-producing units is evident, but it is hard to believe that a current of heated air let loose in a house, and free to escape by the numerous cracks and crevices that exist even in the best regulated buildings, will be as efficient as a hot-water system confined by pipes and radiators.

There will undoubtedly be some economy of labour, but with the pipeless system we are liable to be confronted with the dust nuisance, for the current of hot air from the furnace may carry with it dust particles, even though there is no direct communication between the hot-air chamber and the fire-box.

As regards fuel consumption, we have been given some figures. With pipeless heating, we are told that 40 lbs. of coke a day will heat a ten-room house, but to what degree? And for how many hours of the day and night? Professor F. W. Dye is a recognized authority on central heating, and he gives useful figures as far as hot-water heating is concerned, and states* that for a 24-hour day,

* *Warming Buildings by Hot Water.* F. W. Dye. Published by E. & F. N. Spon, Ltd.

under reasonably good conditions, the consumption of coke for installations of moderate size averages 1 cwt. a day for each 400 sq. ft. of radiation. Now assuming that in our ten-room house, six rooms require to be heated, and of these, three are living-rooms and three are bedrooms, all with an average capacity of 2,500 cub. ft., we find, from the figures given in Table 1 (*a*) on p. 61 of the *Water Supply Manual,* that the radiator heating surface required is $202\frac{1}{2}$ sq. ft., and the coke consumption will, therefore, be about 57 lbs. a day. Professor Dye advocates a rather higher temperature than that required by the *Water Supply Manual* and, using his Tables, the consumption for the same house works out at 70 lbs. a day. From this it would appear that the pipeless system is the more economical as regards fuel expenditure, but the value of this comparison relies on the data being identical in the two cases, and we must know whether the 40 lbs. coke consumption given for pipeless heating is for heating throughout the 24 hours of the day, and what degree of temperature is attained in the rooms.

The question of the regulation and distribution of the heat is a very important one, and it is in this respect that the pipeless system appears at a distinct disadvantage. The only real regulation possible is at the " register " or grating through which the heated air passes as it leaves the apparatus. This would enable one to turn off, or to diminish the total volume of air entering the living rooms, but any regulation of the supply to individual rooms is impracticable. Obviously then, it will be almost impossible to have a warm room at the top of the house without considerably overheating the ground floor, particularly when a few windows are open. The makers assert that the warm air rises to the top of the house, rushes into every cranny and corner at all levels, and finally descends to be reheated. Surely there must be some fallacy in this, for the air will only ascend until it has cooled sufficiently to be heavier than the warm air rising, and will then begin to fall again. It is doubtful whether it will rise more than ten or twelve feet before this takes place. Further, if the kitchen premises are not entirely cut off from the rest of the house, they will receive their share of heat, and in some cases become intolerably hot ; in fact, they may even receive more than their share owing to the draught caused by the range. And then there may be rooms with open fires burning in them. If they are receiving their share of the heated air, it will surely be very hard to prevent overheating. In the case of low-pressure hot-water, a few turns of the valve-handle of the radiator would at once diminish the heat reaching any particular room. Also, in planning a hot-water system, the distribution of heat can be regulated to a nicety. Larger rooms can have larger radiators, and in small and unimportant rooms the heating surface can be cut down. Rooms which are near the furnace can have small radiators so that they will not rob more distant parts of the building. It is easy to make allowance for those rooms which have exposed walls, large window areas, etc. All this is impossible with pipeless heating, for with that system, all the heated air is discharged into the building at one spot, and no further regulation is possible. Referring to hot-water systems, the writer of the previous article states (p. 201) that "the circulation of the hot water is troublesome to regulate," but is this really the case? The reverse appears to be more exact. With steam circulation, it is true that a radiator must be completely "on" or completely "off," but with any of the low-pressure hot-water systems, partial turning of the radiator valve-handle is satisfactory, and regulation is possible at any radiator. Perhaps the paragraph quoted was intended to show that it was troublesome to walk round a building to turn these handles. If this is so, the remedy is not to turn the handles—even then, one is no worse off than with the pipeless system which has no handles to turn!

Another "disadvantage" of other systems mentioned (p. 201) is the stuffy feeling experienced in the buildings. Here we must disagree as far as low-pressure hot-water is concerned. The writer has lived in houses heated in this way on both sides of the Atlantic, and has never noticed any "stuffiness" on account of the heating. It certainly is found with the high-pressure system, and with steam-heating, and is probably due to the scorching of particles of dust and hair in the atmosphere, owing to the high temperature. It is particularly noticeable in steam-heated railway trains and many American hotels. It is also stated (p. 201) that, with hot-water circulation, the air feels uncomfortably dry. This is doubtful, and seems to be a matter of opinion, but the fault can always be remedied (when it does exist) by placing a small bowl of water on or near a radiator.

A "pipe" system is certainly comparatively expensive to install, owing to the more extensive apparatus and the cost of cutting through walls for the pipes. The pipes and radiators occupy space, and are said to be ugly. This, however, is a fault which has a remedy, and the illustrations of modern radiators, made by the National Radiator Co., Hull, show that the latest designs are not unpleasing to the eye. (*Figs.* 1 and 2). The wall radiator is made in various dimensions, with a depth of $2\frac{1}{4}$ in; it is mounted on special brackets, and then only protrudes slightly from the wall, and occupies no floor space.

The panel system is a modern method of heating, which is being used where an even temperature is required and radiators are undesirable. The arrangement of boilers and circulating mains is as for a radiator system and, when desired, panels and radiators can be used on the same mains. The heating surface takes the form of coils of jointless piping, fixed to the bare walls or ceilings, or in

Fig. 3.

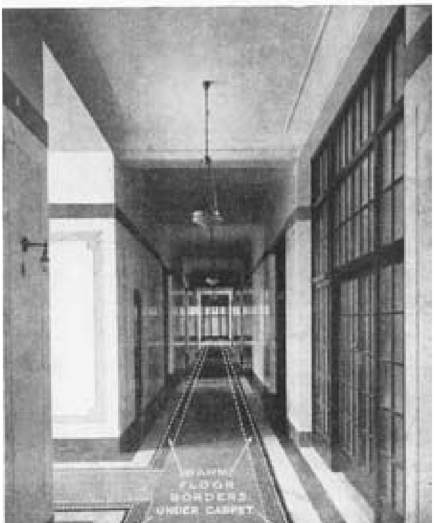


Fig. 4.

FIG 3 & 4

the floors, and then covered over. The tubing is of special quality with welded joints, and is subjected to a high test pressure to eliminate any risk of breakage. When the coils are embedded in ceilings, or other places where there is no risk of perforation by nails, they may be made of soft metal jointless piping, which simplifies fixing, and reduces the weight to a minimum. Each panel or series of panels is regulated by a valve, exactly as in the case of a radiator system.

The panels in walls and ceilings are usually covered with a special plaster which is inexpensive, the finished surface being reinforced to prevent cracking. The arrangement of the coils does not permit of large movements due to expansion, and the covering material easily adjusts itself as the system becomes heated. The surface can be painted or distempered, or mouldings can be planted on it if desired. Walls, or floors finished in materials such as marble, slate, tiles or mosaic are quite suitable for panel heating (*Figs.* 3 and 4).

The temperature of the water in the system is normally quite low (90°-130° F.) and this permits of increasing the heat considerably in very severe weather. It should be noted that the rooms are mainly heated by radiation from the walls, etc., comparatively little of the heat being distributed by convection currents in the air. This is not the case when radiators are used, for then, only a small proportion of the work is done by radiation, most of the distribution being due to the circulation of heated air. The promoters of the panel system claim that removal of the air by ventilation does not cause serious heat losses, and one can, therefore, heat a room with panels, even if the windows are kept open. A further advantage is the comparatively low temperature used, which will not cause dust particles, etc., to burn. The distribution of heat is uniform, and there is no risk of cold currents or draughts. It is claimed that the fuel consumption with this system is less than with any other form of heating.

The panel system is no doubt expensive to install in an existing building, but, with a new building, its cost will compare favourably with that of radiators. It would appear to be particularly suitable for hospitals, where an even temperature is essential, and radiators may collect dust.

The system is not a new one, but has been in use for some fifteen years with success. It is fully patented, and further information on the subject can be obtained from Messrs. Richard Crittall and Co., Ltd., 43, Bloomsbury Square, London, W.C.1. Panel heating has recently been installed in many large buildings, including the Stadium Building at Wembley Park and the Bush Building, Aldwych, but it appears to be quite suitable for dwelling houses as well as public buildings.

There are many piped installations which have given trouble in the past, but this is the fault of the architect, or builder, and not of the system. A properly designed plant will invariably work well. Central heating has not been used much in this country, owing to the mild winters and the conservative hankering after the open fire. Consequently, its principles are not always well understood by architects, and the latter hesitate to call in specialist heating engineers when only small plants are to be installed. This has been the cause of much trouble, but happily the essentials of designing installations are now better understood.

Heating by the circulation of hot air is no new thing. In America, it has been called hot-blast heating, and was probably the first way ever tried of heating buildings by a central furnace. It was found, however, that although the first cost was small, the stove was less durable than a boiler, and in case of damage to the stove (not an uncommon occurrence with this type of heating), or leaks caused by alternate expansion and contraction at the joints, sulphur dioxide and carbon monoxide from the fuel may get into the living rooms with disastrous results. Later, this method of heating was largely abandoned except in cheap houses where small first cost was of prime importance. In his book on heating, Mr. F. W. Raynes* expresses what the present writer believes to be the general feeling with regard to hot-air heating. "In America, hot-blast heating for public buildings, as generally carried out, is looked upon by many with disfavour. The high temperatures to which the air is usually raised bring about chemical changes by decomposing some of the contained dust. Thus the air loses its freshness, and becomes to a certain extent vitiated before it enters a room. It is also thought that the overheating process devitalizes air by robbing it of properties that cool fresh air contains." The same argument would apply to private buildings as well as public. The above paragraph has a general reference to hot-air heating, and was written before the pipeless system was introduced; the latter, however, appears to suffer from some, if not all, of the defects mentioned.

The suggestion was made that pipeless heating should interest the R.E. officer for financial reasons. D.O.'s want to save money, and there can be no doubt that this system gives a large saving in first cost, but let us remember that that is not necessarily economy. Cheapness means a lot to the D.O., but that cheapness must not be at the expense of efficiency. We have to consider the capital cost, the cost of upkeep and the running expenses, and against these must be weighed the interest on our money which we are getting in the shape of calories and comfort. For small buildings, low pressure hot-water heating pays good interest. It may be possible to say the same of pipeless heating, but we should be cautious in installing such a system before details of the running expenses over a number of years are made available.

* *Heating Systems.* F. W. Raynes. Published by Longmans & Co.

THE INFLUENCE OF FAST-MOVING TANKS ON THE ENCOUNTER BATTLE.

By COLONEL J. F. C. FULLER, D.S.O.

PREFACE.

MY object in this paper is not to prove that the tactics and training made use of in our army are valueless or that existing weapons are useless, but that we are to-day living in a transitional period in which changes are beginning to take form, changes which, I believe, must radically modify our military conceptions. No man can say with certainty what is going to happen, but we may say with some assurance that only by attempting to probe the future shall we be able to discover the probable nature of the changes which confront us. In this paper I have outlined in brief a few ideas, they are nothing more than ideas, but they may assist as a working base for further speculation and research. Though we must adhere to the doctrine laid down, it should be remembered that one day all our Manuals will have to be revised and, consequently, if we have not thought out beforehand the new directions that war is taking, when we are called upon to assist in this revision we shall fail in our duty as soldiers.

PART I.

Argument.—In this paper I intend to deal with a speculative problem—the influence of a fast-moving tank on existing tactics and organization. It is a problem which has not been studied, except by a very few, and it is an immense problem. In order to bring it within the scope of an article, I intend to limit my speculations to an encounter battle between two Continental nations —Red and Blue, each possessing 1 Cavalry Division, 6 Infantry Divisions and 7 Battalions of tanks. In the Red Army the Tank Battalions are an integral part of each Division, in the Blue they are Army Troops. The tanks with which these two armies are equipped, I will suppose, are proof against armour-piercing bullets, possess a maximum speed of 20 miles p.h., and weigh about 10 tons.

I will now lay down two postulates :—

(i) The *arme blanche*, the bullet and wire are useless against tanks.

(ii) The tank is useless in thick woods, swamps and on the slopes of mountains.

Accepting these, and that two-thirds of the theatre of war is open agricultural country, I will consider some of the possible problems which may arise under the headings of Approach, Contact, Deployment, Battle, Counter-attack and Pursuit.

Approach.—First, remember the nature of the tank organization of both sides; and secondly, imagine that war has been declared between the Red and Blue nations.

Red moves off in column of march. Its tanks, in most cases, have been distributed down to Brigades, for the Red C.-in-C. is a firm believer in close co-operation between tanks and infantry. Before the columns have gone very far there is a considerable amount of confusion. The tanks want to go eight miles p.h., the infantry will not go more than two. The tanks are turned off the roads into the fields, but their commanders find that delays occur and control is lost when they are confronted by streams, woods, thick fences, broken ground, etc., and so they look for spare roads on their flanks. They use these and poach on the communications of neighbouring Divisions. Much abuse follows and eventually they are withdrawn and placed behind their respective Divisions. A day or two later the Division cannot get their supplies up. The tanks are blamed—they block the roads. Besides, some Blue armoured cars have put the " wind up " one of the Advanced Guards and have shot a Brigade Commander whilst at breakfast, five miles behind the leading troops; so it is decided to put the tanks in front and the Red C.-in-C. issues orders that they are not to become engaged without infantry support.

Blue moves off in column of march, one central road is allotted to its seven Tank Battalions, the Divisions marching on parallel roads. When air reports inform the Blue Divisional Commanders that the Red forces appear to have their tanks in front, they become jumpy and urge the Blue C.-in-C. to give them tanks. He refuses and, quoting Ludendorff, tells them that the infantry " must rely on their nerves." If attacked, they " must move to a flank." He will support them when he sees fit. He is a man obsessed by the idea of " the manœuvre mass."

Contact.—The Red Cavalry Division is operating well in front of its infantry and is supported by a Battalion of tanks. These machines enter the Blue villages, terrorize would-be *franc-tireurs*, then along come the cavalry. When the ground is broken and difficult, the tanks stick to the roads and the cavalry canter out on their flanks and the advance proceeds rapidly.

One day the Blue cavalry are sighted. The Red Commander does not know whether they are working with tanks or not; he is, however, suspicious. He calls up his tank Commander and they consort a plan.

" You see those two woods to your right and left," says the Cavalry General, " Well, get into them. I will go on with the bulk of my force and engage the Blue Cavalry; there will be no charges, but instead, directly we are in contact, I will fall back across the fields between the woods. Once the enemy is well between them, you will attack him at top speed. If possible, I will wheel round the woods and attack all I can in flank. Do not attempt to co-operate with me, but seize your opportunity and, when you do, hit hard."

The Blue Cavalry advance with caution, they have heard that tanks are about and are much relieved when the Red are met without them. The Red troopers fall back and the Blue push on. The Blue attempt several charges, but are beaten back by machine-gun fire. The Red fall back on the two woods and then further back still. As the Blue approach, 60 tanks move out at top speed—some 18 miles p.h., and the best part of a Blue Brigade is wiped out. The rest retire in panic and do not draw rein until they reach their infantry advanced guard, which they demoralize with the wildest of rumours.

That night the Blue outposts are most unsteady. Every sentry sees tanks. Wild firing takes place and the outpost reserves stand to arms throughout the night.

Deployment.—The Red Cavalry have mysteriously vanished. Except for a few isolated sections of troopers nothing can be seen of them. The Blue are still completely demoralized and their horses useless. The advanced guards are in contact, both sides are deploying.

The Red C.-in-C., a man of methodical habits, is not going to rush the enemy. Under cover of his tanks he intends at first to deliver a frontal infantry attack with four divisions and turn the enemy's left with two. With these two divisions he would like to use more than two battalions of tanks. His Tank Battalions are, however, distributed; to withdraw one or more will create confusion and, further, will seriously affect the *moral* of the infantry who have learnt to rely on them. To withdraw individual companies is difficult. He must have some reserve force for his right flank, so he determines to withdraw one Division into reserve. He is very much annoyed at this change forced upon him through the difficulty of separating tanks from the other arms when close co-operation has become a recognized necessity.

The Blue Army is deploying rapidly, but the seven Tank Battalions on the central road are causing much confusion. The Blue C.-in-C. orders two of these battalions to join the Divisions on their right and left, and five to move to the right flank as an independent force. As the tank movements are to be kept secret, the machines must move out laterally well in rear of the infantry and under cover of darkness. As they cross the various roads, the artillery and transport columns are delayed and as night deepens confusion increases as the tail ends of columns try and catch up with their heads after the tanks have passed by.

Battle.—The Red Army advances whilst the Blue is still deploying. The Blue troops are in a nervous state, particularly the infantry, and are seeking to take up anti-tank rather than attack positions. Their attitude is defensive. Several of their positions are in woods and on hilly ground. These clash with the positions the Blue gunners would like them to take up in order the better to support their attack. Co-operation is difficult to establish. The Blue infantry start digging in, though not a shot has as yet been fired.

The Red forces continue their advance. In many cases the infantry have thrown away much of their equipment in order to keep up with their tanks; the number of stragglers is increasing.

The two battalions of Blue tanks which have been allotted to the Blue Divisions have been pushed out well ahead of their infantry and for the most part are out of sight. The two tank forces meet and long-range fire opens. The Red guns are pushed up at a gallop. The Red tanks which have been ordered to keep close touch with their infantry, want to push on, but cannot; a good many get hit. Besides, the Red tanks are scattered on a wide front and are unable to concentrate against the Blue.

As the Blue tanks advance, the Red infantry opposite them break and stream to the rear. The Red gunners stand to their pieces and knock out several of the Blue tanks, but not many, as their speed makes them difficult targets.

The Red tanks move forward at the request of their infantry and soon lose touch. Then, as one Tank Battalion tops a rise, they see thousands of Blue infantry streaming away in the distance. All Red tanks are now moving rapidly forward, with every gun firing. The ground is littered with infantry equipment; Blue infantry are seen in all directions. Hundreds are caught up and shot down. The Blue gun positions are approached, some Red tanks are knocked out, but in a few minutes the tanks are on the guns, and the gunners, where they can, join the fugitives.

The Red tanks, pursuing the Blue infantry, have lost all formation.

The Red infantry, on the flanks of the penetration effected by the two battalions of Blue tanks, have fallen back and are seeking refuge in woods and villages and behind streams. With great difficulty the Red C.-in-C. collects some 60 or 70 machines and orders them to follow up the Blue machines which are manœuvring to avoid the Corps and Army Artillery. He is successful; a number of Blue tanks are shot down and the remainder, in attempting to withdraw, come up against a small river and, being unable to cross it, surrender.

In rear of the Red Army there is terrible confusion. Bad news has travelled swiftly and several of the supply columns are in panic.

Counter Attack.—The Blue C.-in-C. hears of the total rout of his infantry. Scarcely a company remains intact, for his reserves have joined in the *sauve qui peut*.

Simultaneously, he hears that his communications have been attacked by hundreds of tanks—fear magnifies numbers. This attack has been carried out by the Red Cavalry Division and its battalion of tanks. The night before, they moved 25 miles to the left flank of the Blue Army and then inwards. The whole of the rear system of the Blue Army is in confusion.

The only force the Blue C.-in-C. has intact is five battalions of tanks. These are well out on his right flank, preparatory to attacking the left flank of the Red Army. He withdraws them to a river slightly in rear, a stream which runs at right angles to his original line of advance. He does so because by air he has learnt that great numbers of Red tanks are attempting to cross it. He wheels his five Battalions inwards and they sweep down the river.

The Red tanks are surprised and taken at a terrible disadvantage. Some try to cross the stream and are ditched, others try to withdraw and are shot down, a few get away.

The Red C.-in-C., hearing what has happened, recalls his Cavalry Division. The horses are dead-beat and some of the tanks are running short of petrol. That evening but a remnant of the force rejoins him. Simultaneously he learns that the greater part of his infantry are in flight. Rumour has it that they have been attacked by thousands of tanks and that Battalions are surrendering wholesale. As darkness falls, the roads are blocked by streams of fugitives. Panic is now in command; even familiar sounds, like the noise of a motor-cycle or the droning of an aeroplane, send mobs of men scattering across the fields in the dark. Except for the five battalions of tanks, under the Blue C.-in-C., there is not an organized body of troops on or near the battle-field.

Pursuit.—The Blue C.-in-C. orders a relentless pursuit. Then he counterorders it, for his supply services are in chaos and he cannot get up petrol for his machines. He cannot get rations for his men, he does not know where his men are, he does not know where his rations are ; all he knows is that most of his lorries are overturned in the ditches and that their drivers have disappeared.

The condition of the Red Army is still worse. Hungry men start marauding, marauders soon become brigands. The peasants take to arms in self-defence. The Red Government goes down with a crash and is replaced by a patriotic but revolutionary assembly.

The Blue C.-in-C. withdraws his five Tank Battalions ; re-ëstablishes his railheads and assembles the equivalent of some two Divisions of infantry. He begins to advance on the Red capital. He enters it only to find that, as a political centre, it has vanished, and that the people have taken up arms. Everywhere he is met by an intangible foe. Rails are torn up, bridges destroyed and water poisoned. His tanks are invulnerable, but with 300 machines he cannot control an entire nation. Directly the tankmen get out of their machines they are shot at. His small force of infantry can just keep open one line of railway and, except for this line and the capital, the country is unconquered.

At the opening of hostilities six Divisions of infantry might have won through. Now he wants at least twelve, possibly eighteen for police work alone, as well as hundreds of tanks and armoured cars. His country cannot supply them and, whilst its Government is scratching its head, President Wilson descends in a parachute from a giant battle plane, patches up peace terms and Red and Blue lands have lived discontentedly ever since.

PART II.

Apology.—I must now apologize for the behaviour of the opposing Commanders-in-Chief. In place of criticizing their tactics, let us examine their difficulties. Both had been brought up in a certain school of thought. Both had been educated on Training Manuals which they were not allowed to contravene. In the Red Manual the Commander had learnt: "To seize and hold a position with infantry remains the only known way of destroying the enemy"; consequently, when tanks were given him, he looked upon them as handmaids to the infantry attack. In the Blue Manual, the Commander had learnt that shock is the decisive factor, so he, consequently, acted as he did.

Now, in my opinion, the initial mistake committed was that both these Commanders could not divorce themselves from particular points of view. A hundred years ago there were three arms—infantry, cavalry and gunners. To-day, we have a multiplicity of arms which are not infantry, cavalry or gunners. Why not, then, change our system of thinking and think in terms of close combat troops (the new infantry), protective troops (the new gunners), and pursuit troops (the new cavalry). Then examine each group, pull out the weeds and organize each so that each can co-operate within itself and later on, perhaps, all three groups can co-operate with each other. Do not let us bother about holding ground or conquering ground—let us organize movement; this is the crucial problem. I will now examine each phase of the above encounter battle.

Approach.—Throughout the approach we see one outstanding difficulty, the difficulty of co-ordinating movement. Though tanks are roadless vehicles, when they are not fighting, their normal position is on a road, just as the infantryman's is. Man is a roadless animal, but if he has to walk from Aldershot to London he goes by road and not across country. If he has to fight an enemy along the way, he will often get off the road, but whenever possible he will get back on it. In fact, he only gets off the road so that he may get along it the quicker. With tanks we must do just the same

The tank wants to go at eight miles p.h. and boils over if we try and make it go at two; the infantryman wants to go at two miles p.h.

and boils over if we push him along at eight. As we cannot increase the marching-power of infantry we must produce a tank which can move at any pace without injury to itself. There is no difficulty in doing this. Then, if necessary, each company of infantry can have its own platoon of tanks and there will be no need to place tanks in front or behind formations, or on separate roads. If armoured cars come along, they will be ready to meet them. Such tanks can protect infantry as long as they move at from two to three miles p.h. Have we solved the problem? No!

Contact.—Cavalry can move for very short distances at twenty miles p.h., or for fairly long ones at eight. Can these tanks and cavalry co-operate closely? No! Why? Because tanks are protected against bullets and cavalry are not. The Red Cavalry Commander seems to have realized this, for he did not turn himself into a worm with the tank as the hook. If, in place of Blue Cavalry, he had met Blue tanks, I imagine he would have done very much the same thing. He would have used his cavalry as eyes, not as fists, and, if pursued, he would have scattered so as to reduce the target. He would, therefore, before he advanced, have settled on his "bounds" forward and have selected various rallying points if he were forced to scatter. In fact, he would be ready to dematerialize his command at any moment and materialize it again, anyhow in groups, an hour later and well in rear or to a flank. "Dematerialization" is the opposite of charging.

As long as tanks cannot move quicker than horses, cavalry will remain a useful arm.

A point worth noting in this contact engagement is that if, in war, we can strike a crushing blow first, even if we only crush a small force of the enemy, we not only gain a physical victory over the force we have crushed but a moral victory over every man behind this force. The lesson here is that cavalry and tanks, when working together, must act with the greatest audacity and cunning. To avoid jealousies they should belong to one mobile arm—the pursuit troops. Pursuit does not necessarily mean waiting until an infantry battle has been fought. If we are mobile soldiers let us get the infantryman out of our heads and pursue whenever we can. Our object is not so much to "fix" the enemy, but to endow him with extreme mobility in the opposite direction to which he wishes to go. Why? Because by so doing we shall turn him into a demoralizing projectile. We must always remember that the enemy has nerves.

Deployment.—Granted that the tank can, without detriment, move at the same pace as the infantry, deployment with tanks is no more difficult than deployment without them, especially if each Battalion has a Company of tanks of its own. In other words, we have dismissed the idea of infantry and replaced it by that of close-combat troops.

But have we really solved the problem of deployment? No!

What is this problem? Rapidity of movement. The tanks can move at twenty miles p.h., that is, eight times the speed of infantry. Twelve miles of infantry take a whole day to deploy; twelve miles of tanks will take two hours, perhaps less. What if the enemy detach an independent Brigade of tanks to attack us whilst we are deploying? Should we detach a Brigade also to attack the enemy's Brigade and so cover our deployment, because we consider it essential that our close-combat troops must not exceed two miles p.h.? Here, once again, we catch ourselves thinking in terms of infantry.

What if we have not got an independent Tank Brigade up our sleeve? Are we going to let ourselves be run over? Would not we detach every tank we could from our close-combat forces to frustrate such an ignominious end? What would the infantry forces say? Would they console themselves with the idea that they were the decisive arm, that they can hold and conquer ground? What would their *moral* be like when their tanks, not as a united body but as a host of separate companies, disappeared over the skyline? What if their tanks were defeated? What if their tanks pursued the enemy thirty miles and defeated them? Are they going to double thirty miles to hold this ground? Or must their tanks abandon the idea of defeating the enemy and replace it by, "We must not go more than five miles or else our infantry will never get here by this evening."

By enabling a tank to go two miles p.h. we may have solved some minor march problem. Why not, in place, mount the infantry in cross-country buses which can move with the tanks and at the same pace? Instead of marching twelve miles a day they will then move one hundred, and deployment will be proportionately rapid and, if enemy's tanks are met with, the buses can fall back twenty miles in a couple of hours and, if our tanks beat the enemy thirty miles ahead, the buses can cover the fifty miles in some five hours and their occupants can hold whatever ground they like as long as their tanks remain close at hand. If their tanks move away, they can hold the ground against infantry. But is it likely that the enemy will attack them with infantry when he can make certain of victory by attacking them with tanks. If he does so, then the infantry will get into their buses and bolt. Their power does not rest in holding ground but in ability to abandon ground, and abandon it at a speed equal to that of the tanks.

Battle.—I will now turn to the battle. Why was it such an appalling chaos? The main reasons were because the tanks were bullet-proof and could move at twenty miles the hour, whilst the infantry were not bullet-proof and could not move at more than four, when in flight. Had they been provided with cross-country buses, most could have saved their lives, but what use would they have been as close-combat troops? None, except in areas in which tanks could not move.

Either in buses or on foot, infantry offer no protection to the guns in rear against a tank attack. If overrun by tanks, their supporting gunners have to fire indiscriminately on friend and foe. If only the guns could be placed in front of the infantry, how much safer would the infantry be! This can only be done by putting the guns on tracks. For a moment I will examine this question of artillery.

In the recent war, tanks, which could move at four miles p.h., had to attack positions held by hundreds of guns. Many tanks were hit, but, in spite of all these hundreds of guns, every well-organized tank battle was a success—an overwhelming success. To-day, we have only seventy-two guns in a Division, and, in spite of the fact that some of them possess split trails, are they going to be as successful against tanks moving at 20 miles p.h. as the German non-split trail 77's were against Mark IV. and Mark V. tanks?

Had the guns of the Red and Blue artillery been mounted on cross-country tractors or in tanks they could have protected the Red and Blue infantry. Their object would not, however, have been to effect this protection, but to destroy the enemy's tanks and tractor-mounted guns. The field-gun motorized is, in fact, no longer a protective arm but a close-combat weapon.

Counter-attack.—The Blue counter-attack succeeded not only because the Blue C.-in-C. had an organized force of tanks in hand, but because this force was homogeneous; it did not include arms which it had to protect but which could not protect it. The Blue C.-in-C. made full use of ground, not as cover but to restrict the mobility of his enemy's machines. He waited until they were hung up by a river and then attacked. This may seem a small point, but it is a most important one. We have been trained to appreciate ground from the point of view of cover and of fire effect. In the future we must also appreciate it from that of tank mobility. All our war maps will have to be changed. They will have to be coloured showing where tanks can go, where they cannot go, and where it is difficult for them to go. What we shall require in the next war are maps on the lines of sea-charts.

Pursuit.—Why did the Blue pursuit peter out? Because the Blue Army's supply system had gone west. To a mechanical army, its lines of communication are more vital even than those of a non-mechanical. This can be partially overcome by oil and gas producer plants, but as long as tanks are driven by petrol, communications must be safeguarded or else fleets of "tramp" aeroplanes must be created to convey fuel to them.

And now as to the last question. Why had President Wilson to parachute out of the heavens like a falling Lucifer? Because, though armies can be defeated by machines, nations cannot be, except at a stupendous cost. To keep a nation in order we want men. Men who move everywhere, who go into houses and who can disperse meetings without bloodshed. To control a nation we want "human touch" ; to conquer a nation we must establish order. When a nation rises, God help us, and to prevent its rising we must organize success and not merely gain victories. To organize success we want men, and the quicker we can move these men about the less likely are the people to revolt.

PART III.

Conclusions.—In my Apology I stated that a hundred years ago there were three definite arms—infantry, cavalry and artillery. In the 14th century there were archers, pikemen and knights. Wellington did not think in terms of archers, pikemen and knights, and he was right. To-day, we have new arms and we also must cease thinking in terms of the old. We are not certain of these arms, let us try to group them in the three essential groups.

(i) *Close-Combat Troops.*—Tanks, motorized field and medium artillery and motorized infantry, the last for attacking regions unsuited to tank action and for outpost work.

(ii) *Protective Troops.*—Motorized heavy guns and infantry pioneers. The latter to be used mainly on the lines of communications to build and garrison anti-tank block-houses and to lay mine fields. The duty of these pioneers is to hold ground and they should be equipped to do so.

(iii) *Pursuit Troops.*—Cavalry, as long as they are useful ; fast, lightly-armoured tanks and scout tanks, also aeroplanes.

Behind this army of conquest will advance an army of occupation and of administration. It will consist of men and it will hold the countries won by organizing tranquillity within their boundaries.

Now I will conclude this paper by saying that I entirely agree with the *F.S.R.* when it tells us that infantry is still the decisive arm. I agree, because if we went to war to-morrow we should not possess sufficient tanks to wage such a battle as I have described. As long as we have no tanks we must rely on infantry. If a great war broke out to-morrow, I believe, because of the enormous number of machine-guns which now exist—five hundred to a Division in place of twenty-four as in 1914, the war would go static at once. Behind a wired machine-gun wall great tank forces would be created. How would they be organized, this is the question ? Would we think of them in terms of infantry, cavalry and artillery ? Of course we would, unless we had troubled ourselves to think out their values in other terms.

This, then, is the gist of my paper.

We must be loyal to the present, because we live in the present. Do not, however, let this prevent us being loyal to the future. To be disloyal to the future is to imagine that the present cannot change. It *will* change, and in terms of our ignorance or forethought.

THE TALUS SLOPE, GIBRALTAR.

By MAJOR H. E. COAD, A.M.INST.C.E., S.R.E.S.

THE Talus Slope on the Mediterranean side of the Rock of Gibraltar consists of an immense bank of sandy earth overlying ancient detritus from the compact limestone of which at this point the Rock is formed. The sand has been blown up over this debris in the course of ages by the almost constant Levanters, and lumps of rock weighing from 30 tons downwards, the more recent detritus from the sheer cliff behind, are interspersed in it.

The area of the Talus is about 16 acres, and the angle of slope is, roughly, 35° on the average, but, in places, the theoretical angle of repose is exceeded. After heavy rains, the unstable material is washed down and nuggets of rocks are exposed and lie in a state of potential danger. Owing to the shifting nature of the sandy surface, any form of vegetation which might have tended to consolidate the surface is very sparse.

The only road from Gibraltar to Catalan Bay village and to Sandy Bay beyond, runs at the foot of the slope, and the danger to passers-by from falling rocks has for long been a bugbear to the Division Officers of the Gibraltar North R.E. Division, who are in charge of this area. Whilst narrow escapes from falling fragments are on record, no injury to life or limb has yet resulted at this point.

Falls of debris have, however, occurred a few steps further south at Catalan Bay, the most serious of which took place in 1811, when 18 inhabitants were killed. In 1910 a large boulder crashed through a tent of an Artillery Camp in Catalan Bay, the occupants of which escaped just in time. Again, in 1917, during a heavy storm, a large mass of debris fell into the village during the night, happily without loss of life.

The constant danger, therefore, has always been a cause of anxiety to those using the road, and this anxiety has been accentuated by the presence of the danger notices which prohibit loitering on the road in the vicinity.

Some years ago a deep trench was cut around the slope about 60 ft. above the road. Judging by the number of small rocks in it, this trench has undoubtedly saved many falls on to the road.

There recently were some large rocks near the crest of the slope, at an elevation of about 450 ft. above sea level. These were in the foot of an almost perpendicular bank situated above a moraine of very loose sand leading to a small precipice about 40 ft. high. These rocks weighed about 20 tons each. Whilst partly supporting the bank of the slope above, they appeared to be in such an unstable state as to be in imminent danger of falling. It was proposed to remove them, for, owing to their shape and size and the height they were resting at, it was considered that, should they slip, the trench would not stop them from reaching the road. The soil in which they were partly embedded was of so friable a nature that cascades of dry sand streamed down the bank wherever it was disturbed. The opinion was expressed that it would be better to leave these rocks alone, rather than to touch them and so endanger the upper bank of sand and stones, but after several inspections, it was determined to remove them and to smooth off the overlying bank, which at that point was lying at a slope of about 60° with the horizontal.

Owing to fears of a sudden landslide it was considered impracticable to attack the rock from below. The superimposed debris was therefore carefully removed by native workmen, roped well back to more or less safe ground. After exposing the rocks as far as could be safely done, it was seen that no further excavation by hand could be carried out without a serious risk to the lives of the workmen, since the loose material from above was cascading around and about them and there was a strong possibility of the whole of the upper bank collapsing. They were accordingly withdrawn and four slabs of guncotton laid just behind the key rock and detonated electrically. The main result of this charge was to partly shatter the key rock, but it was seen that the charge had shaken the supporting rocks and made the bank more dangerous still. A further charge of equal size was detonated and this completely blasted the key stone out. It was then a simple operation to start the remaining rocks with a crowbar, and about 200 tons of sand, earth and rocks moved slowly down the moraine, the large rocks gradually gaining impetus until they bounded with a roar down the slope, across the road, to find their destination in the sea. The appearance of the moraine after the fall was somewhat peculiar, a stream of sandy earth about 10 yards wide, with small boulders turning over and over in it, flowed sluggishly down, the material issuing from the bank above like water. For a time it appeared probable that the whole of the upper bank would collapse, but, after about 20 minutes, the stream moderated and came finally to rest several hours after the explosion, a large portion of the bank having fallen out.

A few small outstanding rocks were then overturned by hand and the upper slope appeared to be far safer than before.

It is intended to deepen the trench referred to above in order to make certain that any smaller rocks which may fall in the course of time will be caught, and it is believed that the whole of the Talus Slope will then be in a safer state than it has been within memory of man.

AN EMERGENCY METHOD OF FIRE CONTROL FOR ANTI-AIRCRAFT ARTILLERY.

(*From the United States Army "Coast Artillery Journal."*)

By LIEUT.-COLONEL D. M. F. HOYSTED, D.S.O., R.E.

A CAREFULLY thought-out suggestion for control of anti-aircraft guns in case of sudden damage to all the height and deflection finding instruments, is set forth in the *Coast Artillery Journal* of the American Army for January, 1923.

It is the collaborated work of two captains of the Coast Artillery Corps. The method consists of the use of a diagram previously worked out for each class of gun, projectile and fuse in general anti-aircraft use. The diagrams vary also with the pre-assumed speed of the hostile plane. In general terms the suggestion is that the gun commander should have a series of the diagrams always at hand, so that in case of such emergency he could at once make use of the one which should most nearly suit the needs of the moment.

The diagram consists of five concentric circles plotted to scale and representing angular heights of 75, 60, 45, 30 and 15 degrees respectively, round a centre point which is designated " Position of Plane." From the same centre, and cutting all the circles, are plotted radii at 15° interval, labelled as under :—

(For this description comparison has been assumed to a compass card with the 0° line at 12 o'clock of the circle.)

Radii on	0° and 180° (compass)	lines	labelled	Going 0° and Coming 0°
,,	90° and 270°	,,	,,	,,	Passing +90° and Passing −90°
,,	15° to 75°	,,	,,	,,	Going +15° to Going +75°
,,	105° to 165°	,,	,,	,,	Coming +75° to Coming +15°
,,	195° to 255°	,,	,,	,,	Coming −15° to Coming −75°
,,	285° to 345°	,,	,,	,,	Going −75° to Going −15°

It will now be seen that each radius cuts five circles and each circle cuts 24 radii. At each cutting point is a small rectangle, called by the author a " box." And in each box are shown certain readings for altitude, fuse range, vertical deflection and lateral deflection—five readings for each.

The height readings in each case are the assumed heights of one, two, three, four and five thousand yards.

The corresponding readings for fuse and deflections have been worked out for those five heights on the assumption that the engine speed of the hostile plane is, say, 110 miles per hour.

Each box (except seven) therefore contains five sets of readings dependent solely upon the assumed altitude of the target.

The seven boxes on 75° angular height circle and on radii 125° to 225° inclusive contain the instruction "Hold fire until target is going."

The readings have been calculated on "A dead time of maneuvre of eight seconds . . . in determining the various fuse ranges (*sic*)."

The "gun pointer" lays on the target and announces the angular height.

"The battery commander makes an estimate of the angle of approach of the target and its altitude."

The battery commander consults the "box" at the junction of his estimated angle of approach radius and angular height circle, and takes therefrom the fuse range and deflection under the figure for the nearest estimated altitude of target.

Thence he makes his bracket and necessary corrections.

A series of Addenda to the diagrams show how to calculate quickly any variations of speed below or above the actual engine speeds for which the diagrams are designed. These corrections apply to variation of engine speed of 15 miles per hour on either side of the normal speed shown for the diagram. The diagram for a normal speed of 110 miles per hour would therefore be used for engine speeds varying from 95 to 125 miles per hour.

The use of such diagrams might be of assistance to a battery commander who had absolutely no instruments of precision to assist him.

The American collaborators also point to the use, in future, of heavy machine-guns and automatic guns of small calibre for the attack of aircraft.

The projectile of the latter to be a small explosive percussion shell, with a fuse sensitive enough to burst on contact with any part of the aeroplane.

This seems to take us back to an improved type of pom-pom such as we used for attacking hostile aeroplanes in France in 1914.

When watching such attacks, at the beginning of the war, the author could not help wondering where the hundreds of small 1-in. shells *did* eventually burst, as they *never* seemed to hit the target.

Anti-Aircraft Defence in France.

The rôle of the Anti-Aircraft Defence Service appears to be as follows :—

A. *At all times, both by day and night.*

1. To keep Headquarters and the Air Service informed concerning all activities of the hostile Air Service and prevent surprise from the air.
2. In case of probable aerial attack to warn all persons concerned in sufficient time for the necessary counter measures.
3. To provide both military and civil authorities with information concerning the construction of bomb-proofs against aerial attack.

B. *By day.*

1. To co-operate with the Air Service to prevent, by direct attack, hostile aircraft from crossing the lines or frontier, and, if they succeed in crossing, to hinder them from accomplishing their mission.
2. To hinder hostile aerial observation by means of camouflage.

C. *By night.*

To ensure protection against aerial attack on important points such as headquarters, parks, depôts, stations, etc., by following means :—

1. Attack of hostile aircraft with artillery at certain points in their course and close to the important points to be defended.
2. Creation, by means of searchlights or other method, of series of illuminated spaces within which the defending planes may operate.
3. Obstacles in the probable route of hostile aircraft.
4. Leading hostile aircraft astray by camouflage of reference points and objectives.
5. Rendering targets invisible or modifying their appearance by camouflage.

To obtain the above results a broad "belt of detection" is to be maintained near each frontier in the hope of rendering it impossible for hostile craft to enter French territory without being seen or heard.

These belts of detection consist of observation posts which are to be situated not more than 15 km. apart, and which will be united in groups to "Information Centres of Anti-Aircraft Defence," which will, in turn, be grouped and united to "Centres of Anti-Aircraft Defence."

The telephone lines connecting these posts and centres are on no account to be put to any other use.

There are three types of 75-mm. gun mounting used in the Anti-Aircraft Artillery: the automobile mounting, the towed mounting and the fixed platform mounting, of which the relative mobility is obvious.

There are two forms of listening apparatus in use, the Bailland and the Perrin, the former of which is heavy and can only be used in fixed positions.

They are still in more or less the trial stage.

The searchlights in use are of 90, 120 and 150 cm. and are mounted on wheeled carriages hauled by a motor tractor which also forms the generator.

They are used in groups of eight lights some 3 km. apart, three such groups forming a Searchlight Company. It is laid down that the lights should be constantly moved to new sites so as not to form a guide for the hostile craft. Upon instructions received during the morning, a Searchlight Company should be able, by the same evening, to organize its portion of a light defence zone within a distance from its station of 50 km.

When machine-guns are used against low-flying aeroplanes, the French method is to use them in groups of at least eight guns echeloned with reference to each other: fire is controlled by bursts of 15 or 20 shots from each gun.

In the French Army the Camouflage Service has formed part of the Anti-Aircraft Defence Service since 1918, as it is principally used as a means of protection from aerial observation.

MILITARY SURVEY.

By MAJOR M. N. MACLEOD, D.S.O., M.C., R.E.

SURVEY has long been regarded as a soldierly accomplishment and the construction of maps has been for many years an essential preliminary to the orderly and methodical conduct of a campaign. It is to be expected, therefore, that evolutions of tactics and armaments will entail corresponding alterations in the requirements of armies in these respects.

It is, perhaps, unfortunate that the evolution of maps and surveys, which have become rather technical subjects, has resulted in the ordinary fighting soldier regarding them, in great measure, as things which must necessarily be left to the "expert" and with which he has no direct concern except in so far as he has to make use of the results of this expert's labours.

Nevertheless, military topography has for many years formed part of the military education of every officer; and in the light of recent experience it may be predicted that it will continue to do so for many years to come. The great war has, in fact, accentuated the importance of topography at the same time that it has introduced us to new conditions which radically affect the principles of its application to military operations and the training of officers and men in it.

In this article it is proposed to examine the application of survey to tactics in the light of recent war experience, to point out the effect of modern developments of armament, and to suggest the lines on which training should be carried out.

Up to the commencement of the great war the accepted doctrine took little or no account of the possibilities of survey work as a tactical auxiliary and envisaged a map almost solely as a means of finding the way about a strange country. Tactical details of any operation were invariably worked out on the ground itself after the arrival of the troops or their commanders on it. The topographical training of officers was directed to the understanding of any maps which might be in their possession (*i.e.*, map-reading) and to the construction of rapid sketch maps to enable them to deal with situations in which no map at all was to be had.

Modern developments have affected this doctrine in two ways. In the first place, the power of modern weapons is so great that time and opportunity for examination of the ground held by the enemy, after the fighting troops approach it, can no longer be counted upon. The great extent of modern battlefields rules out the possibility of personal reconnaissance of the ground in detail by the higher commanders.

Whenever it is possible to do so it is better to study the topography beforehand with the aid of an accurate and detailed map and to work out the details of an operation to the fullest possible extent before it begins.

In the second place the introduction and development of aerial photography enables us in any given time to prepare sketch maps far surpassing in extent, accuracy, and detail, anything that could possibly be done by partially trained individuals on foot.

In the use of the map on the actual battlefield also, important changes have taken place which affect profoundly the type of map which it is desirable to provide. These changes are mainly the result of the increasing "specialization" of armaments; progressive gains in power being offset by a progressive difficulty in ensuring effective use, until the efficient co-operation of the various arms in battle has become the outstanding tactical problem of the day.

As long as men continue to fight with projectiles the aim of tactical methods will be to force the enemy to expose himself to view and then to destroy him from a distance without exposing oneself. This leads naturally to the sub-division of forces into two parts, one of which attempts to close with the enemy to discover where he is, and the other of which attempts to destroy him by indirect fire at continually increasing ranges as soon as his position has been found.

In practice, what all this amounts to is that, if the arms employing long-range fire, *i.e.*, artillery and machine-guns, are properly to protect the infantry while they are exposed in closing with the enemy, it is essential that as soon as the enemy is discovered, the artillery, etc., should be informed exactly where he is; and that when they receive this information they should be able to attack and destroy him before he can either injure the exposed infantry or escape to another position.

Hitherto the latter aspect (the destruction of the enemy) has perhaps been studied more closely than the former (the discovery of his position) and we have evolved artillery methods which do enable guns to attack with success targets which they cannot see but whose positions are known. The problem of locating targets has not yet, however, been seriously taken in hand, and we have been content to assume that the position of an artillery target can be located by direct observation (*i.e.*, without any special apparatus, etc.) in one or other of the following ways:—

1. By the battery itself from its O.P.
2. By observation from the air.
3. By the infantry or other front-line troops.

If, however, any of these methods is examined, it is seen that each is subject to many limitations.

The first presupposes that the battery can, and has time to, establish observation over the target, when the observer, having first located the O.P., may derive the position of the target by estimation (or guesswork) from it.

The second is only possible when the target happens to be near some topographical features and the airman is in possession of a suitable map showing these features in such a way that he can identify them correctly.

The third, like the others, depends either on the map or on a preliminary determination of the position of the observer.

This hypothetical observer, whether he be infantryman or gunner, has, however, at present no means of determining his position, or that of the target, except by "map reading"—at best, a rough-and-ready method, which depends on the following tacit assumptions:—

(*a*) That a suitable map is available.

(*b*) That there exist on the ground topographical features in the immediate vicinity of the observer or the target which he can identify.

(*c*) That the distances and directions of these features from the observer or from the target can be accurately estimated or guessed.

None of these assumptions is justified. "Map reading," in short, cannot be relied on for this purpose. It has, in fact, received innumerable trials and has repeatedly failed, and this, even when good maps and numerous topographical features were at hand.

These failures are usually ascribed to the inability of some individuals to read a map, but this is not really the true cause, which lies in the inherent shortcomings of the method.

When bad maps only are to be had, or, as in desert fighting, when there are no topographical features, it is quite obviously useless, and it can hardly be contested that a better and more reliable method is urgently needed. In such cases the problem of the observer is, in essentials, identical with that of the sailor steering his ship into harbour, or of the detail surveyor setting out to make a map. Each of these solves the problem in virtually the same way, deriving his position, when necessary, from previously fixed points, not necessarily in his immediate vicinity, by instrumental observation.

This determination from fixed points—resection, in fact—may be done in various ways. The surveyor finds a plane-table convenient, the sailor uses a sextant and a station pointer. In neither case are the particular instruments employed well adapted for use by an infantryman, but there is no reason why they should not be simplified. The principle is simple enough, depending, as it does, on the measurement of two angles only, and in the prismatic compass the officer already carries an instrument for measuring them; the result may be worked out either by the observer himself or by someone else, say at Battalion Headquarters, to whom he can transmit his observations.

The working out of the result with an instrument such as a "station-pointer" of simple design can be done quite mechanically in a few minutes and requires no technical knowledge of any kind. The only points which require consideration are the accuracy required in the determination and the form in which the result should be obtained.

To decide these points it is necessary to turn to the other side of the picture and consider the action of the gunner who has to hit the target once it has been located.

If the target can be seen from the Battery O.P. or by any intelligent person in communication with the battery, fire can be corrected by observation and great accuracy in the location is not essential. Speaking generally it may be said that the trend of most of the tactical methods we are now trying to work out, is based on the idea of enabling anyone in a position to observe the results of fire to report the results of his observation to the battery firing, in such a way that the battery can make the corrections required to get on to the target; thereby hoping to cut out the delay caused by the battery itself having to establish an O.P.

From every point of view it is desirable that methods of correcting artillery, and long-range indirect fire generally, by observation (whoever the observer may be) should be worked up, but the difficulties to be overcome are formidable, particularly when the number of batteries in action is large. In our endeavours to overcome these difficulties we must take care not to lose sight of the advantages to be gained from the ability to place the fire right on to the target from the outset without any observation at all. If this can be done the enemy has no time to get under cover or escape while ranging is going on, and the chances of inflicting material and moral damage on him are very greatly increased. It might be added also that correction of fire by observation is much simplified if the opening rounds fall close to the target.

The problem of effectively engaging a target without observation depends on, firstly, a knowledge of the performance of the gun under varying conditions of weather; secondly, on the ability to work out the direction and range of the target before fire is opened; and thirdly, on the ability to lay the gun in the required direction thus worked out; the accuracy required in the last two being commensurate with the accuracy obtainable in respect to the first. The Artillery are addressing themselves to this problem, and are within measurable distance of its solution. This is the chief *raison d'être* of what is now called "Artillery Survey."

It is unnecessary here to go into details of the procedure adopted; the basis of it is resection from trig-points, and it may be said that if these are available in sufficient numbers the gunner can already undertake to engage, without observation, any target within range with reasonable prospects of success, provided he knows its correct position within certain limits of accuracy.

The limits of accuracy required are conditioned practically by the width of the "50% zone" of the particular gun used and may be taken roughly as something between 10 and 20 yards; a degree of accuracy, in fact, considerably higher than anything ordinarily attainable by map-reading without the aid of instruments, particularly on small-scale maps.

In order to simplify and speed up the procedure, which necessarily involves a certain amount of observation and calculation, the gunner prefers to work on a system of rectangular co-ordinates, and it is on the same system that the position of the target should be reported to him. "Clock-codes" and similar methods of indicating targets, which are now officially advocated, are really only makeshifts which do not allow the gunner to get full value from his piece. If the gunner can and does work by rectangular co-ordinates there is no reason whatever why other arms should not do so also, basing their determinations of their own positions on observation of fixed points, either trig-points (if suitably "beaconed" and visible) plotted on a grid, or on map-points taken from a large scale-gridded map. These determinations are, of course, only a step towards the final object, which is the position of the enemy, and although exact knowledge of the position of our own forward troops is invaluable to gunners and everyone else in rear of them, it is not a solution of the whole problem.

Provided, however, that the advanced troops can determine their own positions, they possess, in compasses and range-finders, instruments with which they can locate the enemy with very fair accuracy up to distances of, say, 600 or even 1,000 yards. At greater distances than this it is probable that special arrangements of some kind would be necessary. The problem is essentially a survey problem susceptible of several possible solutions, all of which may require special training, or in extreme cases, special troops.

There is always a natural reluctance to employ any man who would otherwise be handling a rifle or other lethal weapon on "auxiliary" work of this kind, and before suggesting that anything of the sort should be done it is advisable to consider the problem again and weigh up precisely what advantages are to be gained by its solution.

Suppose that it is admitted that the infantry can in no circumstances locate a target with the accuracy necessary to enable the gunner to engage it without observation ; what does this imply ?

It implies that effective artillery support in a moving battle cannot be given until the artillery can establish observation over the target. It implies guns accompanying the infantry ; the use of artillery in a manner which exposes it unduly to the enemy and which makes the supply of its ammunition extraordinarily difficult.

If, however, targets can be precisely located by any means, it means that any gun within range can engage them, without waiting to establish observation ; artillery support need not be confined to such guns as can accompany or maintain direct communication with the infantry and can be given without the same restrictions as to expenditure of ammunition or exposure of the gun crews.

The two alternatives are not " shall we withdraw so many riflemen and arm them with survey instruments which hurt no one ? " but " Shall we provide a few surveyors to locate targets and hope thereby to save many gunners, and also many infantrymen who would be protected by the gunners' fire ? "

The number of men required for this purpose is not large, and it can hardly be doubted that, if they can do what is expected of them, they will be more than " worth their place."

If it is accepted that some special arrangements for locating targets are necessary, the true alternatives which require consideration are, whether an attempt should be made to train the fighting troops to do it themselves, providing them, if necessary, with special equipment for the purpose, or whether a proportion of special troops, trained and equipped for the purpose, should accompany the fighting troops.

If it proves to be practicable the first alternative would always be preferable, both because administration and command of small detachments accompanying other units is troublesome, and because a special detachment would probably not be occupied for more than a fraction of the time covered by an operation and might not be on the spot when wanted.

Provided that the fighting troops are backed by a survey organization strong enough to provide adequate and suitable data, there does not seem to be any insuperable difficulty in training troops—officers and senior N.C.O.'s at any rate—in methods of making use of it.

If this argument be accepted it follows that the topographical training of officers and men should not be directed, as heretofore, to the production of indifferent sketch maps, which can be made much more efficiently by aerial photography, but should form part of a considered survey policy bearing a definite relation to the weapons in use and the method of their employment.

The aim of this policy should be to enable troops of all arms to locate their own positions and those of the enemy on the field of battle, up to a limit of accuracy which may be fixed for the present provisionally at about 20 yards.

The methods by which they have to do this should be specifically adapted for use on the battlefield. This rules out all methods involving walking about, such as the "pacing" of distances, which have hitherto been the foundation of the topographical training of officers and men, and compels reliance on methods of resection depending on the observation of previously fixed points with suitable instruments.

The positions of these points must be defined in a simple manner well adapted for communication to others; this points to the use by all arms of a single system of rectangular co-ordinates extending over the whole field of operations.

These points must be fixed by technical services, the R.E. Field Survey Units, whose numbers and equipment should be such as to ensure that they will be available in good time for any operation.

If sufficient natural features suitable for such points do not already exist, the Field Survey Units must be prepared to erect artificial beacons and to arrange for their illumination so that they can be seen by night as well as day.

(In war, the hours of darkness are often the only times when survey work in close proximity to the enemy is possible; up to the present time we have neither practised nor made any provision for such night work.)

In addition to these fixed points the Survey Services should aim at the provision, at the earliest possible moment, of an accurate large-scale gridded map. This map should be called a "Tactical" map and should not be regarded as an alternative to the trig-points, but as a supplement to them. It is simply a convenient way of showing the positions of terrestrial features on the grid, which is the basis of the whole system.

Such a system of grid and fixed points is already being used by the Artillery and will have to be provided for them; it is only a short step forward to ask the infantry and other arms to make use of it also.

In addition to determinations of position it is necessary to consider the question of fixing heights. In hilly country a knowledge of the relative heights of gun and target is often almost as important as knowledge of their positions; the determination of height is, unfortunately, considerably more difficult, and can hardly be done with the instruments at present carried by an officer. It would seem that reliance must be placed for the present on a contoured map, though something could undoubtedly be done with aneroids and small portable clinometers if the troops who have to use them could be persuaded that the results of their use were of value, and no maps were available.

The problems the R.E. Survey Services have to solve are, firstly, how to carry forward a triangulation or traverse system at a speed equal to the rate of advance of an army, or how to lay down such a system at any stage of its advance in time for it to be of use in any considerable action ; and secondly, how to prepare an accurate large-scale map, showing, more particularly, contours, for some distance ahead of the front line troops.

The difficulties to be overcome are serious, but he is a pessimist who would say that the resources of the Corps in brains and energy, if they are applied to the task, cannot overcome them. It is, in fact, here contended that a system of fixing positions direct from trigonometrical points established by a special organization, is perfectly practicable, provided it is properly foreseen and organized, and that it is in general much more accurate and "fool-proof" than one which depends on the nature of the country (*i.e.*, on the existence of numerous well-marked features easy to identify) and on the possession of accurate large-scale maps of it.

In certain types of country, such as England and similar highly developed regions, "map-reading" may occasionally be simpler than resection from fixed points, because of the difficulty in establishing such points and the numbers of them which would be necessary. The difficulty of establishing points, in such places may be admitted, but it is precisely in such regions that the existence of good maps is most probable and the dependence, as regards accuracy, on observation of points would be least.

Even so, the fact remains that resection with instruments from map-points, such as cross-roads, hedge-corners and the like, is the best and quickest way of accurately fixing the position of any point which does not happen to coincide with some feature already shown on the map, and that rectangular co-ordinates and a grid system are the best means of defining this position when it has been determined.

The fact that it would be difficult to establish sufficient points or that they would be unnecessary in such country is a poor argument against a system which can be applied most easily in those regions where our present methods have been proved as most likely to fail, and to which, at the present time, our attentions are principally directed.

Provided a satisfactory solution of the technical problems can be found, as assuredly it can be, surveys and maps can be regarded as definite tactical accessories and the instruction of troops in the correct method of making use of them should be comparatively easy, much easier, in fact, than our present systems of so-called "Map-reading" and "Military Topography."

LIGHT FLOATING BRIDGES IN MESOPOTAMIA.

A Lecture delivered at the S.M.E., Chatham, on 11th October, 1923.

By MAJOR F. V. B. WITTS, C.B.E., D.S.O., M.C., R.E.

Introduction.—In my lecture to-night, I am going to try to give you some idea of what was involved in bridging large rivers like the Tigris and Euphrates. The whole campaign in Mesopotamia was inseparably bound up with them, whether as lines of communication, as sources of water supply, or as obstacles. They were consequently always with us and equally always had to be bridged. And yet in the *Bridging* volume of the *Work of R.E. in the European War*, 1914–19, there is no reference whatever to the campaign in that country.

My lecture is based chiefly on my personal experiences, and, before going further, I wish to apologize for its inevitably personal character.

I arrived at Basra from France on 1st January, 1916, and was left with my half-company of No. 4 Company Bengal Sappers and Miners to assist in building landing stages.

In the middle of March I was given the command of a newly raised Bridging Train, which was arriving from India. Its basic strength was 80 Indian sappers, afterwards increased to 100, and it arrived without any sort of equipment whatever, so I had a hectic week collecting tools and stores. Pontoons were arriving from India, of the Indian pattern made of sheet iron; in those days stores, etc., were still unloaded from the transports in midstream, and the embarkation authorities thought they had at last got something easy to handle, which needed only to be lowered into the river and floated ashore. However, they soon discovered their mistake—the pontoons were of such an inferior workmanship that they could not stand the knocking about of transit, and sank as soon as they reached the water. It was a bright beginning.

Orah.—We got up to the front at Orah at the end of March, 1916, when preparations were being completed for the final attempt to relieve Kut, and immediately took over the boat bridge there. This had been constructed by the Madras Sappers and Miners and was still being maintained by one of their field companies.

This bridge was some 400 yards long, and consisted of country boats known as *bellums* and *mahelas*. Those in use varied from

4 to 7 ft. beam, 25 to 40 ft. in length and 5 to 7 tons carrying capacity. The roadway, consisting of extemporized pontoon equipment superstructure, was carried on small trestles built up on the keel and supported on the gunwales. Like all the other bridges I refer to to-night, unless specially excepted, it was a light bridge, *i.e.*, for infantry in fours and vehicles of 2-ton axle-loads.

The river was then in full flood, running at 6 or 7 knots in the fastest places, and very stormy weather had been experienced. As a result, the bridge was, more often than not, quite impassable. It had consequently been decided to introduce larger boats in the most exposed portions. These were of the same design but much bigger, 13 to 17 ft. beam, 50 to 60 ft. in length and 40 to 70 tons carrying capacity. In their case the roadway had to rest on the gunwales, which required no special strengthening, but to keep them on an even keel, as a load passed over, their masts were utilized. These were spars of 50 to 60 ft. in length with a 12-in. base diameter, and they were firmly lashed right across the gunwales of every two neighbouring *bellums* on both sides of the roadway.

The bridge was anchored by every description of cable, from 4-in. manila and 3-in. steel downwards. The anchors used were the grapnel anchors belonging to the *bellums* themselves, varying between one hundred and two hundred pounds in weight.

The work of changing the boats had hardly been finished when a gale of wind blew up from the south-east against the current and I had my first experience of what a storm on the Tigris meant. Waves were anything up to 6 ft. in height and the bridge was frequently clean swept by them. All my sappers were continually on duty keeping it from breaking up or sinking. It was impossible to walk on it without serious risk of being thrown or blown into the river, and crawling on all fours was the only safe method of progression. Road-bearers were wrenched off their saddlebeams, and chesses were thrown into the river. Some of the sappers even suffered from sea-sickness. It soon became obvious that the rigidity necessary to save the superstructure from being broken up, and achieved by diagonal bracing between boats, would only lead to the smaller boats being swamped. The superstructure was therefore dismantled and the boats left to ride out the storm. Later on, life-belts were issued at the rate of one per sapper for use on similar occasions and, at any rate, greatly reduced the anxiety of mind of the Bridging Train commander.

Sandy Ridge Bridge.—To accompany the relief force, in its attempt to reach Kut, material for a second bridge had been collected, consisting of Indian pattern pontoons and light *bellums*, to be towed up river by tugs. Our disappointment was great in being left behind to look after the Orah bridge, but my men were all recruits and entirely inexperienced in bridging, and the mobile bridge was therefore entrusted to two field companies of the Madras Sappers and Miners. It was erected at Sandy Ridge, where it remained until after Kut had fallen: it was put across at the top of the flood in another appalling storm, and the work took 24 hours; it was only kept afloat by a liberal use of tarpaulins, of which, fortunately, a large supply had been arranged for.

Orah Bridge.—Although deprived for the moment of the interest and excitement of accompanying the relief force, our life on the bridge at Orah was full of incidents, of which I propose to relate a few.

On one occasion a motor-launch came across the river too close above the bridge and was carried by the current down on to one of the bigger *bellums*. The launch sank immediately and was never seen again. The occupants managed to catch hold of various ropes and lashings and were soon pulled out by my sappers, who were very astonished to recognize in the dripping party the Commander-in-Chief of the Expeditionary Force, his C.G.S. and two or three other highly-placed G.H.Q. officers. They had a very narrow escape.

On another occasion a small steam-tug fouled the bridge in the dark and remained broadside on, resting on the bows of the boats: the crew, perhaps wisely, leapt on to the bridge, and got clear. However, nothing happened for the moment, and something had to be done to try to rescue the launch and the bridge, both of which were in imminent danger. Fortunately the Mejhidieh—the largest river-boat in the country—was anchored just below, and the commander agreed to proceed above the bridge, anchor, let down a boat and cable to the tug and try and haul it off. He succeeded on his second attempt. This was Lieut.-Commander Cowley, who, a few days later, lost his life in a gallant attempt to run a shipload of provisions through to Kut and was awarded a posthumous V.C.

About this time, two of my sappers lost their lives in a most unfortunate way. Firewood was very short, and my men had orders to catch any driftwood floating down. Two of them saw a harmless looking piece of wood coming along, and jumped down into a boat and pulled it out; they had the surprise of their lives; it was the float of a small home-made Turkish mine, which partially detonated, killing them both, but without doing any serious damage to the bridge. The Turks were sending a number of mines down about this time, but I do not remember hearing of any other damage resulting.

It was shortly after Kut fell that the bridge finally received its *coup de grace*; the skipper of a large river steamer, with the usual barges lashed alongside, was caught napping by the current, and was carried broadside on to the centre of the bridge, where the bigger boats were; for a few seconds the bridge held and its boats seemed almost to climb on to the barges lashed to the steamer; then, with reports like guns, the bridge gave, the 3-in. steel cables either breaking or pulling clean away from their boats, and the steamer drifted down-stream surrounded by more than a hundred yards of the bridge. The skipper of this ship had come from the Yukon: he was relieved of his command and consigned to a much warmer climate. Material was not available to rebuild it, and, with the fall of Kut, there seemed no necessity for it: so permission was asked to dismantle it completely. This was shortly afterwards given, and the bridge was moved down to Shaikh Saad, which now became the advanced base, and re-erected at a much narrower and more sheltered site.

Shaikh Saad.—The summer of 1916 was spent at Shaikh Saad, and I propose at this point to describe how river traffic was dealt with.

Definite hours were published in orders during which the bridge would be open for road traffic and for river traffic. In this connection, the expression "the bridge will be open" is by itself entirely ambiguous, and in the early days caused frequent misunderstandings. Another cause of confusion, which took a long time to be appreciated, was the fact that it took a considerable time to open and close the bridge. Dealing with a large cut in a bridge of boats of local materials is a very different matter to forming double cut with pontoon equipment.

Cuts.—This leads me on to the question of cuts. Their position in the bridge depended on the requirements of navigation, the ruling point usually being the channel and course of traffic coming down with the stream. Their width was governed by that of a large river steamer with a barge lashed on each side, which amounted to 120 ft., and cuts of 300 ft. were often made. This was either done by breaking the portion concerned into rafts of two or three boats or by swinging the entire cut. In a strong current, breaking up into rafts was found to be the only practicable method, though swinging was adopted whenever the conditions permitted. On two occasions I have seen the swung portion break away when opened, and depart downstream. To enable the swung portion to be closed rapidly by one cable from the end, it had to be very strongly braced between boats. In the absence of submarine cable, signal wires were often laid over a bridge, when special contact arrangements had to be made at the cut.

Signalling.—Another most important point is an efficient method of signalling to shipping coming downstream, to show whether they may proceed or not. The rule was that, unless shipping could see the "all clear" signal, they must anchor well above the bridge; the "all clear" signal consisted of a large cone by day and four lamps by night hoisted on a tall mast; this arrangement is much safer than any danger signals which, in a storm, are liable to be blown down or blown out. The ends of the cut were, of course, also well lighted at night with red lamps.

Shipping coming downstream had right of way over any shipping coming up, though I have known two large river steamers actually pass in the cut. On another occasion I saw a naval gunboat drift through broadside on !

Anchors.—When we left Orah it was found impossible to recover the anchors, though a river steamer with steam anchor winch was used. Tò prevent a recurrence of their loss, should the bridge again shortly be moved, they were periodically raised. It was difficult to judge how often to lift them to ensure that they were not irrevocably imbedded in the alluvial mud, and yet retained sufficient holding power to meet possible floods or collisions.

Mobile Bridging Train.—I now turn to an entirely new phase. One of the many preparations, which were initiated in the summer of 1916 with a view to turning the Turks out of the Sannaiyat position and recapturing Kut, was the formation of a mobile bridging train. Hitherto no land transport had been provided and a bridging train had depended for mobility on tugs, supplied as required.

Pontoons and Superstructure.—It was decided that pontoons and superstructure should be of English pattern and they were accordingly ordered from home. So far all pontoons and superstructure had been of the Indian pattern, and I propose, before going on, to describe them generally and point out where they failed. The original pre war Indian pontoon was a bipartite pontoon made of copper, and was a thoroughly serviceable article, its only drawback being its weight and its cumbersome method of joining up sections. The same may be said of the original superstructure; the road-bearers, for instance, were not tapered and not hollowed out, and were consequently much heavier than the British pattern. But when Indian factories were asked to turn out large numbers, copper for the pontoons had to be given up and sheet-iron substituted, and the workmanship and quality of both pontoons and superstructure reached a very low ebb. Bow and stern sections of pontoons were not interchangeable; as soon as one leak was patched they started another; and leaks were extraordinarily troublesome to mend. Road-bearers and chesses were made of inferior wood, and often broke under very small loads or warped to such an extent as to be unusable in bridge.

Transport.—The next point considered was the method of transport. It was thought that the English pattern pontoon wagon would be too heavy for the roadless plains of the country, often feet deep in dust or mud: the Indian pattern wagon was twice the weight and intended for bullock draught, the slowest known form of transport. Experiments were therefore carried out with the Indian A.T. cart—a very light two-wheeled cart with pole draught for two small mules: a longer axle was fitted, which enabled one section of a pontoon to fit down between the wheels, and a longer pole was necessary to keep the haunches of the mules clear of the front end of the pontoon section. With these alterations, and a few minor fittings, a thoroughly serviceable cart was evolved, which could go practically anywhere that the ordinary A.T. cart could go, and that is quite the most handy form of wheeled transport. Its unusually wide track and length of pole were its only drawbacks. The cart was equally serviceable for carrying loads of supplies when required, and, in a country like Mesopotamia, that was a really serious consideration. The superstructure, anchors and cables were to be carried on ordinary G.S. wagons. Transport was arranged for 500 yards of bridge, *i.e.*, 200 pontoon carts and 56 G.S. wagons, involving 900 animals and 600 driver personnel.

Arab Village.—The bridging train I commanded had the good fortune to be selected for conversion into the Mobile Bridging Train, as it was officially called, and we were moved up to Arab Village.

Wadi Bridge.—Soon after this move the arrival of the rainy season was ushered in by a very heavy storm in the Pusht-i-Kuh range, clearly visible to us sixty miles away in the plains below. There was a bridge of boats and Weldon trestles across the Wadi which comes down from these hills. My successor at Shaikh Saad realized that this bridge might be in danger, and he wired to the O.C. battalion posted there asking " if the bridge was causing him anxiety " ; the reply he received was very much to the point ; it ran, " Bridge causing no anxiety whatever, it was completely washed away half an hour ago." The spate apparently came down in a 10ft. wall of water, and swept everything before it.

I was told to do something about it. A floating bridge was obviously out of the question, but we had available a large amount of 3-in. steel cable, intended for use with anchors. The span was 105 or 120 ft. and I rigged up a tension bridge, using pontoon superstructure for the roadway. Material for the piers and anchorages was obtained by breaking up a wrecked *mahela*. It was calculated to carry a 12-pdr. man-handled across: a year or so later I was asked by wire how it could best be strengthened to take lorries. I was gratified to hear it was still standing but felt perfectly justified in replying, " Pull it down and build another."

Secrecy.—Sir Stanley Maude had, in the meantime, taken over command, and he was a great man for surprise. Amongst other things he wanted the formation of this mobile bridging train to come as a surprise to the Turks. The pontoons, therefore, came up by river, either towed or on barges: the transport marched all the way by road, carrying supplies, and looking to the casual observer every bit like the ordinary A.T. cart. On arrival at Arab Village the carts were not allowed near the pontoons. My men, therefore, had no practice in packing and unpacking. It was only the day operations started that we were permitted to load up. The full number of carts had not then arrived, and a few pontoons had to be carried on G.S. wagons, a most unwieldy load. A G.S. wagon, on the other hand, is a surprisingly suitable form of transport for a couple of bays of superstructure of light bridge.

A general description of the operations which followed, with particular reference to bridging work, can be seen in the August number of the *R.U.S.I. Journal*, and I propose to-night to touch on certain details, technical and otherwise, not there mentioned.

Operations Round Kut.—Bridging the Hai was a very simple matter at the start; in fact, no bridge was really essential, as it consisted of a succession of deep pools alternating with dry stretches. However, the water-level in the Tigris rose soon after and converted the Hai into a respectable river 150 to 200 yards wide, which gave us plenty of opportunity to practise for the major operation of forcing the passage of the Tigris, which one realized was in store.

The first attempt to get across some 15 miles above Kut depended for success entirely on surprise and the complete absence of opposition. When these conditions were found to be lacking, the attempt was soon abandoned, but not before all concerned had received very valuable experience.

General Maude then conceived the idea of imitating the River Clyde episode at the Dardanelles. His intention was to send up motor lighters, of which a number had come out from Gallipoli: they were to run the gauntlet of Sannaiyat and the back defences, as far as Kut, where they were to turn into the Hai. Here they were to pick up landing parties and then dash out, cross the river and beach themselves on the other bank. It is characteristic of the man that he took extraordinary precautions to keep this idea to himself. Soundings were necessary round the mouth of the Hai to see if the scheme was practicable, so he summoned the Bridging Train commander to a private interview. I was much surprised at being sent for, and still more so at being sworn to absolute secrecy, being particularly warned against whispering a word of what he was going to say to even the most senior members of his staff. He told me what he wanted and added that my reports were to be private letters addressed to him personally by name. Paddling about in a pontoon for two or three nights with the Turks on one bank and our own troops on the other was no joke, and though the river was 400 to 600 yards wide, I was not sorry when I was in a position to report the scheme impracticable. He then told me to take every opportunity of reconnoitring the river for a bridge.

Pontoons for Live-Stock.—Pontoons had other uses than mere bridging. On one occasion I had to send a dozen out with the

Cavalry Division on a raid: they came back filled with a couple of dozen sheep. It was not for a fortnight that any enquiries were made for these sheep, when I had to confess we had eaten half of them. However, it was about Christmas time, so no serious notice was taken of it. One pontoon section I had fitted with a movable wire-covering and used as a mobile hen-coop: consequently I was never short of fresh eggs, but I always dreaded this pontoon being launched, in the hurry of the moment, complete with hens.

Shumran.—When the Turks were finally cleared from the right bank, I was told to reconnoitre the Shumran bend. It was possible to get up to the river bund without difficulty at any hour, but it was not so easy to measure the width with any accuracy, particularly as special orders had been given not to attract undue attention to the locality. The 3-in. to 1-mile map, based on aeroplane photographs, gave one a good idea, but it was very desirable to check it, and particularly to note the effect of a possible flood. I took very good care that my estimates, based on prismatic compass readings, were on the right side. The site of the old Turkish boat bridge was finally abandoned in favour of the apex of the bend, which was by far the most suitable place tactically and also the narrowest. I made it out to be 340 yards. A pocket sextant is invaluable for accurate measurements of this sort.

The ferrying arrangements were kept quite separate from the bridging and were worked out to the last detail and carefully rehearsed by night on the Hai. Only pontoons were used.

Turning to the technicalities of the bridge, it was made by forming up. Unlimited labour was available, overcoming the objection of having to carry baulks and chesses two or three hundred yards; and it was also considered safer, in view of the strong flood running and of the inevitable interference from hostile artillery. For anchor work two motor launches, carried on Indian bullock-drawn pontoon wagons, had been provided; these were successfully got up and launched and proved invaluable. The rate of construction was entirely controlled by the time required to get out the anchors. The current was between five and six knots and the handling of the launches was a very delicate matter: one launch did foul the bridge, and complete disaster was narrowly averted. In view of the flood running, all the downstream anchors were sacrificed, the anchors themselves were used in kedge upstream and the cables to lengthen the upstream ones. Every second pontoon thus had a 1-cwt. anchor with a ½-cwt. anchor in kedge at the end of 400 ft. of 3-in. cable. As a result of these precautions no anchors seriously dragged, in spite of a tendency to do so when first cast.

Further details of these operations can, as I have said, be found in the August number of the *R.U.S.I. Journal*, and I will therefore now pass on.

Dialah.—I was not personally present at the crossing of the Dialah, but I cannot pass it by without notice, as it was quite one of the most heroic episodes in the whole campaign in Mesopotamia. The Turks were in retreat, and it was therefore decided to act boldly and try to rush the crossing without any adequate preparations, which meant loss of time. The first night pontoons appear to have been launched successively at more or less the same spot and each met the same fate—every man in them being shot down; the river was only 100 to 120 yards broad and no proper covering fire could be arranged in the time. The second night, under cover of a local barrage on the opposite bank, the first pontoons got across, but when the barrage had to lift, succeeding pontoons met the same fate as on the previous night and their occupants were exterminated. But some sixty men of the Loyals were established, and held out under heroic conditions for 24 hours until the crossing was finally effected. This was largely due to the threat of the Cavalry Division and 1st Corps, which had been moved over to the right bank at Bawi, partly by steamer ferry and partly by a pontoon bridge which had been towed upriver from Arab Village. On this third night General Maude put into practice the River Clyde stunt he had considered before. Two armed motor lighters carrying 500 men started off to run ashore half a mile above the mouth of the Dialah. They grounded on the sandbanks in the Tigris, but in any case they would have been too late. The threat on the right bank had made the Turks move. The actual bridge then built over the Dialah near its mouth was an ordinary pontoon bridge and needs no comment.

Baghdad.—The Turks destroyed their bridge of boats in Baghdad before evacuating the place. The pontoon bridge from Bawi was towed up and put across at the old bridge site—the narrowest point of the river. My mobile bridging train marched up from Shumran and we put a bridge across at the new advanced base just below Baghdad.

These bridges were later replaced by two, known as the North and South Bridges. The North Bridge was made of large open iron pontoons sent out from India. The South Bridge was formed of dredger pontoons supplemented by a few locally made bridge boats. These dredger pontoons had previously been used in a bridge over the Euphrates at Gurmut Ali, where they were anchored end on right across the current, violating all the rules for floating bridges; this was done in the absence of sufficient material for any other method, and proved satisfactory. A 60-pdr. could be man-handled across the South Bridge. It sank once during construction and was completely destroyed later, when it was replaced by the Maude bridge, which met a similar fate in the floods this spring. Full details of this fine bridge can be found in the volume *With the Inland Water Transport in Mesopotamia.*

We stayed at Baghdad for a fortnight or three weeks, and were then ordered forward to take part in the operations for the capture of Samarrah.

Two incidents in connection with this move are, I think, of interest. Our orders came by clear line telegram one morning about ten o'clock to march that night at ten o'clock to a place some 20 miles ahead. The bridge was across the river and in use. I arranged my time-table for dismantling the bridge and loading up so as to allow my men three hours for rest and food before marching. About six o'clock in the evening I received another wire telling me not to dismantle the bridge until a certain brigade of artillery had crossed. By this time the bridge was completely dismantled, and loading up was nearly completed. When I telephoned to point this out I was informed that ten o'clock was the time ordered for my march. The time required to dismantle 300 yards of pontoon bridge and load it on to transport, not to mention the fatigue caused to the men, had once again been overlooked entirely.

During the day I had taken the precaution to ask for the latest map. It seemed from it that if we stuck to the railway during the night we should find ourselves near the river in the morning. Instead, however, there was no sign of the river or of any other water; we therefore struck north and had some five miles to march to the river, making 25 miles in all. The map was all wrong. It was the same map which had led to our turning the Turkish position at Mushaidieh three weeks earlier; the Turks did not anticipate such a wide detour from the river, and, in fact, there was no intention of making it.

After a halt for a day or two at Fort Kermea, we marched on to Beled. On the way we were caught by very heavy rain, the ground was completely flooded and we were able to water the mules as they stood. The only way we could get on again was by temporarily abandoning half our carts and wagons and double-teaming the other half the remaining four miles to camp, and then sending back the double teams.

Sinijah.—From Beled we moved down to the Tigris at Sinijah and put a bridge across there. This place practically marks the limit of the alluvial deposit, and, from here on, the bed of the river consists of shingle with occasional rocks. I particularly remember this bridge for two reasons. To start with, every road-bearer and chess was in use, and there was literally not a single one spare; wagons were, therefore, particularly carefully scrutinized before crossing, and I recall bitter complaints from the gunners at being told to throw off tents and grain from their ammunition wagons. Then the night it was done we got warning that the Turks had set fire to two ammunition barges which they could not take away upstream; that they were adrift and floating down towards the bridge. We opened a cut and sent a tug up. The latter piled itself up on the shingle almost at once. Fortunately the barges too soon stranded.

Samarrah.—As soon as Samarrah was occupied at the end of April, 1917, the bridge was moved up and put across there, and there it remained in peace for the next eight months. The site chosen was the most suitable during the low-water season, but it was evident that it would have to be abandoned during the floods, for which reason a site 500 yards wide was selected and prepared. But when the floods finally came, it was found impossible to keep a pontoon bridge afloat, and it was replaced by a steamer ferry.

At Samarrah there was a difference of 23 ft. between low and high-water marks. Floods were due either to heavy rain or to melting snow in Asia Minor; the former caused possibly the more sudden flood, but the latter was responsible for the highest floods. The water occasionally rose 8 ft. in the 24 hours. Elaborate flood-warning arrangements were initiated, but were of little value to the bridge furthest upstream, as our enemies the Turks would not co-operate!

During this summer, in addition to the main pontoon bridge, a flying bridge was maintained at another point. The raft was of the ordinary four-pontoon type and worked on a 3-in. steel rope, suspended between a tripod on the higher bank and a length of the Baghdad railway up-ended on the other bank, which was practically water-level.

This flying bridge was later replaced by a bridge of half-pontoons some 200 yards long. It did useful work, but is not a satisfactory form of bridge.

A handrail was made of oars fitting into hoops on the kelson and held by the rack-lashing and carrying spare anchor cable fixed by clove hitches. It was of considerable moral value, and its flimsiness was an advantage, as it did not complicate cutting a wagon clear, if the bridge itself was in danger after an accident, as often happened in a strong current.

The 60-pdr. guns and 6-in. howitzers had also to be moved across occasionally. This was done on a standard pattern 60-pdr. raft, moved across below the main bridge by ropes, pulled by sappers walking across the bridge.

The number of baulks in bridge was brought up to nine per bay to enable armoured cars to cross freely, but transport was only provided for seven baulks per bay.

The powers that be were very worried about mines, and a buoyed 3-in. steel cable was therefore maintained, with considerable difficulty, across the river above the upper bridge. The Turks tried to send mines down on several occasions. They were contact mines of the latest type, but our protection lay in the windings of the river and the many banks in its course. None ever reached the so-called mine-boom; though I was sent out on two or three occasions to blow up mines stranded upstream.

During the summer, pontoon wagons arrived from England to replace G.S. wagons for carrying superstructure. All the time our sappers were kept hard at work keeping pontoons in repair. These were of the Mark II pattern and were never designed for continual use of this nature, and, though they lasted well if always in the water, if taken out after a long immersion and required again two or three days later, they were useless. Waterproof canvas, india-rubber solution and marine glue were in great demand: the planking, too, often warped seriously and had to be replaced. Various notes on the pontoon equipment based on experience in this country were published in the *R.E. Journal* for November, 1921.

By this time, arrangements and regulations for the control of traffic across the bridge had been elaborated in considerable detail. A detachment of 1 N.C.O. and 6 men of the Military Police were permanently attached to the Bridging Train, and two of their number were always on duty. A sapper maintenance detachment was also on permanent duty, consisting of 2 N.C.O.'s, together with three sappers per hundred yards of bridge, thus allowing of one sapper always on duty in each hundred yards of bridge. When artillery crossed, an officer of the bridging train was always on duty, and extra sappers, to allow of one in every other pontoon: any breakages were therefore promptly detected: a breakdown gang with drag-ropes, knives, and hand-axes were kept in readiness on the bank. One pontoon was always ready to be manned as a lifeboat, and often one of the launches was also in immediate readiness. I was fortunate never to lose a gun, but one or two ammunition and ambulance wagons were lost, and A.T. carts on numerous occasions, owing to the innate foolishness of the mule. The one ambition of many mules seemed to be to push its pair off the bridge, and a regular pushing match would ensue.

There was very good fishing at Samarrah. One of my warrant officers caught a 98-pdr. Tigris salmon on a rod and line: it took 1½ hours to land. A 132-pdr. was pulled out by one of my men on a ground line. The Arabs used to catch them by throwing in a loose bait containing opium: they then swam out and caught the drugged fish which came to the surface with their hands. Some of those they missed were often picked out as they floated through the bridge by my men.

Euphrates.—In January, 1918, we were suddenly ordered to march back to Baghdad, leaving all our actual pontoon material behind. At Baghdad we drew an entirely new outfit from the Engineer Field Park at the Advanced Base, and then marched over to the Euphrates, where operations were in preparation to round up the Turkish force.

However, we did little beyond building bridges which were never used, and thoroughly frightening the Turks. One of their aeroplanes observed us on the march and mistook our column of more than two miles in length for substantial reinforcements of field artillery; the Turks withdrew their advanced posts next day.

The Euphrates was much like the Tigris up to Hit, where it emerged on the alluvial plain. Above Hit it ran in a wide rocky bed, much cut up by stone weirs built out for water-power purposes during the low-water season.

We spent the summer of 1918 just above Hit, and the only incident of note was the complete swamping of the bridge—some 300 yds. long—in a sudden violent squall. It sank and was swept away *en bloc*. Pontoons were scattered miles down the river, but only about half-a-dozen were never recovered, though all were much damaged.

Life at Hit was dominated by the bitumen springs which belched out sulphuretted hydrogen and made things almost unbearable in certain winds.

Tigris.—We marched back to the Tigris in September in time for the final push just before the Armistice. For this we were reinforced by half the other mobile bridging train, which had been formed some time before, giving me 750 yds. of light pontoon bridge on wheels to play with.

During these operations we had our hands full and bridged the Tigris at Baiji and Fathah, the Lesser Zab at its mouth, and finally a bridge of half pontoons at Hadraniyah, where the two cavalry brigades had previously forded the river, and cut off the Turks. All these bridges were in position at once.

Fording the river here was a wonderful feat: the 18-pdrs., with which the horse artillery were specially armed, completely disappeared from view in the middle of the ford, which was almost a rapid. A number of men and horses were drowned, and one gun washed away but recovered by a subaltern of mine some days later. However, the Turks thought the river absolutely unfordable and were completely surprised. It was a great "finale" to the campaign.

Conclusion.—In conclusion there are two things I should like to mention. The first is that one bridge over the Dialah was constructed of *gufas*—the circular boat, made of reeds and bitumen, dating from the days of the Ark. Each pier consisted of two *gufas* held in correct position by a wooden frame. The other is that the Grand Stand at the Baghdad Racecourse was made throughout of Weldon trestles and pontoon superstructure, and is evidence that they, too, like pontoons themselves, have other uses than mere bridging.

NOTE.—*The lecture was illustrated throughout by lantern slides.*

UNARMED DEFENCE.

By A THIRD SAPPER OFFICER.

THE article by "Two Sapper Officers" under the above title in the June number of the *R.E. Journal* calls for some comment. It is difficult to understand the aim of the writers in impressing on their brother officers the somewhat obvious fact that it is not a "sound policy of defence" to allow another nation to invade and occupy one's country. In fact, this can hardly be considered a policy of defence at all. Though many will disagree with the view that, among civilized states, armed invasion and occupation can ever confer any lasting benefit on the invader, however ruthless he may be, yet it is obvious that, even though quite profitless to the invader, this is an extremely unpleasant and humiliating state of affairs for the invaded; and the unpleasantness increases in proportion to the ruthlessness of the invader. No nation's policy, therefore, deserves the name of "defence," unless it aims at preventing armed occupation of its territory. This may surely be taken as the chief object of national defence.

But there seems to be more implied in the two writers' conclusion than would appear from this literal interpretation. In the absence of any qualification of their conclusion that "disarmament as a policy of defence is unsound," it must be assumed that they imply opposition also to the proposal for general disarmament, which holds a foremost place to-day in the field of international politics. This may be a wrong inference, but it is one that will be naturally drawn from this conclusion.

Now, the idea of general disarmament, widely advocated to-day, is quite a different matter from the partial and one-sided disarmament, specifically dealt with by the two writers. The latter policy would be suicidal folly, but it is equally foolish to consider the former merely as an impracticable theory of idealistic cranks.

In these days, all civilized nations ostensibly maintain their armed forces solely for defence. The average civilized individual is not wantonly aggressive by nature; he believes in the doctrine of "live and let live," and has no natural desire to invade a neighbouring country and slaughter its inhabitants. Apart from moral and ethical considerations, he stands to gain nothing personally by such action, but stands to lose a great deal, and self-interest is a very powerful factor in the conduct both of individuals and states. The very existence of law and order in all civilized communities supports the assumption that the general inclination of civilized mankind is towards this peaceful condition of affairs. It follows, therefore, that there should be no fear of aggression among civilized states, and, therefore, no need of armed defence to meet it.

Unfortunately, under present conditions, the wishes and common-sense of the average intelligent individual cannot always exert sufficient influence on the national policy. A certain number of powerful and unscrupulous men in any country may consider that they stand to gain considerably, by an access of power or wealth, from aggressive action against some other state, and they may be quite prepared to force their country into such action, to gratify their ambitions. The policy of Germany before the war is an obvious example of this condition of affairs; and, in this case, the policy had been so long and elaborately planned that the rising generation had been systematically educated, against their natural inclinations, to believe to some extent in the aggressive attitude and amazing self-conceit of their rulers; any teachers who attempted to oppose this deliberate educational policy promptly vanished into obscurity.

Under these circumstances, every nation is at present forced to face the possibility of aggression by its neighbours, and to prepare its defences accordingly. A defence policy of some description being necessary, it remains to determine what form that policy shall take. Before the late war, the commonly accepted form was to ensure one's own superiority in armed strength over any likely aggressor, or group of aggressors, assisted if necessary by alliances or understandings with other governments who happened at the moment to be friendly. This led logically and inevitably to ever-increasing competition in armaments. As this policy began to prove such a financial burden to the states concerned, attempts were made from time to time, by partial arrangements and understandings, to set some limit to the progress of this ruinous competition; but the underlying conditions being as they were, these arrangements could never hope to be more than mere temporary palliatives.

The result of this universal policy is very recent history, and needs no comment, except that it very obviously did not lead to the slightest natural benefit to any of the states chiefly concerned and, if persisted in after this recent experience of its inevitable result, will assuredly prove vastly more disastrous in the not very distant future. It was generally hoped, and quite confidently believed, when fighting ceased, that the "war to end war" had exposed the futility of this method of preserving peace, and would finally put a stop to this suicidal policy. Up till now, these hopes have not been fulfilled. It seems as if the recent cataclysm has taught Europe no lessons of real value, and that the race for supremacy has already begun again. It is urgently necessary, therefore, to devise some alternative to this worn-out policy, in the hope that it is not beyond the wit of man to invent some better system for the regulation of international affairs.

Let us, then, consider what is the alternative to cut-throat competition in armaments, and to the essentially unstable method of preserving peace, known as the Balance of Power. For it is obvious that this Balance of Power must, from its very nature, be as essentially unstable as the mechanical balance from which it derives its name, since any small increase of power on either side will automatically endanger its stability.

I do not now, as my forefathers did, walk about in public armed to the teeth, to defeat any blood-thirsty ruffian who demands my money or my life. I rely on the force of public opinion, in support of law and order, and personified in a force of police, to lay such ruffians by the heels, and make the country safe for peaceable citizens to live in. And in return for this protection that is afforded to me, I undertake, firstly, not to walk about armed to the teeth, myself a menace to other peaceable folk, and secondly, to assist the police when required in the execution of their office.

Undoubtedly, the most far-reaching result of the late war has been to make it clear to numbers of thinking men throughout the world, that the only reasonable method of keeping aggressive and bloodthirsty nations in check is by concerted action on the part of all peaceable nations directed towards the maintenance of peace. It may be objected that this method was tried after the Napoleonic wars, and failed. But, as we are pleased to think, civilization has progressed since that time, and there can be no doubt that, owing to the far greater scale of the last war, and to the fact that whole nations, and not merely professional armies, were engaged, the general desire for peace to-day is very much stronger than it ever was before. It should also be remembered that this previous attempt failed, principally from the fact that the new general alliance or league made the fatal mistake of attempting to interfere in the purely domestic concerns of its constituent parts.

But, as in the case of an individual, if a nation wishes to obtain the protection and support of other peaceable nations, when it is threatened or attacked, it must comply with two conditions. Firstly, it must not arm itself to such an extent as to be itself a menace to the nations whose support it desires; and secondly, it must be prepared to give its own support whenever required to the suppression of aggressors and the maintenance of law and order. To fulfil the second obligation, armed forces must be maintained; but to comply with the first condition, they must only be of such a strength as is approved by the other parties to the agreement. This idea is the whole basis of the present proposal for a universal limitation of armaments, coupled with a general treaty of mutual guarantee against aggression, a proposal which is one of the most important results to date of the establishment by the Treaty of Versailles of the League of Nations.

Now, in some quarters, the bare mention of the League of Nations is a signal for an outburst of contempt and abuse, while in other quarters the subject is regarded merely with apathy and indifference, as being of no practical importance in present-day affairs. It is, perhaps, somewhat natural that this new idea should not at first find much support among soldiers, as our whole energies and training are directed towards preparation for war, which it is the primary object of the League to prevent. But it should be remembered that our country, by its ratification of the Treaty of Versailles, is definitely pledged to the League's support, and it is worthy of note that it has the active support of such eminent soldiers as, for example, Sir Frederick Maurice, and the present Chief of the Imperial General Staff. And, if the subject is regarded from a rather broader point of view, it is apparent that there is no real antagonism between the object of our army, and that of the League.

Very few officers will be found to maintain that our Army exists for aggressive action and the conquest of peaceable states. The whole policy of our country is essentially opposed to such use of its armed forces, which are maintained solely for the defence of our territory, honour and interests against aggression. Even such a distinguished opponent of the League as the late Field-Marshal Sir Henry Wilson, strongly urged that the primary object of our army should be, not to win a war, but to prevent the outbreak of war; in other words, to preserve peace. The primary reason for the existence of most armies and of the League of Nations is, therefore, in essence the same, namely, to preserve the independence and territorial integrity of states, and to restrain, if necessary, by force, any aggressive nation that attempts to disturb that state of affairs; and armies are the tools by which, in the last resort, this purpose must be enforced. That being so, there seems no reason why the League should not command the support of all soldiers, who give any thought to international affairs.

It is objected by many that the League in its present form is incapable, owing to various defects, of attaining the objects for which it exists. Admittedly, the machine is imperfect, as are all new institutions until they have had time to learn from experience, and perfect their organization accordingly. But its constitution is elastic, and susceptible of unlimited adjustment and improvement, given only the spirit of determination to make it work. Those, moreover, who would abolish it forthwith on this ground, never suggest any practical alternative to take its place, so that their criticism takes the easy and useless form of pure destruction.

With those who oppose the League on the ground that war is not an evil, which it is the duty of progressive civilization to root out but actually a benefit to the human race, it is useless to reason. Their mentality and outlook on life are entirely different from that of the normal man, and they are of a type whose ideals have made little progress from those of its primitive ancestors who lived in caves. And though many of them may call themselves Christians, their view proves that they have not the slightest conception of the meaning of the Christian idea. Moreover, Western civilization itself has been put to the severest test by the recent war, and it seems probable that a future war, on the same or a greater scale, with the increased powers of destruction which the rapid strides of scientific invention will afford, would destroy our Western civilization for good. It is to be hoped, therefore, that those who honestly regard war as a boon to mankind, are in a negligible minority; and this hope gains some support from the generally observed fact that it is only as a last resort, when all other arguments have failed, that opposition to the League takes this extraordinary form.

If, then, the League of Nations is accepted as essential to the true progress of mankind, the policy of limited armaments and mutual guarantee must be accepted, too. For it is on the success or failure of that policy that the League will stand or fall. It clearly cannot continue to exist in the atmosphere of hostility and distrust, inseparable from the old policy of competitive armaments.

In short, while disarmament by isolated states, as their policy of defence, is obviously unsound, it is equally true that the general limitation of armaments, with mutual guarantees, affords the only real hope of the future preservation of peace, and is in the end the soundest policy of defence for all concerned.

THE "LOUD-SPEAKER."

By "Metre."

A novel feature of the R.E. Sports Meeting at Aldershot on May 26th, 1923, was the employment of the loud-speaking telephone system in place of the traditional megaphone (with brazen-lunged N.C.O. attached) for collecting competitors and making announcements. Anyone who has run regimental sports knows the difficulty of assembling competitors; whatever elaborate arrangements have been made, recourse to the megaphone is inevitable, and as for the announcement of winners, etc., the result is usually unintelligible, and rouses a feeling of unreasoning animosity against the unfortunate megaphonist in particular, and the management in general.

These petty annoyances were completely abolished by the use of the loud-speaker. Competitors were coaxed to appear and results announced with a minimum of effort and a maximum of effect. The identity of the speaker is even more easily recognisable than in the case of the ordinary telephone.

The actual instrument used was the No. 3 size of the Public Address System, made by the Western Electric Company, by whom the demonstration was given. This is the smallest of three sizes, the largest of which makes it possible to address with ease and clarity a crowd of 200,000 people. A similar instrument was installed at Olympia, where the music from a single band was transmitted to the five separate halls of the Ideal Homes Exhibition.

The outfit, which was very compact and portable, consisted of a special table microphone with a thermionic amplifier, having accumulator batteries of 12 and 250 volts, and three loud-speaking projectors hung from the Events board outside the tent. Two of the projectors, at an angle of about 60° one to the other, were directed towards the principal enclosures, while the third was directed backwards over the field towards the dressing tents. The microphone, amplifier and accumulator were installed inside the Committee tent. (Fig. 1.)

The microphone, which is similar to that used in the broadcasting of opera, etc., has a metallic diaphragm mounted under such tension that its lowest natural frequency of vibration is above the upper limit of audibility. On each side of the diaphragm is a microphone button, these buttons and the diaphragm being connected to a

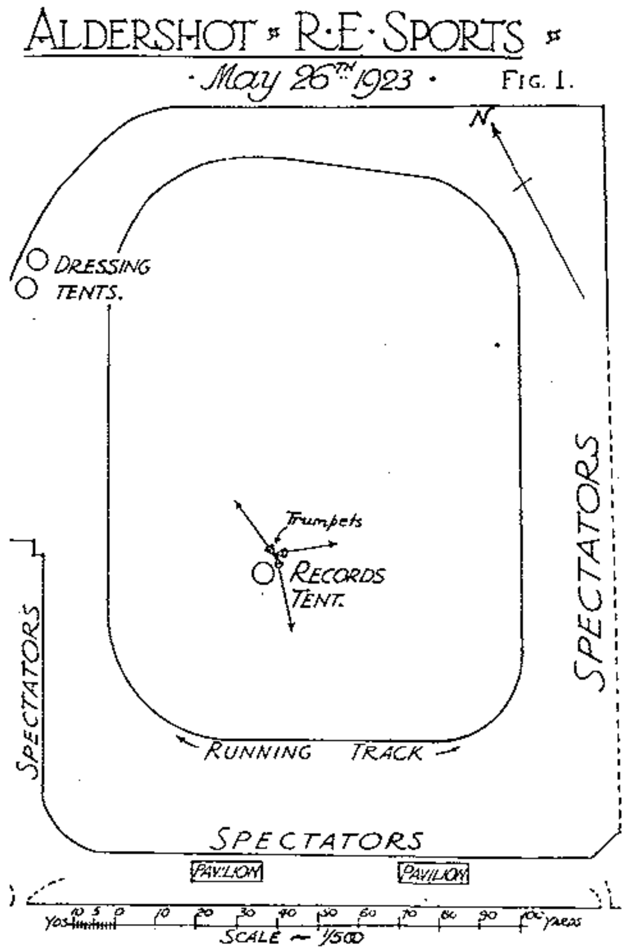


Fig. 1.

centre-tapped transformer so that in the two microphonic systems the effects of normal diaphragm vibration are additive. The whole microphone is suspended on springs in an outer case so as to protect the microphone from casual mechanical vibration.

The microphone controls (through a tapped transformer which provides for a wide variation in amplification) the input of a three-stage thermionic amplifier, transformer-coupled throughout, of which the last stages consist of a pair of triodes coupled in a "push-pull" circuit, a device which minimizes distortion due to curvature of the triode characteristics. The four triodes used in this amplifier were of the Western Electric coated-filament type, which, although not so familiar in this country as the tungsten-filamented tubes, have remarkably good characteristics and life.

The loud-speaking receivers fitted to the projectors are of the "moving coil" type, in which the coils carrying the operating

THE LOUD SPEAKER

current move in the field of a permanent magnet. The controlling force is derived from a stiff metallic spring, while the diaphragm is a corrugated disc of bakerlized linen. A skeleton diagram of connections is shown in FIG. 2.

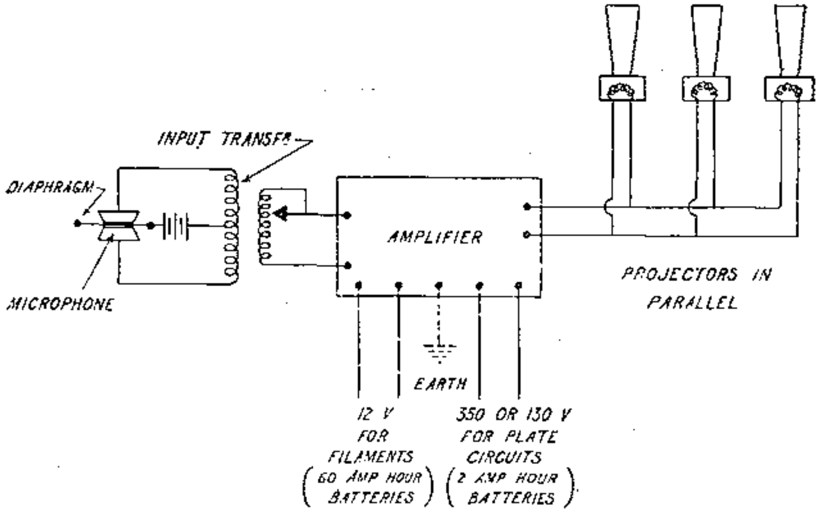


FIG. 2.

The system, while providing great amplification, has been designed specifically to reduce the distortion which is the inherent defect of acoustic amplifiers and their accessories, and considerable success has been attained in this direction.

The extreme sensitivity of the instrument was strikingly demonstrated in the tests preceding the actual sports meeting, when the rustling of a programme in the Committee tent was clearly audible at every point on the ground. In actual use, announcements made by an officer speaking in a normal manner about a foot from the microphone were clearly heard above the music of the band, and even in the public roadways outside the sports ground.

Altogether the demonstration was most interesting and contributed in no small degree to the success of the meeting.

LIEUT.-COLONEL WILLIAM CUNINGHAME OF ENTERKINE.

By F.E.G.S.

THE Royal Engineers Museum has recently received from Major-General R. Bannatine-Allason, Colonel-Commandant R.H.A., the gift of a valuable collection of documents selected from among the papers of his ancestor, known to readers of *The History of the Corps of Royal Engineers* as Lieut.-Colonel W. Cunningham, who achieved distinction by his magnanimity and gallantry in the unfortunate defence of Minorca in 1756, and died at Guadelupe in 1759. Pieced together, these documents tell the tale of a most strenuous and active life which, while it lasted, can hardly be matched in the long history of the Corps. Of his early life mention is found in a letter dated June 25th, 1742, in which he says, " From my entering into the world till February, 1740–1 I served as Volunteer and Officer in the Dutch Service," and elsewhere he says that during the first seven years of his service he was abroad in Flanders, France and Germany.

His first service under the British flag was the expedition which sailed for the West Indies in August, 1740, under Lord Cathcart, who unfortunately died at Dominica, leaving the command in the hands of the incapable General Wentworth. The expedition, after visiting Jamaica, and joining the fleet of Admiral Vernon, disembarked early in March, 1741, near Boca Chica in the island of Cuba, with the intention of taking Carthagena. After some delay Boca Chica was captured without difficulty, but in a letter written later in the year, after he had seen the gazette—probably written by the Admiral—describing the operation, Cuninghame complains that " the taking of the place is attributed to causes that no way tended to that Effect, and entirely omits mentioning General Wentworth or those who served under him and contributed entirely by the construction of the 20-gun Fascine battery and oy^{r} works there carried on to y^{e} surrender." This was followed by the unfortunate and costly attack on Fort St. Lazare, covering Carthagena, the failure of which is attributed by Mr. Fortescue to the unskilfulness of the Engineers and their failure to plant a battery on a neighbouring hill commanding the Fort. Some light is thrown on this by a dispute which took place some months afterwards between the

General and his Chief Engineer, Mr. Armstrong, in Cuninghame's presence. It arose out of a remark by the General that for Engineers "he had no Coehorns or Vaubans, but gentlemen of very good capacity who only wanted experience to complete them in their business." On Armstrong objecting, the General said, "You yourself owned to me when you was asked if you could raise a battery against St. Lazare, of which duty you excused yourself and said you could not do. . . . Did you not say when you was call[d] before the Council of War held at La Quinta, when ask[d] if you cou[d] raise a battery, that you desir[d] till next day to consider of it, that we agreed to give you time to reconnoitre and determine. That next day when I met you at the advanced guard you was standing w[th] your arms a Kimbo and when ask[d] if you had come to any resolution you answer[d] me S[r] you must attack you must attack." Armstrong's defence was "I don't remember I ever made use of such an expression, but thought an attempt of that kind more advisable than to take up so much time as would require to raise a battery and, Sir, you must excuse me to defend myself I observe that this is to be made a handle of ag[t] me and the whole blame of that miscarriage thrown upon me . . ." Incidentally, the "only competent engineer" mentioned by Mr. Fortescue as having died at Boca Chica seems to have been a Mr. More. Wentworth's fine army, sadly reduced by wounds and disease, now returned to Jamaica, but on July 19th the remnants again landed in Cuba, this time at Walthanham Bay, near Guantanomo, under the mistaken impression that it was a convenient spot from which to attack Santiago, which was nearly 100 miles distant! We have the voluminous orders, with notes, of this futile expedition. Nothing was done, it is a sad tale of inaction and sickness, and the whole force was back in Jamaica by the end of the year, each commander laying the blame on the other, but Cuninghame loyally supporting his General.

Early in 1742 yet a third expedition sailed, now for Portobello Bay in the isthmus of Panama, with the intention of crossing the isthmus and attacking the rich town of Panama. But again nothing was done, and the incident is only casually mentioned in this correspondence. It should be mentioned that, although a junior officer, Cuninghame corresponded regularly with the Master-General of the Ordnance, and drafts of many of the letters are included in the collection.

Shortly before this a proposal of the Governor of Jamaica had been under discussion to send a small party to found a colony on the island of Ratan or Ruatan, in the Bay of Honduras, for which Cuninghame had volunteered his services. In July, 1742, he was not nearly so keen, but Wentworth insisted that he should go, and, to add to his annoyance, Armstrong was sent to lay out the town and plan of defence, and to leave orders for Cuninghame to carry out. Cuninghame had a friend at Jamaica, Major James Forrester by name, with whom from Ratan he corresponded in French, no doubt for the sake of privacy. There is a priceless passage in one of these letters which deserves to be quoted :—" D'ailleurs Mr. Armstrone donne assez des amusemens qui reveille quelque fois ma fiel mais je le traite comme vous avez fait au feu Madame votre espouse pour le faire crever de rage." Cuninghame languished in this delectable island for two years, but resisted all temptations to settle there, although he received a grant of 200 acres of land from the Governor, Major Jno. Caulfield. He came home in 1744, and in March was appointed a Volunteer Engineer in Ordinary with the Army in Flanders, " assisting General St. Clair as Qrmr. Gen., and had the honour to be employed by His Royal Highness " (the young Duke of Cumberland) " on the entrenchments and most of the works going forward during the Campaign." The Connolly records tell us that he was present with St. Clair's regiment at the sanguinary battle of Fontenoy, on 30th April, 1745, and at the unfortunate action at Melle on 28th June, after which he witnessed the loss of Ghent on the 30th. He was sent home with Sir John Ligonier and joined Marshal Wade's Army for service in Scotland, and was seriously wounded at the battle of Falkirk, on 17th January, 1746. Mr. Connolly also mentions that he took part in St. Clair's abortive expedition to L'Orient in October, but I am inclined to believe, from the following incident, that he was not there but in Flanders, and was present at the battle of Roucoux which was fought on the 10th of that month. The incident which, he says, " fell under my own knowledge," is worthy of quotation : " After the Battle of Rocoux an officer of the Scots Dutch who had been wounded and Strip^d and Thrown indiscriminately with Sojers in the Same Condition into a Waggon driving to the Hospital ; A French Officer Seemingly of an inferior rank Stop^d the Waggon and asked the Scots Officer how he came to be Stripped, Regreated his Misfortune and alighting put his hand in the Officer's breach pocket remarking the Breaches were of English Shagg. The Prisoner imagined he was to be further Stripped excused himself from not being able to move because of his wounds, the French Officer beg^d his Pardon and said he meant nothing such, and went of. When the Scots Officer arrived at Leign and put his hand in his Pocket he found a purse of Gold The French man had Sliped into it."

Although serving as Deputy Qrmr.-General he had as yet no regular appointment in the Army, but shortly after this we find him addressed as " Captain William Cuninghame, One of His Majesty's Engineers," with the pay of £45 12s. 6d. a quarter, regularly forwarded to him in Edinburgh by Mr. Boddington of the Board of Ordnance, who deducted £4 11s. as " Agency on £182 " for the year, " Errors Excepted."

There is nothing to show how long he was employed in Scotland, but in 1751 he was ordered to Minorca, in the rank of "Engineer in Ordinary," with Thomas Armstrong, probably his old friend, as "Director." We need not linger over this part of his career, which is fully described in the Corps History, how, on Armstrong's departure he was recommended for the post of Director, but failed to get the appointment, and when Bastide arrived to supersede him, obtained leave and started for home in disgust, with his wife and children. At Nice he gained certain information of the projected attack on Minorca and after spending all his savings, £1,600, on timber and other necessary engineer stores for use in the defence, he returned to the island, served throughout the siege as a Volunteer, and gained especial distinction in opposing the final assault on the Queen's Redoubt, in which he was again severely wounded. His passport "to go wherever his affairs required" was granted as a special clause in the Articles of Surrender, and as a reward he received from the King a Company in the 3rd Regiment of Guards, which carried with it the rank of Lieutenant-Colonel. There are no documents in the collection which belong to this period of his career, but in a diary of June, 1758, he notes that he saw Admiral Sanders sail into Portsmouth with two French prizes, the *Foudroyant* and the *Orphée*. "The *Foudroyant* is one of the Largest Ships ever built in France" and was "Admiral Galissonière's ship in which he engaged Admiral Byng, whose captain (at that time Gardner) had now the good fortune to take her in the *Monmouth*, a 64-gun ship, and Bravely fell in the Action." "Nothing can be oversaid in Praise of the *Monmouth's* behaviour, who had all the Merit of Compleat Victory. Had the *Foudroyant* and her Squadron met with so warm a reception off Minorca It is highly probable our Fleet would have rode triumphant, The transports of The French Army would have been destroyed And the garrison held out, as was afterwards demonstrable, From its not capitulating till 5 Weeks and 2 Days after this Engagement, without any re-inforcement. If any had got there what wou'd have been the consequence to Marshal Richelieu and his whole Army, Unsupported by a fleet, without transports, without ammunition, A scarcity of Provisions, and our Fleet riding Triumphant in the Harbour of Mahon. These things were so. The Consequences I humbly think undeniable, Sorrowful indeed are such reflections to any one who was employed in these Transactions."

In 1758 he received from Field-Marshal Ligonier, now Master-General of the Ordnance, the appointment of Chief Engineer to the Conjoint Expedition, under Commodore Howe and The Duke of Marlborough, then preparing for service against the coasts of France. The Instructions which he received on this occasion are among the documents and deserve to be quoted in full.

SEAL.

Instructions for Lieutenant-Colonel William Cuninghame, Chief Engineer.

You are Carefully and Diligently in every respect to perform the Duty of Chief Engineer upon the present Service and Strictly to observe what is prescribed by His Majesty's Instructions, a copy of which, so far as it relates to the Duty of a Chief Engineer in Time of Action, is hereunto annexed, and we require you to see that the several Engineers do their Duty strictly conformable to their Instructions.

You are to make fair and exact Draughts of all Harbours and their Soundings, and Accurate Surveys of all Countries and Places you come to, of Attacks, Trenches, Intrenchments, Batteries, Incampments, or anything else wherein you may be employed or concerned.

You are to Muster the Engineers, and order the Paymaster to Pay them from time to time and in case any of them should die or be killed on this Service, you are to order the next in Rank to do duty in his Stead for which end you will receive herewith a List of the Engineers with the Dates of their Commissions, and you are to secure the Effects and Equipage of those so Dying or Killed and to cause an Inventory to be taken of the same as soon as possible in presence of an Engineer and the Commissary or Clerk of the Stores, so that his or their Lawful Representatives may be satisfied of your impartiality therein, and to send us a Duplicate thereof by the first opportunity.

You are from time to time to order the Commissary or Clerk of the Stores to Deliver such Instruments and Stores as are applicable to your Branch and he has orders not to Issue any Tents or other Particulars appropriated for the Engineers without directions in writing from you or the Commanding Engineer for the time being.

You are to transmit to us by every opportunity an Account of any Alterations that may happen among the Engineers, of their Conduct and behaviour and of every thing relating to the said Engineers so far as shall come to your knowledge.

Lastly—you are to follow all such Orders and Directions as shall be given you by the Master General, Lieutenant General and Principal Officers of the Ordnance for the time being, and to pay due obedience to the Commander in Chief of the Expedition or any other your Superior Officer according to the Rules and Discipline of War.

Given at the office of His Majesty's Ordnance under our Hands and Seal of the said Office this Fifth day of May, 1758, in the Thirty-First year of His Majesty's Reign.

Signed GEO. SACKVILLE; W. N. EARLE; A. WILKINSON.

CHARLES R. INSTRUCTIONS FOR OUR PRINCIPAL ENGINEER.

ARTICLE 7. In Time of Action or when there is intention of Forming or laying a Siege against any place he is to have a Draught or Ground Plot of the Place if possible if not to take a careful view of its situation as near as he can and thereof to make a Draught and to see where the Attaque or Attaques are most Advantageously to be made, how the Circumvallation and Contravallation (if need be) is to be laid out and designed and to direct and see the breaking of the Ground, planting of Batteries, making of Platforms conducting of Trenches and Mines and to leave such Engineer and Conductors as will be necessary to see them carried on and Executed and to be constantly moving from one attaque to another to see that all possible Expedition be made and so to divide the Engineers under him that they may relieve one another and never to suffer (as far as his Authority Extends) any Single Person to be wholly entrusted with a work or an Attaque without he will be assured of his Ability and Capacity to undertake and discharge such a Service.

Countersigned L. Jenkins.

The above Instruction Explains Perfectly the Duty of every Engineer that happens to be the Eldest upon any Service Particularly at Sieges, and there is no occasion for any other Instruction.

Signed J. L. Ligonier.

List of Engineers for the Isle of Wight with the Dates of their Commissions.

Chief Lt.-Col. Willm. Cuninghame	– Sub Directr.	4th Jany. 1758.
Captain George Morrison	– In Ordiny.	4th Jany. 1758.
Ensign Charles Tarrant	– Practr.	14th May 1757.

We have the full "Journal with Remarks on the Expeditions to France in 1758," and also the "Book of Orders," handsomely bound in calf, with the royal arms printed on it in gold. These orders include very many points of interest, with which it is hoped to deal separately on a future occasion. The Expeditions have been described by many authors, including even Thackeray in "The Virginians." The first, when they landed at Cancale Bay, near St. Malo, and the second, under Gen. Bligh, when they destroyed the unfinished docks and defences of Cherbourg, were considered to be successful, but the last, again directed against St. Malo, when they landed in the bay of St. Lunaire and had to embark, fighting, with the loss of about 700 men, in the bay of St. Cast, a dismal failure. Colonel Cuninghame thought, and wrote, very seriously on the licentiousness of the troops on these and on the American expeditions of that year and recommended that the strongest action, even to the execution of senior officers, should be taken to put a stop to it. But he gives the following anecdote as a brilliant exception: "Reconoitring one day during our Late adventure to the Coast of France I was invited to dine at a gentleman's house on the Bassin of St. Maloes. A Lady at Table drunk Captain Cope's health, a Capt. in our Army in Lord Charles Hays Regimt; I enquired how he came to have the Honour of being known to her, She said his Actions entitled him to the Knowledge and Esteem of Every Person That the first time we were at St. Maloes this Gentleman Commanded a Party near St. Servan at a Gentleman's Seat Abandoned by its Master and Stript of his furniture; that Capt. Cope had found a Concealment of 20000 Livres worth of Plate which he buried in the Garden and wrote to the owner at St. Maloes who entertained The Highest sense of Gratitude and Esteem For So Generous Proceeding."

He contrasts the harbours on the Coast of France, "better Fortifyed than any in Europe," with the unprotected smaller harbours of England, but considers that "The French could make no Considerable impression, Except by exciting rebellion, or in the Channel, Unless they have Superiority at Sea, which is the great National object to Prevent." Still he recommends that these smaller harbours should be fortified, as at present many are liable "to have Ships cut out by Every Cruizing Privateer, who may even set the open defenceless Towns on fire."

The troops were back at Portsmouth by the third week in September, and on the 12th November Cuninghame sailed on his last campaign, the Conjunct Expedition against the French Caribee Islands, under Commodore Moore and General Hobson. "The Muster Roll of the Brigade of Engineers for December, 1758, at Sea" gives the names of the following officers:—

Chief Engineer Lieut. Col.	Willm. Cuninghame.
Sub. Engr.	Thos. Wilkinson.
Practitioner Engrs.	Richd. Muller. Theo. Lefanu. Archd. Campbell. Robt. Morse. Patk. Ross.

and he was joined later by Captain Lieut. Alex. Kennedy, Lieut. Orasgol, and Practitioner Engineer Shaund.

Lieut.-Colonel Cuninghame's two last letters to the Board of Ordnance are included in the collection and, as they give a full account of the action of the expedition, will be given in full:— The first is dated January 29th, 1759.

RIGHT HONBLE. AND HONBLE. GENTLEMEN,

The Fleet arrived at Barbados Jany. 3rd several of the Ships were amissing which dropt in Day after During our stay in Carlisle Bay and all arrived before we sailed from thence except ye Hospital Ship and a few others of small Consideration. I applied to the Commander in Chief for somethings necessary for carrying on a Siege particularly 6000 Pickets which were paid by his order and stated to the Contingent Accompt. We sailed from Barbados Jany. 13th and arrived before Port Royal in Martinico Jany. 15th. The Harbour Coast and Batteries were reconoitred the 15th and 16th and Report given in to the Commander in Chief of the strength of these Batteries, their Entrenchments, state of the Beach, etc., as more fully specified in the Report given in by the Chief Engineer. In the morning of Jany. the 16th the Men of

War silenced a Battery upon Negro Point and one upon the left of the Entrenchment at Cas na vire and Scoured the said Entrenchment which appeared to be defended by 800 or 1000 men. The Army disembarked about 2 or 3 miles nearer Port Royal without opposition and took the strongest post near to Nigro Point which was the readiest Communication with the Fleet. Next Morning a Plan was given in for the fortifying of the Camp and beginning the Approaches to Port Royal, but a Resolution being taken to reimbark that Evening and the Troops retreating, three slight Redoubts were hurried up on the Right Left and Centre of the Ground which the Troops occupied, these were finished before Night. The Troops reimbarked without any molestation and were off the Town of St. Piers next morning. The Town, Forts, Entrenchment and landing Places were reconoitred and Report made by the Quarter Master Genl. and Chief Engineer to the Commander in Chief and Commodore, next morning being the 20th Jany. the QrMr. Genl. and Chief Engr. were ordered to go on in the Winchester Man of War to reconoitre Basseterre in the Island of Guada Lupa. Sketches were made of the Bay, Batteries, Number of Guns, Entrenchments and proper landing Places and an Opinion given in to the Genl. and Commodore of what was thought most expedient to be done in the Attack of the Fortifications of Basseterre, as per Report. The 22nd The whole Fleet plied off the Bay of Basseterre, next Morning the Ships went in and attacked the Fort and Batteries, as expressed in the Plan, by night these Batteries were silenced. The Bombs were ordered in to play upon the Fort and did some execution, they threw Carcasses into the Town, which was set on fire, burnt a great part of the Night in several Places and all next Day, which consumed most part of the Town. The Fleet came all to an anchor the 24th Janry. and the Signal was made for the Debarkation which was immediately accomplished without any loss. The Town, Entrenchments and Fort (also named Fort Royal) were abandoned and the Troops took possession of the most advantageous Ground in the Circuit of the Town. These Posts are a fortifying and the Enemy who have retired two or three mile into the Country on heights and in woods seem to be doing the same thing. A little skirmishing dayly passes. Numbers of Negro's come in, but not so many as was expected. Some Conferences have passed between our Commanders and the Governor the issue of which is not publickly known. The fortifications of Fort Royal are repairing with all the Expedition our Time or Power will allow:

Right Honble. and Honble. Gentlemen,
Your most obedient
Humble Servant.

The second letter is dated 5th March :—

My last to the Board was dated—Janry., a Copy of which is sent with the present Occasion, since that Time the Army has remained in its then Position, frequent Skirmishes have happened betwixt our out Posts and the Enemy which have been attended with the loss of some Officers and a considerable number of wounded men. The Enemy continue entrenched as at the beginning and by a Deserter we hear they receive Supplys from Martinico of Provisions and Ammunition. It being determined to Garrison Fort Royal and to strengthen it as much as the Time of the Army's staying here would admit of I have escarped a great Part of the Foundation of the Ramparts where they were thought Accessible. Filled the Ditch with Trous des loups to make it more impassible for an Escalade. A safe Communication is made to the Sea under the Cannon of the Fort, and otherwise defended above Surprize. A Place of Arms is made for Part of the Garrison to encamp in. A Covered Way is formed and palisaded. Some Buttresses are made to strengthen the Rampart, and built up where Damaged. All the Buildings in the Fort are pretty nigh repaired of the Damage done by the Shot and Shells. New Shades for Barracks are building and new Casmates are a making in the Body of the Rampart. All these particulars are more fully set forth in the Report of the State of the Garrison to the Commander in Chief A copy of which I have transmitted to the Honble. Board with a Plan distinguishing the Additions made to the Fort. I have likewise transmitted a Copy of my Thoughts on the Defence of the Place left with Lieut. Col. Debrisay now appointed Governour of Fort Royal. Lieut. Wilkinson sub Engineer and Mr. Muller Practitioner on hearing of a Garrison ordered to be left applied to me to be appointed for that Service as by their Letters Copys of which are inclosed and I recommended them accordingly to the Commander in Chief. Fort Lewis was taken 1 Febry. by a Detachment of Men of War from the Fleet. The Entrenchments were attacked and taken by the Highlanders and Marines under the Command of Lieut. Col. Prycant. It is a Star Fort and by the Report of Engineer Orasgol is in a better state of Defence as to its Ramparts than this Place. There are two detached Redoubts commanding the Entrenchments which are very Extensive. The Harbour is the best and safest in the West Indies. I have not been allowed to go from this or make any Survey of it but shall as soon as my Duty here can be dispensed with. All the Engineers are in perfect good Health not withstanding their having been more on Duty than any other Corps of Officers in the Army which are now very sickly. The Officers of the Line who were ordered to do Engineer Duty are now rendered to their Regts. because of their want of Officers and I have ordered their payment so far as they were employed. Genl. Hopson died on the 27th Febry. and is succeeded in the Command by Major Genl. Barrington. I am with all due Respect, etc."

He paid his intended visit to "Fort Louis on Grande Terre," and his report upon its "Tenableness," dated 21st March, 1759, is the last paper of the series. The Corps History states that he died in Quadalupe shortly afterwards.

PROFESSIONAL NOTES.

"CIMENT FONDU."

WITH reference to the article on *Ciment Fondu* by Capt. J. C. P. Tosh, M.C., R.E., which appeared in the September issue of this Journal, the following extract from the *Concrete and Constructional Engineering* for August, 1923, gives an opinion of the engineering profession on the utility of the material.

"Mr. Butler's paper*, referred to above, also referred to a new aluminous cement which possesses the property of rapid hardening, the strength at an age of one or two days being equal to that of Portland cement at twenty-eight days. This cement is composed essentially of aluminate of lime, and in this aspect differs from Portland cement, which is composed for the most part of silicate of lime with only a small proportion of aluminate of lime. The property of hardening rapidly is one of considerable value in certain directions, notably in road repair work, where it is possible to limit the exclusion from traffic to forty-eight hours. For other emergency work this cement will also have advantages, and among other claims it is asserted that piles can be driven three days after moulding.

"Concrete users have become so accustomed to waiting for periods of days or even weeks before concrete is sufficiently hard to carry its own unsupported weight or to bear superimposed loads, that it is difficult to envisage the saving in time and economy in procedure that may result if concrete attains in twenty-four hours the hardness usually developed in a month. Subject to certain considerations, it is possible to foresee remarkable developments in connection with aluminous cements. These considerations are endurance and cost.

"There has been no published evidence that aluminous cement maintains its high strength and does not deteriorate with time. Concrete blocks made with this cement a dozen years ago and immersed in sea water and water impregnated with sulphate are reported to be intact, but apparently the maximum period at which tensile or compression tests have been made is three years, although again it is reported that there is no evidence of retrogression during this period. There is no reason on chemical grounds, to suspect deterioration, but it is obvious, that engineers must proceed with caution, and the new cement will have to stand the test of time before it is regarded unreservedly as a substitute for Portland cement.

"The second consideration is that of cost. Aluminous cements require

* "British Standard Specification for Portland Cement."

as one of the raw materials an aluminous mineral such as bauxite or corundum, and neither of these is known to exist in England. Hence at the present time aluminous cement is made only in France and Switzerland, and the price in England is double that of Portland cement. Even if manufacture is commenced in England the aluminous raw material will need to be imported, and this will form a substantial addition to the cost of manufacture, which will also have to carry the additional cost of grinding the very hard-fused material to the great fineness that is necessary. However, with an industry still in its infancy, there are doubtless possibilities of cheapening the manufacturing processes. The high price now current will, in fact, tend to restrict the use of the cement, and thus the caution which we have suggested is necessary will automatically result. But we do not lose sight of the possibility that in course of time aluminous cements may lead to marked changes in constructional methods, may extend the uses of concrete, and to a certain extent replace Portland cement; at the same time, rendering concrete of still greater importance in the engineering and constructional operations of the world."

The French company which manufactures *Ciment Fondu* have now opened an office in London under the name of the Lafarge Aluminous Cement Co., Ltd., Regent House, 89, Kingsway, London, W.C.2., and are willing to answer enquiries with reference to their products.

THE STREAM-LINE FILTER.

(Hele-Shaw System.)

A new and most interesting form of filter has recently been placed on the market known as the "Stream-Line Filter." The construction is simple and, from the records of the laboratory tests made, its efficiency is marvellous.

The essential portion of the Stream-Line Filter consists of a stack of sheets of waterproof paper pressed into contact with one another by suitable means. When so arranged, the numerous circular holes with which the sheets are perforated coincide and form passages or tunnels running from end to end of the stack. Of these tunnels about half the number communicate with the receiving end of the filter and the remainder with the delivery end. The liquid to be filtered is led under pressure to the receiving tunnels and escapes through the delivery tunnels after passing between the faces of the waterproof paper sheets.

The filtration is effected at the edges of the paper forming the sides of the receiving tunnels, only the liquid filtrate passing between the sheets of paper. The wear and tear of the paper is therefore practically *nil*, the grit never passing between the sheets. The sludge or residuum is all collected on the sides of the receiving tunnels, from whence it can be easily removed by various means when the filter requires cleaning.

The paper used is prepared by a patented process and is of a fibrous texture, with a dull surface. In appearance it is very similar to a common type of paper in daily use. Calendered paper with a glossy surface does not appear to effect filtration, the surface being too smooth.

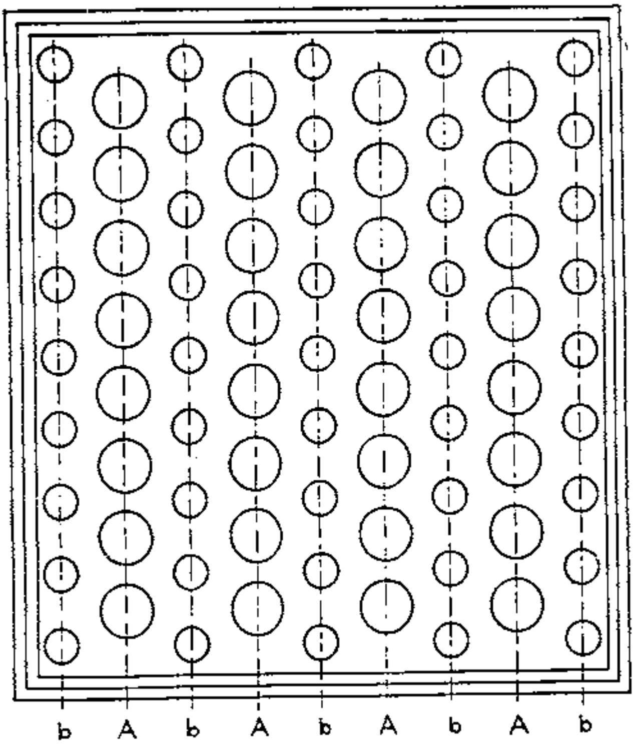


FIG. I

Fig. 1 shows the arrangement of the holes in the filter paper, the line of flow of the filtrate is between the receiving tunnels A and the delivery tunnels b.

Fig. 2 shows the general arrangement of a filter capable of dealing with about 700 gallons of water an hour under a pressure of about 50 lbs. per sq. in. The height of this installation is about 4 ft. 3 in. and breadth about 2 ft.

A battery of 16 filters, capable of dealing with 10,000 gallons an hour, occupies a floor space of about 9 ft. by 4 ft. From this it will be seen that the apparatus is extraordinarily compact.

The degree of filtration effected can be regulated by the pressure of the packs of paper, and some of the results which have already

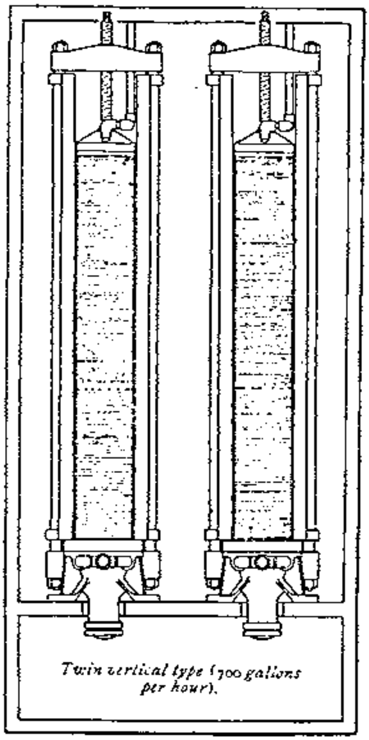


FIG. 2

been effected by fine filtration are extraordinary. Not only can grosser impurities, such as suspended matter, be abstracted from a liquid, but emulsions can be separated into their constituents, and even liquids coloured by some substance in solution can be filtered clear and colourless. Moorland water stained by peat which has hitherto resisted every attempt to remove its colour by filtration, can be delivered in a perfectly colourless condition. The powerful dye Erythosin, which has a brilliant orange colour with a florescent, green glint when diluted with 5,000,000 parts of water, is completely separated, leaving a colourless filtrate.

In order to understand why a small filter, as illustrated in *Fig.* 2, has such a large capacity, it will be necessary to arrive at an idea of the available filtration surface in the apparatus. Each pack of papers consists of approximately 8,500 sheets and each sheet is pierced with 32 receiving holes of approximately $1\frac{1}{2}$-in. circumference. The liquid is forced between each sheet round the circumference of every hole, and there are, therefore, $8{,}500 \times 2 \times 32 = 544{,}000$ units, each $1\frac{1}{2}$ in. long, contributing to the flow, or nearly 13 miles of filtration surface. A rate of flow of approximately one drop per minute per inch of filtration surface would produce the 700 gallons per hour.

The sludge or residuum collects in the tunnels and can be very simply disposed of. If it is valueless and can be run to waste, the ends of the receiving tunnels can be opened by means of a stop-cock and flushed out by the unfiltered liquid under pressure, the whole operation taking only a few seconds. If, however, as is often the case, the residuum is a valuable by-product and it is desired to collect it the following method is used. In each of the receiving tunnels is a light, free-fitting, floating piston, which normally lies in a pocket in the end covers. When it becomes advisable, owing to a falling off in the flow, to remove the residuum from the filter, the liquid prefilt under pressure is admitted behind the piston which then traverses the length of the pack and drives before it the sludge, which is evacuated through ports in the end cover.

The commercial uses to which a filter of this description can be put are manifold. Many trade wastes which hitherto have been neglected, can now be worked profitably. Certain salts in solution have already been extracted and it is quite within the bounds of possibility that potable water will be manufactured from sea-water at a far less cost than by distillation. Milk can be filtered, the filtrate being a colourless liquid, while the residuum is white and solid.

Although research into this method of filtration is still in its infancy, from results already obtained it would appear that it is possible to discriminate between molecules of varying sizes. If a solution is made of two salts, say, copper sulphate and common salt, it is possible to extract all the copper sulphate in the filter, the filtrate being a solution of common salt. Little at present is known of the pressures required to abstract various substances, but it is reasonable to infer that, by having a succession of filters at varying pressures, an emulsion or a solution of several chemicals can be separated into their original constituents. If, as it appears, this filter can deal with masses of the nature of molecules there should be no difficulty in dealing with bacteria, and it may be possible to grade bacteria according to their sizes, thus opening out further fields of research.

D.K.E.

SURVEY NOTES.

Late in September and early in October the Field Survey Platoon returned in two parties from Constantinople. Captain Hutchison, who was the Assistant Director of Surveys in that area, came home some months ago, but the Platoon, which has been engaged in the preparation and printing of maps, remained till the last, under Lieut. Godfrey-Fausset. Their labours in dealing with Turkish material have been very interesting. The Turkish geographical units were trained on French lines, and are producing good, reliable maps, both on the large scale of 1:25,000 and on the 1:200,000. Like most surveys, however, the Turkish requires knowing, and there is a strip in the Ismid Peninsula where triangulations from the Asiatic and the European sides are scarcely on bowing terms. The printing machinery was in the last stage of collapse and the demands upon it were often abnormal. As a body, the Platoon says that it is not sorry to come back to the more prosaic, but easier, routine of the Ordnance Survey.

Captain P. K. Boulnois and Captain James, Assistant Commissioners on the Darfur Boundary Commission, have also returned. Their surveys extend over a matter of 1,000 miles, and in an area which has cost the Soudan Survey a heavy price, for Colonel Pearson died from fever contracted during the field work, and Mr. Boyce, his successor as Surveyor-General, has had a very arduous and trying time. The French Commission also suffered by losing their Doctor, whose loss was as deeply felt by his British Colleagues as by his compatriots. Technically, the most interesting feature of the Commission was the determination of longitude from wireless time signals. No survey which is beyond the reach of existing triangulations can afford to neglect this method, but it is not easy to keep pace with the rapid advance of wireless reception and to standardize methods with any hope of even some permanency.

Captain Latham has just sent home the first sheet of the new topographical survey of Trinidad. It should be a most attractive series, for the country is delightful to look at on a map, although the difficulties of survey must have been great. Oddly enough, the scale chosen is 1 : 50,000. The popularity of this scale is marked. The new French " Carte de l'Etat Major " is a 1 : 50,000, and German, Austrian and Italian mapping is steadily inclining to the same policy. A large block of Central and Southern Spain is also mapped on this scale, as are Holland and parts of Switzerland and Sweden. The maps produced by the Field Survey Platoon of the Ismid and Chanak areas were also at this scale.

The national Surveys of Germany and Austria are interesting just now on other grounds. Like all other European surveys, they were, before the war, military or semi-military in character. Now they have been converted into civil departments for the reason that the military establishments allowed are too small to permit of any other solution. But the German survey has, none the less, decided on a programme which will vastly lighten the geographical work of home defence and are about to introduce a grid, similar to our present military grid, on all topographical maps. Their new cadastral scale is to be 1:5,000 (or 12 in. to 1 mile approximately).

Our European Boundary Commissioners, in so far as the delimitation of the frontiers affected by the Treaty of Versailles are concerned, are nearing the end of their labours. Lieut.-Colonel Giles in Albania is, no doubt, having the most thrilling time of all of them. His troubles, in ascending order of magnitude, may be described as technical, political, climatic and animal. When these commissions are past history and our representatives are free to describe their experiences, we should hear much of interest. Other commissions will, no doubt, form soon for the delimitation of Eastern frontiers. These will tend more to a geographical character than the present European commissions have done.

Everyone else has their staff rides and exercises, and Survey Units have followed the prevailing fashion. An exercise in which R.A. and R.E. surveyors co-operated was held in July last. It is natural that one of the most important points which emerged was the importance of immediate interchange of data. In France, during mobile operations, observers had to rely on the erection of noticeable beacons on prominent spots, on helio, or (in dull weather) on the Lucas lamp, to get into touch with each other. These alternatives were all very unpopular with troops in the vicinity. There seems room for a vertical rocket, or luminous and vertical projectile, as used by the Germans; but even so, either telephonic (preferably wireless) or personal touch between R.A. and R.E. surveyors is essential if the Artillery are to be properly served. The survey exercise was, this year, theoretical in character. It is hoped to conduct a similar exercise next year in a more practical fashion and to complete the full technical programme.

Some interesting exploratory surveys have been completed lately in Arabia. Major Holt, of the Iraq railways, read a paper before the Royal Geographical Society on the "North Arabian Desert and its Future" in February last. Sir Percy Cox very kindly consented to his working afterwards with the Geographical Section of the General Staff in plotting his route. Fortunately, his observations of latitude, longitude and height were admirable, and the result of his labours is to fill with reliable matter a little-known strip between Basra and Palestine. Captain Cheeseman has also given us most valuable information regarding the western shore of the Persian Gulf, where he has broken entirely fresh ground, and has extended the Gulf of Salwa no less than 40 odd miles to the south.

In China General Pereira's recent journeys are helping to pull the vague mapping of the central and south-western provinces into more definite shape. The Carnegie Institute have provided a badly-wanted skeleton by fixing the latitude and longitude of many Chinese towns, but valuable as such work is, it does not help the topography much without some form of connecting link. It is gratifying to note the fair agreement between General Pereira's route sketches and those of Major Davies (now General Sir Francis J. Davies, K.C.B., etc.). There is, however, still far too much play-for the imagination in mapping Asia, and unfortunately the vagueness understandable in, shall we say Borneo, is found even in old-established British Colonies.

The R.E. staff at Hong Kong have, very wisely, given up waiting for the systematic survey of the leased territory by special civilian or military bodies, and have started to extend the 8 in. to 1 mile map which covers part of the area by an excellent 1 : 20,000 plane table survey. The first field work, done by Lieut. Taylor, R.E., has recently arrived and seems of a high order. It is a pity that more accurate mapping is not done by the many officers who are capable of it. Reconnaissance is a name which covers a multitude of omissions. It is not of much value to read of an admirable water supply if there is but a remote chance of ever finding it.

The *Text-book of Topographical Survey* is to be revised again, and, fortunately, Sir Charles Close has consented to re-edit it. There is no other book on survey so remarkable for the effective way in which it covers the necessary range and avoids the fads of the enthusiast.

The Colonial Survey Section has been formed again and has embarked for the East with Captain Kirby in command and Lieut. Willis as his subaltern. The remainder of the section, five in number, are topographers and observers from the Survey Companies, including C.S.-M. A. C. Wilde, D.C.M., R.E., who is a host in himself. The Colonial Survey Section has a very fine record behind it and, composed as it now is, can hardly help adding to its laurels.

Those of us who are members of the Royal Geographical Society, and have got to know something of Mr. Reeve's untiring efforts and inventive mind, congratulate him heartily on the award of the "Cullum" Gold Medal of the American Geographical Society for 1922.

W.

MEMOIR.

COLONEL WILLIAM FITZHENRY SPAIGHT.

ON May 19th of this year there passed away one of the older generation of Sappers in the person of Colonel W. F. Spaight, in his 81st year.

Colonel Spaight gained his first commission in the Royal Engineers in 1863, and joined at Addiscombe. He later served at Aldershot (where he was Adjutant of the R.E. Companies), Malta, Ireland (where he spent some time on the Ordnance Survey), Egypt, and Jamaica. He served in the Egyptian Campaign of 1884-85, for his services in which he was mentioned in dispatches and gained a Brevet Lieutenant-Colonelcy, being later appointed Brevet Colonel. He served as C.R.E. in Jamaica, and for the last five years of his service was C.R.E. in Cork. He retired in 1895 with the rank of Colonel.

An Irishman, Colonel Spaight came of a line of soldiers. On his retirement he settled down at Union Hall, County Cork, devoting his time there, and at his old home in Clare, to his tenantry and estate. A J.P. for the County, he occupied himself with the social and economic questions of the day, but he avoided politics. His endeavour always was to promote fellowship and good feeling between all members of the community, especially between landlord and tenant. His interests kept him in touch with a wide circle, and he never lost connection with his old Corps. His keen insight into character and his innate sense of justice brought him grateful recognition by many in widely different classes as friend and counsellor.

During the Great War his age and health prevented him from offering himself for active service, but he did good work in helping, to the best of his ability, pensioners and dependents of those in the Services.

The last two years of his life were spent in enforced exile from his old home, when, in common with many of his neighbours, his home was burned to the ground—a reprisal, it was stated, for counter-destruction by the "Black and Tans." He never fully recovered the blow, but bore no personal grudge against the perpetrators, realizing that he was but one victim in the general upheaval, which was directed not against individuals but against a class and country.

His death is regretted by a wide circle.

T.

BOOKS.

GERMAN STRATEGY IN THE GREAT WAR.

By BREVET LIEUT.-COLONEL PHILIP NEAME, V.C., D.S.O., *p.s.c.*, R.E.
(Edward Arnold. 10s. 6d.)

FOLLOWING the excellent example of Major-General Sir G. Bowman-Manifold, Colonel Neame has published some of the lectures which he gave when on the Directoring Staff of the Staff College. It is to be hoped that other instructors will be emboldened by the lead given by these two Engineer officers. It is hardly within the memory of any serving officer that the instruction provided at Camberley has thus been made available for all. The book is no dry strategical treatise, but an epitome of the whole war on the continent, apart from its trench-warfare features. It is enlivened by remarks on the personalities of the leaders and significant asides. To those who have only studied the Western Front it will be of special value, as it gives a very clear summary, with plenty of maps—there are seventeen in the volume—of the campaigns on the Russian Front. How many of us could say what happened in the Russian offensive near Lake Narotch in March, 1916, which the author suggests was undertaken in unsuitable weather for the chivalrous purpose of trying to help the French, then engaged in a death-struggle at Verdun ?

The chapter headings give a good idea of the contents. They are : The German Strategic Plan, The Frontier Battles of the Western Front, The Change in the German Plan of Campaign, The Battle of the Marne and Events in the West to the end of 1914, Russian Plan of Campaign, Battles of Tannenberg and the Masurian Lakes, First and Second Invasions of Poland, "1915," "1916," The Rumanian Campaign, "1917," Preparations for the Offensive in 1918, The Five German Offensives in 1918, and Ludendorff, his Career and Character. As regards Ludendorff, it might be pointed out that he, like Col. Neame, was an instructor at his Staff College.

Some pretty problems are suggested. What, for instance, would have been the effect of a German withdrawal in June, 1916, before the battle of the Somme, like the one Ludendorff had already carried out in Poland in the autumn of 1914, and was to repeat in 1917 ?

It is to be regretted there is no chapter on the influence of fortresses. Colonel Neame does not think that the defence of Liége delayed the Germans ; he barely mentions Maubeuge ; and does not draw attention to the value of Lötzen and the fortifications among the Masurian Lakes in holding back Rennenkampf in the Tannenberg Campaign. Nor, though he mentions the facts, does he deduce any conclusion from the effective support given to the Germans by the Nied fortified position, and to the French by the Grand Couronné. He admits that " the French Eastern fortifications still precluded any hope of a rapid advance or victory on the common Franco-German frontier." It is to be hoped that the General Staff of to-day is not being trained to despise technical assistance as its predecessors of 1914 were.

Otherwise Col. Neame seems to have taken up every point of importance in regard to the German strategy, even to the operations of the Railway Troops, and the influence on the Supreme Command of the Royal Princes commanding armies. In his estimate of Ludendorff he might have laid stress on the extraordinary care exercised by the First Quartermaster-General in the selection of his subordinates, and the way in which he made Hoffmann, Wetzell, Bauer, Bruchmüller and others do the detail work, whilst he made the great decisions and found the will-power. Like Moltke in 1870, he was extremely well served, and deserved to be.

As the book will certainly be widely read for examination purposes, it must be pointed out that there seem to be two slips in it. The first is that, in comparing Schlieffen's plan of 1905 with Moltke's deployment in 1914, Colonel Neame tells us that in 1905, 78 divisions (including 16 Ersatz divisions) were allotted to the offensive wing north of Metz–Thionville, and 9 divisions to Alsace-Lorraine. He does not say this was for a one-front war and does not deduct the 10 divisions which Schlieffen thought necessary to operate against Russia. In 1914 he says Moltke sent 12½ to Russia (only 9 active and reserve divisions really), 61 divisions to the offensive wing, 27 south of Metz (the German accounts say 16 active and reserve; to make up 27, the garrison divisions of Metz and Strasburg, not counted in 1905, and 6 Ersatz divisions must be included). Thus the comparison made in the book is not a true one. It is further vitiated by the fact that the Ersatz divisions were not field troops, but, in 1914, bodies of untrained men without transport, and fit at best only to hold defences. For the purpose of comparison it would seem that the figures for active and reserve divisions, were in 1905: Russia 10, offensive wing 53, defensive wing 9; and, in 1914: 9, 54 and 16. Of the 4 Ersatz divisions, Marine divisions and Landwehr troops sent to Antwerp no account whatever is taken. That the war was lost by Moltke " watering down " Schlieffen's receipt for victory is one of the favourite pleas of the German General Staff; it seems strange to find a British General Staff Officer appearing to agree. It was the Allies who spoilt the scheme; and it was, after all, a mere Staff College plan evolved without sufficient account being taken of the action of the enemy, casualties or the influence of fortresses. It might have worked out at a war game at manœuvres, but was bound to fail in war. Even though the French committed many serious mistakes on which the Germans cannot have calculated, it failed. Possibly, had Great Britain landed her 13 Mounted Brigades at Ostend on 27th August, instead of one brigade of R.M.L.I., it would have collapsed in the 39 days that Schlieffen calculated he required to settle the French.

J.E.E.

THE OFFICIAL HISTORY OF AUSTRALIA IN THE WAR OF 1914–1918.

Vol. VII. SINAI AND PALESTINE. By H. S. GULLETT. (Sydney: Angus & Robertson. London: The British Australasian Book-Store, 51, High Holborn. 28s.)

THIS is the second of the volumes of the Australian Official History to be published. The first dealt with Gallipoli. The present one, though it refers generally to the operations in Sinai and Palestine, is concerned almost entirely with the work of the Australian Light Horse.

The author accompanied this force as official correspondent for the special purpose of collecting material for a history. He has written, not a military record, but a popular account. This, though it may enthral the relatives of those who fought, is of small value to a student of war. The Palestine campaign was described in the British Official Record, *A Brief Record of the Advance of the Egyptian Expeditionary Force*, as a "medical and engineer war"; the official German account of Falkenhayn's command, issued under the name of "Yilderim" by the *Reichsarchiv*, quoting a phrase of Lord Wolseley, called it, in entire accordance with the British view, an "engineer and doctor's war." Mr. Gullett has tried to convert it into a cavalry war, or, to use his words, a "mounted infantry" war; for he says:

> "The light horse was not a cavalry force. Its members were not armed with sword or lance. They were mounted riflemen, or, in other words, mounted infantry."

The book is full of personalities and petty skirmishes.

Thus we find the following appreciation of a certain general:

> "Standing well over six feet, handsome and well proportioned, General —— (the name is really given in full!), looks what he is, a very spirited cavalryman. He is, by intuition, a master of cavalry rather than a leader of mounted riflemen. . . . 'Fighting Charlie,' as he was known after South Africa, had never been a deep student of war. He relied on his native wit and his common sense rather than upon the text-books."

Of General Sir Archibald Murray the author writes:

> "Murray possessed some great qualities as a soldier and many charming qualities as a man. But he was the wrong man for Egypt."

There are 844 pages in the volume; but there are little more than a dozen references each to the engineer and medical services. As there is no order of battle, there is no clue to the staff and units employed. The only engineer unit of which we can find mention is the 1st Field Squadron Australian Engineers, at the passage of a river. Elsewhere the "Engineering Field Squadrons" and a Field Troop of the Camel Brigade are alluded to, and Brigadier-General R. E. M. Russell, R.E., is spoken of three times as commanding the Engineers. There are casual mentions of the Engineers being engaged on water supply, repairing a bridge near Damascus and taking part in the demolition of a railway.

The Medical Service hardly gets as much mention, though it is given general praise, and it is said:

> "In no branch of the Army was the fight waged with more zeal and effect and with more influence on the success of the campaign";

but its organization is not given, and, beyond the construction of incinerators to burn refuse, and the initiation of "extraordinary devices" to prevent the breeding of flies—which are not further described—there is little notice of the medical work.

Mr. Gullett takes a new view of General Murray's battles of Gaza. He thinks that there was no necessity for the withdrawal at dark in the first, and suggests that

> "the leader or leaders responsible for the orders were too far from the ground of operations."

The second failure is attributed to a certain general's

> "boundless confidence that he could crush the Turks at any time and on any ground he chose."

There is a tendency throughout the book to praise Germany's political and military sagacity and German organization and to depreciate and even ridicule British methods.

The book is illustrated with 83 photographs of persons and scenery and has 77 maps.

J.E.E.

THE AUSTRALIAN FLYING CORPS.

Vol. VIII of the Official History of Australia in the War, 1914–1918, by F. M. Cutlack. Price 24s.

Australia succeeded in raising and maintaining four air squadrons during the war. No. 1 served in Egypt and Palestine, while Nos. 2, 3 and 4 reinforced the British squadrons on the Western Front. The doings of these four squadrons are remarkably well told by Mr. F. M. Cutlack in Vol. VIII of the official history of Australia in the war. The book automatically divides itself into two parts. The opening phase of the campaign in Mesopotamia, ending with the investment of Kut, and the operations in Egypt and Palestine are dealt with in the first part, while the second deals wholly with the war on the Western Front. In all these theatres of war Australian airmen bore their part.

The campaign in Palestine is unique in that the air force played a preponderating rôle. This is no place for debate on the merits of an air force, but no one with an open mind can afford to ignore the lessons of the air campaign in Palestine. The victory was overwhelming and complete. A retreat was converted into the most disorganized rout in the history of modern warfare—and this was largely accomplished through the agency of the air service. Mr. Cutlack's first twelve chapters, which culminate with the battle of Armageddon should be closely studied by all students of Imperial Defence. Not only are these chapters the chronicles of No. 1 Squadron, Australian Flying Corps, but they excite admiration and wonder. By stating the facts of the most significant air campaign of the war they give food for thought.

The Australian flying squadrons were conspicuous for the thoroughness with which they did their work, and in air-fighting they were pre-eminent. Even while they were making history in the air their records were most carefully compiled on the ground. Would that other units had conformed more religiously to *Field Service Regulations* in the matter of war diaries. How much easier would be the task of the unfortunate historian.

Mr. Cutlack has not allowed himself to be fettered by red tape or official jargon. He has given us something of the nature of an intimate unit history, in which he has taken care to stick strictly to facts. The book is well compiled and explanatory matter, which might interrupt the narrative, is dealt with in Appendices and Footnotes. It is unfortunate that Mr. Cutlack did not have at his disposal Volume I of the official history of the war in the air by Sir Walter Raleigh. This would have prevented many errors, chiefly in the Introduction and Appendices. For example, he tells us on page xxii of the Introduction, that of the four squadrons of the Royal Flying Corps which accompanied the original Expeditionary Force to France, "Two were equipped with homogeneous flights of B.E.2's, Henri Farmans and Maurice Farmans." Actually of these squadrons No. 3 made use of Blériots and Henri Farmans and No. 5 of Henri Farmans, Avros and B.E.8's. On page xxiii he gives the S.E.4 as a type of machine which replaced the Farmans. No S.E.4 was ever used overseas. Again on page xxiv he credits the D.H.2 with the destruction of Immelmann. Actually, McCubbin accomplished this in a F.E.2b. There are a few others, but these, however, in no way affect the value of this book, which undoubtedly will be read widely and with great interest.

J. MORRIS, *Captain,*
Air Historical Branch.

PHOTOGRAPHY AND ITS APPLICATIONS.

THE intellectual development of man has been chiefly the result of his aptitude for devising tools and implements. As Mr. O. G. S. Crawford has said, in a recently published book: "Man was the first animal to grow a limb outside of himself by making tools out of wood and stone. . . . Each step in advance was a small one, hardly won, perhaps; but each step makes the next more easy." To this it may be added that it is impossible for the most far-seeing of men to say where the invention of a new "implement" may carry us, or what consequences may follow, scientific or practical.

No better illustration of this fact could be found than in the invention of photography. The first true photograph was taken by our fellow-countryman, Fox Talbot, in the year 1835, eighty-eight years ago; he had begun to experiment in the matter in 1833. The book under review* quotes Fox Talbot with reference to a photograph of Lacock Abbey, his country house; he says: "this building was the first that was ever known to have drawn its own picture. It was in the summer of 1835 that these curious self-representations were first obtained. Their size was very small; indeed, they were but miniatures, though very distinct: and the shortest time of making them was nine or ten minutes." In these early days of Fox Talbot and Daguerre it is natural that the only anticipated application of photography was pictorial. Paul Delaroche, the painter, is quoted as saying: "Painting is dead from to-day." Well, painting did not die, and is not likely to die, so long as there are people intelligent enough to appreciate the essential and invaluable, pictorial and subjective element in art. But though photography has not killed painting, its scientific and practical applications broaden every day, as this book is evidence.

The scope of the book is wider than its title would indicate. The first four chapters, of some two hundred pages, are devoted to excellent expositions of the history, optics, physics and chemistry of the subject, by Mr. Gibson, Professor Conrady and Dr. Sheppard. The theoretical explanations are abreast of modern views and mention the difficulty of reconciling the wave theory with the quantum theory of light. Sir William Bragg is appropriately quoted: "For the present we have to work on both theories. On Mondays, Wednesdays and Fridays we use the wave theory; on Tuesdays, Thursdays and Saturdays we think in terms of flying energy quanta or corpuscles." Physical science seems to be on the verge of a fresh generalization. The uses of photography as a scientific and practical implement are described in the rest of the book. Each chapter deals with a special subject and is written by an expert. There are chapters on Astronomical Photography, Photography in Physics, Photomicrography, Photographic Surveying, Aeronautical Photography, Colour Photography, Kinematography and so on. In the chapter dealing with Astronomical Photography Mr. Davidson points out how much the astrographic chart owed to the energy of the late Sir David Gill, so well-known to many of us as H.M. Astronomer at the Cape. For the measurement of the Einstein Gravitational Displacement it is explained that an improvement will be introduced in the photographic method employed, which will enable the absolute displacement to be measured, instead of the displacement relative to that of stars on the same plate not very near the sun's limb.

In the chapter on Photography in Physics we are given a description of the methods used by Professor C. V. Boys in photographing a rifle bullet whilst in flight. [An account of the S.M.E. experiments, of some years ago, for determining the motion of recoil of the rifle itself (*R.E Journal*, January, 1905), might also have been given.] We have, in the same chapter, an account of X-ray Photography, and of the photographing of α particles, with much else of interest.

For the soldier the most valuable chapters are those on Photographic Surveying, by Colonel H. St. J. L. Winterbotham, R.E., and Aeronautical Photography, by Squadron-Leader F. C. V. Laws. The former chapter

* *Photography as a Scientific Implement. A Collective Work.* London, Blackie & Son, Ltd. 1923. 8vo. pp. 546. 30/-.

is an excellent summary of the development of photographic methods of surveying during the last thirty years, and deals with ground photo-topography, air photo-topography and stereo-photogrammetry. The latter gives much interesting information with regard to aeroplane cameras and their mounting, and about plates and films, the precautions to be observed in taking aerial photographs, and the construction of "mosaics." In view of the recent successful experiments of Professor Melvill Jones and Major J. C. Griffiths, in keeping an aeroplane on an even keel, it may be said that the direct use of mosaics, without correction, promises excellent results for rapid reconnaissance and large-scale exploration. Mr. J. W. Gordon's revival of the method of Taylor (of Taylor's Theorem), for finding the position of the horizon on an inclined photograph, is not mentioned; but then, Mr. Gordon's book has only just been published.

The reader will not easily find another book which covers the same field as that under review and which gives, so clearly and concisely, such a reliable account of the history and physics and of the many applications of photography. There are not many omissions to record. No mention is made of Galton's composite photographs of groups of human faces, which serve to record "types." And, (a more important omission), the archæological use of photography is nowhere indicated. Perhaps the reason for this latter omission is that this particular application has only recently made its appearance above the scientific horizon. The application in question is due to the discovery of the fact that air-photographs reveal features of the earth's surface which are quite invisible on the ground. Ancient tracks, ancient fields, ancient dwellings, show themselves on the air-photograph in an almost magical way. One appears to be looking at the distant past as it were through a veil. This was noticed in Mesopotamia by Lieut.-Colonel G. A. Beazeley, R.E. and others; and Mr. Crawford, of the Ordnance Survey, has, by this means, been able, in certain areas, to construct a map of the fields and roads of pre-Roman Celtic Britain. If we could only go a little deeper and obtain a kind of X-ray photograph of the structure of the earth!

C. F. CLOSE.

MILITARY ORGANIZATION AND ADMINISTRATION.

By MAJOR W. G. LINDSELL, D.S.O., O.B.E., M.C., *p.s.c.*, R.A.
(Gale & Polden, Ltd., Aldershot. 7s. 6d.).

Now that the period of grace for promotion, without having passed an examination, is drawing to a close, the appearance of Major Lindsell's book will be hailed with a sigh of relief by officers nearly due for promotion and many others who are trying to keep pace with recent developments. It is strongly to be recommended to all such officers.

At a time like the present, when organization and training are only beginning to crystallize into a more permanent form, after the post-war period of reform, the book is especially valuable.

Already new manuals, new establishments, and new rulings have left some of the detail in Major Lindsell's book out of date; and one must all the more admire the courage of this officer in publishing his book at such a time, for it is certain that frequent new editions will be required during the coming years if the book is to remain of use to those for whom it is written.

In certain particulars Major Lindsell, in his position as an Instructor at the School of Administration, may bring us ahead of published policy, but in some important points he differs from the manuals. The following two examples may be quoted:—His description of the organization of No. 1 (the Baggage and S.A.A.) Company of a Divisional Train on page 71, and his explanation of the working of the two echelons of the D.A.C. on pages 86 and 87. Both these run counter to the official publications. Under the circumstances, however, the wonder is that there are not more frequent differences.

The choice between what detail should be inserted and what should be omitted in such a manual is difficult to decide, but one is inclined to wonder what can have guided the author in several cases in his choice. For example, detailed figures are given as to what may be added to or deducted from a man's pay, while the total of what his pay actually is is omitted.

Again, a book which gives a detailed menu of what the soldier should be given to eat for two whole weeks, summer and winter, might be expected to show where and how tools and engineering stores may be obtained in war. In view of the importance laid on the Pay and Mess Book, in recent examinations, more detailed explanations, with examples, might be given of the system of keeping it up.

The book is well arranged in clearly divided sections, with a good table of contents. An index, however, would have been a welcome addition.

The system of references might be improved by giving detailed reference to the authority for each paragraph. The method adopted of giving general references to manuals for a whole chapter is not usually sufficient. The diagrams scattered through the book are excellent, and even more might have been done by their means to add to the conciseness of the information, thus making room for rather more information, of which an officer working for promotion or the Staff College would be glad, considering the comparatively high price of the book.

R.P.P.-W.

CARGO-HANDLING AT PORTS.

A survey of the various systems in vogue, with a consideration of their respective merits. By BRYSSON CUNNINGHAM, D.SC., B.E., M.INST.C.E. (Chapman & Hall. 13s. 6d. net).

LITERATURE on the subject of cargo-handling at ports is, in this country, practically non-existent. A few articles on the subject appear from time to time in technical journals, but apart from these very little information is obtainable as to the principles underlying the art of getting cargoes expeditiously in and out of ships, or of moving goods to and from transit sheds.

The writer of the volume under review has approached the subject from the point of view of the engineer, and has not included any chapters on the documentation and management side of cargo-handling.

The subject, therefore, though not exactly a military engineering one, will be of value to R.E. officers when viewed from the civil engineer's point of view.

No intelligent person could read the book without being interested, in that it reveals to the uninitiated how the goods that satisfy his daily wants are packed for shipment, how stowed, trimmed, handled, and finally deposited at their destination.

The engineer will read the book with double interest. He has certainly, during some part of his career, had to lift, transport, sort out, and handle stores. In "Cargo-Handling" he will read how these problems are tackled in the ports of different countries the world over.

The subject is treated logically. Cargoes are divided into groups such as Bulk, Special and General cargoes—each kind requiring a different method of stowage in the ship and handling at the port. Ships' gear and quayside gear for handling the different types of cargo are then described.

There is an interesting chapter on quayside cranes. Electric motive power is now in the ascendant for these, and is gradually superseding the hydraulic ram for lifting and lifting-gear, whilst compensated luffing action is the feature of all modern quayside cranes. Such cranes have no great need for large weight-lifting capacity. There is little need to supply cranage power in excess of 1 ton or 30 cwt. This point was certainly not realized at the beginning of the late war, and there still appears an idea in many minds that the ordinary quayside crane is capable of dealing with all loaded wheeled army vehicles.

Quayside cranes are more prevalent and more complicated at ports where tidal influence is most felt. With tidal variations of the order of 20 ft. to 40 ft., a ship's derrick is often below quay-level. A crane on the quay is, however, capable of being mounted so as to be workable at all states of the tide.

In British and North European ports the quayside crane is fully developed, while in New York, and the ports of the Western seaboard of the North Atlantic, the Burtoning system is in vogue, partly on account of the tides, and partly because the quays in these parts of the world are built on piles, and are incapable of taking heavy loadings such as are brought on by crane foundations.

The process of Burtoning consists in attaching the cargo-lifting hook jointly to the end of two lines, and swinging the load between the vertical positions which the lines occupy at the extremities of their range. One line usually is passed over a sheave on the ship's derrick, and the other is passed through a sheave attached to some point well above quay-level. The Burtoning method of handling cargo is quick, expeditious, and makes use of the ship's lifting gear as well as the quayside winches.

Conveyers and elevators present many admirable features for the transport of goods from one place to another, but it is essential that there should be enough work for these appliances, or they become expensive luxuries; a minimum load of 10 tons an hour must be assured. The various forms of conveyer and elevator are well described and illustrated.

The chapter on trucking goods at the quayside and in transit sheds is interesting, and should appeal to any R.E. officer who has had to deal with large dumps of material. Elevating trucks for use with loaded skids, petrol-driven tow motors for trucking goods, Elwell-Parker trucks deriving power from storage batteries, are all described, and have their performances tabulated and compared.

Stress is laid on the importance of the lighter as a cargo-carrying agent; some 80–90 % of all goods brought to the Port of London being unloaded into lighters, while in New York the figure is 65%.

Interesting descriptions are given of the handling of bulk cargoes such as coal, ore, grain, refrigerated produce, oil, timber and the like together with figures showing comparative efficiencies of the different methods of handling bulk cargoes of the same kind.

The volume is full of interesting facts, it is very well illustrated, and all explanations of different gears and machines are clear and easy to follow.

G.C.G.

DAMP WALLS.

A Handbook on the various causes of dampness in house walls, etc., by Ernest G. Blake, M.R.S.I., A.B.I.C.C. Published by Crosby Lockwood & Son. Price, 8s. 6d. net.

The dangers to health and property entailed by damp buildings are vividly described by the author in an early chapter, and the rest of the book presents an exhaustive survey of the causes and remedies of dampness. Temporary remedies and palliatives, both internal and external, are described in Chapters III and IV, but the importance of radical and permanent cures is fully emphasized. Permanent remedies and the eradication of the causes of dampness are dealt with very fully in Chapters V to X, including remarks on damp-proof courses, weather-tiling, asphalt, water-proofing compounds, renderings, clay puddle, subsoil drainage, defective sills, flashings and water-pipes.

The use of water-proofing compounds in cement renderings is strongly recommended, and the methods of using hydrated lime, the Sylvester process, water-glass and certain proprietory compounds are described. The relative advantages of powder and liquid water-proofers are discussed, the author considering that the facility with which powders can be transported and proportioned more than outweighs the ease with which liquids can be evenly distributed throughout the mass by adding them to the mixing water.

Chapters XIII and XIV describe various forms of water-proof building construction, including dry areas, hollow walls, perforated bricks, and special forms of monolithic concrete construction. Chapter XV describes fourteen methods of concrete block construction. Chapter XVI deals with cement renderings—for the second time—and describes the use of the Cement Gun. Some notes on *pisé de terre* and other unusual forms of construction are included.

A great deal of information is included in the book, which should be of considerable value to those having the care and upkeep of buildings, but it suffers from being presented in a somewhat indigestible form due to the large number of processes described, some of which are not very closely allied to the subject under consideration, while others are deprecated by the author and still described at length. For instance, the practice of covering a damp wall with match-boarding is described as "an ostrich-like policy" which "allays all fears, so that a false sense of security is produced"; nevertheless, the process is described at length in nearly four pages, including an illustration. A great many proprietory articles and methods are described by the statements made in manufacturers' advertisements, which can only be regarded as a review of the methods and not as the author's recommendations. The general question of the adaptability of various methods to different circumstances is shortly described in one section of the last Chapter, and might advantageously be more fully treated.

As a reference book, the new volume should be of value in any works office, providing, as it does, a complete compendium of information on the subject.

J.C.P.T.

THE LAW OF THE CAR AND EVERY MOTORIST'S OWN LAWYER.

A popular guide for the private and commercial owner and driver. By L. G. REDMOND-HOWARD, author of *Law of the Cinema*, etc., and HAROLD CRANE, LL.B. (Lond.), Solicitor of the Supreme Court. Edited, with an Introduction and Technical Notes, by W. GORDON ASTON, A.I.A.E., A.T.R.AE.S. London, Percival Marshall & Co. Price, 2s. 6d.

MR. ASTON explains in the introduction that "this book has been produced because, in spite of the fact that they are surrounded, circumscribed, harassed, persecuted and bamboozled by the law, motorists, as a class, have never taken the trouble to ascertain anything about it." If the reader drives, owns or deals in private or commercial motor-cars, he cannot fail to find in this small volume an amount of useful information in non-technical language, which he does not but ought to possess. Also, it is probable that he will discover that the law is less of an ass than he thought; as he will find that it gives him many rights and privileges even though, in some of its restrictions, it may temporarily conflict with common sense.

T.

PATIALA AND THE GREAT WAR.

(Medici Society.)

THIS book, printed for private circulation, has been presented by the Medici Society to the R.E. Corps Library. It is a fine specimen of beautiful printing and photograph reproduction and the tale that it tells of the stupendous effort both in men and money which was made by this famous Sikh State in aid of the Souzerain power, deserves to be remembered for all time to the honour of His Highness the Maharaja.

POPULAR FALLACIES, EXPLAINED AND CORRECTED.

By A. S. E. Ackermann, B.Sc. (Engineering) Lond. 3rd. Edition. The Old Westminster Press. Price, 12s. 6d.

This delightful book, of nearly a thousand pages, deserves to take its place beside the *Percy Anecdotes* and *Curiosities of Literature*, as a companion with which very pleasantly to while away an idle hour. Great is Truth, but there is life in many of these old Fallacies yet! Possibly the suggestion that Truth seems "to stand at a fixed centre, midway between its two antagonists—Fact and Phantasm," may apply to some other things besides art. F.E.G.S.

MAGAZINES.

REVUE MILITAIRE GÉNÉRALE.

(*June*, 1923.)—*German Mentality*. By George Blondel, Professor at the School of Political Science.—The writer traces the development of the German school of thought from the days of inter-tribal wars. Tacitus attributed to the Germans a *vis durans*, and native simplicity and exclusiveness delayed their civilization. In the 18th century signs of cosmopolitanism appeared, in the 19th from Luther's doctrine of predestination was evolved the conception of Germany as an elect nation divinely destined to serve as model and guide to nations less favourably endowed—a conception elaborated by Gottlieb Fichte and Frederic Hegel. The latter added the idea that world domination could only be obtained by force. The writer argues that the germ of this idea is to be found in Kant, who taught that organization is indispensable, and that the moral obligation of the individual must cede to the duty of submission to the State. By degrees the Germans have been inspired with respect for constraint and force, until Bernhardi writes that "might is the highest right." Defeat has not altogether abolished these ideas, but there are signs that Prussian blood-and-thunder methods are being subjected to a healthy criticism which may lead to a greater moderation of outlook.

Colonial Warfare, Morocco. By Capt. R. Baillot.—This article is divided into two parts: I., method of conquest and pacification; II., operations. The first describes the country and inhabitants. Peaceful penetration is pursued as far as possible, the Intelligence Officers finding out all they can about the topographical features, especially where water is obtainable, and about inter-tribal relations which may at times be turned to account. II., when military operations are required, a mixed brigade of about five battalions, two squadrons, and two or three batteries of 65's, with hospital and other services, say, 4,500 men and 1,800 animals, has been found to be the handiest force. It has to carry its own supplies, and marches in square, with advance, flank and rear guards, and the convoy in the centre, ready to repel attack from any direction. The advance must be continuous or lately-conquered tribes may be raided by others which have not yet submitted. A perimeter camp is formed at night, for the defence of which Brun entanglement is always carried. To close an operation, a fortified post is prepared, communications established, cultivation commenced, and as the tribes show signs of settling down peacefully the garrison is gradually reduced.

The Fatal Quarrel between a Chancellor and an Admiral.—The article by Capt. de Gaulle is concluded. Tirpitz now gained the help of Hindenburg, possiby in exchange for assistance offered to him in obtaining the post of Generalissimo. Bethmann experienced difficulties with the newly-assembled Reichstag, and the Press of the Right pleaded that the most formidable weapon that Germany possessed should not be wasted. Bulgaria having joined the war, Falkenhayn withdrew his opposition for a time, but in March, the situation at Verdun having turned in favour of France, the Emperor's cabinet decided to postpone the submarine war indefinitely. Tirpitz became ill; his resignation was suggested, sent in, and accepted. Popular excitement grew, and manifestations, the first since the mobilization, and the last until the revolution, organized in Berlin in favour of Tirpitz, had to be dispersed by force. Tirpitz now organized a party called the Patriotic Party, which advocated the dismissal of the Chancellor, the annexation of Belgium, and unrestricted submarine warfare.

The Grand Admiral's resignation did not restore Governmental authority over the Navy, and on 24th March the *Sussex*, with several Americans on board, was sunk by a torpedo. Excuses were offered and reparation promised, but the Emperor had himself to reprimand the submarine commander. The heavy blows struck at Germany by the Allies in 1916 checked the propaganda of the Patriotic Party. In August Falkenhayn was replaced by the military dictatorship of Hindenburg and Ludendorff, who began by characterizing submarine warfare as folly, but by October Germany had regained confidence. In November the Chancellor's proclamation of Polish independence annoyed Hindenburg who, in view of the improved military situation, announced that the time had come to renew the blockade of England. Bethmann endeavoured to obtain a respite, announcing his proposal of a general peace, but on receipt of a refusal of that overture from the Entente Hindenburg carried his point, and a Council of War decided to commence unrestricted submarine warfare on 1st February, 1917. Counsels of delay received from Bernstorff at Washington met with no favour, and on receipt of notification of the blockade the United States decided on war. At the very moment when Germany might have obtained advantageous terms of peace she condemned herself to defeat.

Considerations on War of the Future.—This article is a criticism by Commandant Paquet of an article by Colonel Amadeo Guillet, of the Italian General Staff, in the *Rassegna dell' Exercito Italiano* for November and December, 1922. Colonel Guillet advances the view that what he calls the "aero-chemical" arm, aviation and gas, was the one entirely novel characteristic of the late war, and that "the new aerial arm judiciously organized constitutes by itself alone a force capable of deciding a conflict." He imagines Italy "without any land army, but disposing of such a superior air force as would master that of any of her neighbours. This force would cause in the enemy's army, bases and populated centres, such destruction that human nature must abandon the struggle." He cites the case of Iraq, where England has replaced a land army by a small air force, and states that the United States have recently discovered a gas of deadly and persistent qualities which would appear to be capable of deciding the fate of a war. In answer to this it is pointed out that the A.A. gun and projector have proved themselves a very effective defence against air-craft, also that any improvement in aviation effected in any country is quickly adopted by its probable adversaries, and after the air fleets have fought it out the big battalions will come to their own. Colonel Guillet then argues that the " potential menace " of the superior air force waiting in its aerodromes will keep the enemy quiet even if its territory is not occupied by any land force. But he weakens his case by referring to an eventual resumption of hostilities by the nation conquered in the air, which presupposes a land army, and if this is the case, what will the country do which has nothing but its air force ? It must organize a land army also, and the fact is that war now demands the utilization of the entire resources of a nation, and the best land army, supported by the best air force, will win the day. Colonel Guillet has great faith in his new method of warfare, and proceeds to show what an enormous saving in expense it would cause. He ends his study with a glance at the political and international consequences of an Italy organized for aerial warfare, looks to the air as facilitating the military recovery of Germany, and recommends France to reduce her land army and concentrate on the aerial arm. Italy could deny the Mediterranean Sea to England, and the latter, in view of her interests there, would have to come to an arrangement in return for which she would have to pay heavily in providing Italy with commodities which she needs.

(*July*, 1923.) *Talleyrand and the Open Frontier.* By Commandant Weil.—This is an attempt to fathom Talleyrand's reasons at the date of the capitulation of Paris for not standing out for what has been called the natural frontier of France, the Rhine and the highest peaks of the Alps and Pyrenees. He had a good case, for, prior to the Consulate and to Napoleon's wars of aggression, France had acquired the extended frontier in defensive wars, or at the request of states which had claimed her protection, were still friendly, and spoke her language. Posterity will never cease to blame Talleyrand for his want of firmness. The withdrawal of the frontier from the Rhine to that held by her kings in 1792 has already led to much bloodshed, and may lead to more.

Two Battalion Attacks. By Commandant Janet, from documents supplied by the historical service, and information furnished by combatants.—The two attacks described occurred in September, 1915, one in Champagne, the other in Artois. The events are carefully related, and illustrated by sketches, without which the details would be difficult to follow. Should be read in the original and would afford useful studies for battalion officers.

Strategy and Operations of the Allies in the North.—A continuation of the article by Capt. Kuntz, which traces the operations of the latter end of August, 1914, including the check to the Germans occasioned by the threat to their right flank, and their abandonment of the idea of capturing Lille and Paris and cutting the British communications with Dunkirk and Calais, for the direct pursuit and defeat of the English Army. French Headquarters meanwhile recognized where the heavy blow was to fall, and set about restoring the strategic situation by the constitution of a reserve to be formed by the junction of the 4th and 5th Armies with the English and troops drawn from the East, while the remaining armies held the enemy on their fronts. This was a risky undertaking, as all the troops were in contact with the enemy, but was entered upon with confidence. (*To be continued.*)

Swiss Chronicle. By Major de Vallière.—The 7·5 c.m. field-gun, altered by Salzer Bros., of Winterthur, has been made into an excellent mountain weapon. The shield has been strengthened, the axis of the gun raised several centimetres to allow of giving greater elevation, and the trail has been widened and hollowed out to receive the breech on recoil. On level ground an elevation of 410 per 1,000 is obtainable, and at an altitude of 2,000 ft. on a slope of 11°, and with an elevation of ·6 per cent., a range of just over five miles has been obtained with the normal ammunition. The firer's and aimer's seats fold up on the trail for facility of carriage. Dismantling and assembly each take ten to fifteen minutes with six trained men. The gun and carriage make nine loads capable of transport on light carts, sledges, or by hand, into the highest mountains. Charges of different weights allow of fire on all varieties of ground.

The Federal Council has constituted heavy artillery regiments each of two groups of 12-cm. guns on tractors, and a group of 15-cm. horse-drawn howitzers.

A steel helmet has replaced the képi-shako for all arms.

Le Rôle du Général Gallieni (*Août–Septembre*, 1914). By Paul Pilant.—Written with an evident desire to elucidate the truth, this book is based not only on official documents, but on second-hand and partial information, and conversations of no military value. It refers to "resistance" on the part of Gallieni, and "hostility" on the part of Joffre, where there was only loyal co-operation. Facts are, however, presented with accuracy.

Nieuport, 1914–1918. By Commandant Robert Thys. (Berger-Levrault).—An instructive history of actual events related with indisputable technical knowledge, describing the inundation of the Yser, and all the works connected with them. The book is a work of art, illustrated with admirable photographic views, maps, sketches, portraits, and coloured plates.

Histoire de la Guerre navale, 1914–1918. By Lieutenant de Vaisseau de Rivoyre. (Fournier.)—This work aims at affording young officers, not a complete history, but an exact abridgment—a frame into which facts can be fitted later as they become better known. It is divided into two parts, the first historical, illustrating the intimate relations which must unite strategy and politics, including economic considerations. The second part gives accounts of the principal naval actions, and the lessons they teach. A book of predominant interest.

L'Apocalypse russe. By Serge de Chessin. (Plon.)—A masterly account of the Russian revolution from the Red Terror and formation of the Third International to the final triumph of Bolshevism.

Mémoires du Kronprinz. (Payot.)—A sensational publication, but one which does not reveal much that was not known, or guessed, already. A few obscure points are cleared up, and the Emperor and his son are delineated, such as they were, and both, consciously or unconsciously, responsible for the war. Their relations, if generally correct, were not very cordial, and the son speaks unkindly of his father—possibly a Hohenzollern trait. The book may be popular in Germany, as the Crown Prince is a thorough German, and a few passages which have been well received by various newspapers are the most interesting. As to the rest, the personalitities of the Emperor and Crown Prince evoke a certain sympathy owing to the misfortunes which have overtaken them, and which they in no way understand, but neither had the force of character to guide the events he should have controlled.

(*August,* 1923.)—*The Tactical Employment of Infantry Automatic Weapons.* By Lieut.-Colonel P. A. Cour.—A fairly exhaustive study of the tactical use of automatic rifles, and light and heavy machine-guns in support of advancing infantry, contrasting German and French methods of attack and employment of their weapons in furtherance of their respective ideas, but omitting any remarks on their use in tanks and in defence. The article is worthy of perusal by all concerned with the employment of these weapons in the field.

A Flank Attack. By Major Charbonneau.—This article describes the flank attack made by the 1st Colonial Corps, on 16th April, 1917, against the Germans north-east of Soissons. The attack, delivered in an easterly direction, was intended to facilitate the northerly advance of the 6th Army during General Neville's ill-fated operations on the Aisne, which ended in failure.

Tactics and Army Organization. By Major Pamard.—This article belongs to the series entitled *Introduction to the Study of History,* and as such is of interest. The writer observes that the object of war is to break the adversary's will and induce him to accept certain conditions. Up to the French Revolution armies consisted mainly of mercenary troops, which were expensive to maintain and took some time to replace; it was therefore the sovereign's aim not to waste them. Pitched battles were seldom fought, and the capture of an important town or province usually sufficed to bring the vanquished to terms. A battle, when fought, was a confused mêlée in which individual bravery and skill met their reward. When fire-arms were invented the mêlée became a more difficult problem, and it was evident that the destructive effect of the new arms must be developed, and that movements must be made in formations as little vulnerable as possible; hence the inception of tactics which involved precision and more perfect organization. The evolution of French army organization and tactics from the 18th century onwards to the present day is then sketched, showing Napoleon's influence on the Art of War.

Le Grand Etat-Major allemand avant et pendant la guerre mondiale.—An analysis and partial translation by General Douchy of the book by General von Kuhl. Von Kuhl's book, *Der deutsche Generalstab in Vorbereitung und Durchführung des Weltkrieges,* was published in Berlin, in 1920. General Douchy has not given a verbatim translation. He has more particularly investigated the history of the various plans formulated by the German Great General Staff since 1871 in view of the possibility of having to face at the same time enemies to east and west. The tables and statistics given in the German work are not reproduced, as the French author suspects that they have been compiled merely for the greater glorification of the German General Staff. "With all due deference," he says, "to General von Kuhl, his book is only a piece of special pleading." Bearing these points in mind, General von Kuhl's words are of powerful interest, for he was better placed than anyone else to know what was going on, owing to the high appointments he held before and during the war. The most interesting part of his book is his narration of von Schlieffen's plans, and of the modifications of them introduced by von Moltke the Younger. Another remarkable passage is that in which von Kuhl deplores the decease of the Great General Staff. In regard to this General Douchy remarks that the fact of the existence of such books as this clearly proves that, if the Great General Staff has been officially suppressed, its spirit still lives, and it is probable that at the moment of need its principal elements would very quickly be reunited to produce a formidable organism.

A. R. REYNOLDS.

REVUE MILITAIRE SUISSE.

(*Nos.* 5 *to* 9 *inclusive.*)

The operations of Sordet's Cavalry Corps in Belgium during the period August 6th to 15th, 1914, have been the subject of severe criticism. A work entitled *Historique du Corps de Cavalerie Sordet* has recently been published in Paris (Chas. Lavauzelle et Cie); its author, Colonel Boucherie, who has compiled the book under the supervision of General Sordet, has set out facts culled from official documents in diary form, but has made no attempt to search out and record the lessons to be learnt from an investigation of the handling of this cavalry force. A formulation of these lessons having been left for others to undertake, Colonel Poudret has applied himself to the task and contributes an interesting article to the *Revue* (Nos. 5 and 6), wherein the situation on the Western Front at the opening phase of the Great War is closely examined by him. The now famous plan XVII of the French General Staff contained a secret instruction dated February 7th, 1914, wherein was given the composition of the future 1st Cavalry Corps, its mission and its concentration area. Sordet's Corps was to assemble in the neighbourhood of Montmédy and was, at first, to support the French II Army Corps should the Germans attempt an offensive in the northern part of the Woëvre region; alternatively, in the event of an invasion of Belgium by the Germans, the Corps, which was to be supported by a small infantry force, was to march into Belgium. In the latter event, the mission of Sordet's cavalry was to get at once into touch with the enemy's columns, more especially those advancing from Belgian Luxemburg, to the southward of the difficult region about Houffalize and St. Hubert; its task was to obtain intelligence and at the same time to delay the advance of the enemy to as great an extent as possible. On March 9th, 1914, General Sordet drew up his plan of operations—an outline of it is given in No. 5 of the *Revue*—which was approved by the French Commander-in-Chief-designate. On August 2nd, the units of the 1st Cavalry Corps took up their stations as provided for in the "*ordres de couverture.*" That there was wastage in the Corps during the operations that followed, and, indeed, that it was excessive, is admitted in almost every quarter. Colonel Poudret endeavours in his article to elucidate whether or not this enormous wastage was inevitable owing to the nature of the mission imposed upon Sordet's Corps, and examines the situation critically, with a view to ascertaining how far the wastage could have been avoided altogether, or, at least, minimized. For this purpose, the course of events is analysed, and the directives and orders issued are dealt with in detail. It is pointed out that, whatever doubts the French may have had before the outbreak of war as to the intentions of the Germans, these were removed in the first days of August, when the latter sent their ultimatum to Belgium, an ultimatum which was quickly followed by the invasion of Belgian territory. The question then arises whether, in view of the indications thus given of the probable direction of the German advance, and of their plan of campaign, the instructions issued to General Sordet should have been immediately modified or not. It is admitted that an attack on Liége did not necessarily imply that the Germans intended to operate along the left bank of the Meuse; however, such an attack made it almost certain that the advance of the outward flank of the German right wing would be directed along a latitudinal zone northward of that in which lay Sedan. Clearly then, the sector between Sedan and Namur became at once suspect and required to be watched with the greatest care. Colonel Poudret's view is that, having regard to Germany's ultimatum to Belgium and the attack which was directed immediately against Liége, it would have been a wise precaution to have at once modified the instructions given to General Sordet, and his Corps should have been sent, *via* Givet or Dinant, towards Rochefort. He points out also that, had the German advance on Brussels been foreseen prior to the outbreak of hostilities, it would have been necessary to plan the strategic deployment of the French Army quite otherwise than was provided for in the scheme actually adopted (plan XVII), and in that event Namur would have been the proper concentration centre for Sordet's cavalry; from there both banks of the Meuse could have been effectively reconnoitred, and, at the same time, measures could have been carried out for the closest possible co-operation of the French and Belgian Armies, and they could have then been favourably placed to take part together in a general battle in some selected position, where the advance of the German right wing might have been successfully barred. Colonel Poudret unreservedly condemns the raid on Liége attempted by Sordet's Corps; he is of opinion that such a mission was altogether an improper one to assign to the French cavalry in the particular circumstances. At the time that the raid was undertaken it was more important, he thinks, for the French cavalry to explore in an eastward than in a northward direction. To the suggestion that a diversion in the neighbourhood of Liége by the French cavalry would probably have prompted the idea of the existence of complete solidarity on the part of the Allies, and thus heartened the defenders of the Belgian fortress, Colonel Poudret replies that the silence of the "canon libérateur" which succeeds its roar and betokens the failure of a relieving force to achieve its purpose has a far more discouraging effect on a besieged garrison than the temporary encouragement derived from the knowledge that help may be at hand. His view on this point is perfectly sound. In summing up his analysis of the facts brought to light in Colonel Boucherie's book, Colonel Poudret expresses the opinion that the failure of Sordet's cavalry was due not only to faulty directives and orders issued subsequently to the initial instructions of March, 1914, but to some extent also to defective peace training: the French cavalry soldier was, before the Great War, very conservative; he admitted the possibility of his arm being required to fight dismounted, but was averse to the adoption of a mode of warfare—and consequently, also, to the training necessary—which was at variance with methods of fighting conforming with the cavalry spirit of old time. The cavalry soldier's peace-time training was also responsible for certain other mischievous consequences. Having become habituated to the working out of its special missions, unaided by the other arms, in positions well in advance of the main army, the cavalry had lost the instinct of co-operating with those other arms, and, therefore, did not dream of profiting from the substantial help that the other arms were capable of affording it in the situations that actually came to pass. For instance, support could readily have been obtained by Sordet's cavalry, on August 13th, from Lanrezac's Corps, which had been opportunely directed by its Commander on Dinant; however, no advantage was taken of the presence of this large mixed force by the French cavalry leader for the purpose of consorting measures which would probably have enabled the French to inflict a very serious, if not crippling, blow on the German cavalry.

An article on aviation and gas warfare is contributed to No. 5 of the *Revue* jointly by Captain Primault and R. A. Jacques. Therein it is pointed out that the use of poison-gas for the purposes of warfare is so recent that a very vivid imagination is required in order to plan out future developments in connection with the employment of this weapon. The tactical results obtained by the use of poison-gas were, it is claimed, enormous, and it is predicted that the strategic results likely to be obtained by a proper development of this arm will, in a future war, be very striking; indeed, it is suggested that the further developments in the gas-attack will completely modify the lines upon which campaigns have hitherto been planned. It is in the direction of extending the radius of action of the gas-attack that all efforts should, the authors of the original article think, be turned in order that powerful surprise effects may be obtained not only along an opponent's firing line but also in his "back areas." It is to aircraft that they look as the means for effectively increasing the range in gas-attacks and for securing, by surprise action, strategic results on a vast scale. It is claimed that by means of gas-attacks carried out by aircraft the munition factories in enemy country can be entirely brought to a standstill immediately on the declaration of war. It is suggested that the side possessing the stronger Air Force will be able, at the very outset, entirely to crush, by means of combined operations on the part of the Fifth and Sixth Arms, all preparations attempted to be carried out by an enemy behind his *troupes de couverture*. The claim is a very large one and seems to predicate that one's enemies are likely to be more supine than they have ever before proved themselves to be. Yet, it is recognized by the authors of the original article that many methods of anti-aircraft have been devised; however, they assess at small value the efficacy of the defence measures against gas and aircraft developed up to date and justify the views held by them by pointing out that, after four years of training under the most practical conditions, anti-aircraft artillery at the end of 1918 expended on an average some 7,700 rounds for each enemy aeroplane destroyed. It is further argued that, if gas measures should be adopted in the future as a means of defence against hostile aircraft, such measures are not likely to meet with any greater degree of success than was achieved by the anti-aircraft artillery in 1918. The matters dealt with in the original article are of high importance, and need careful study on the part of specialists.

Colonel Lecomte contributes an interesting article to No. 9 of the *Revue* on certain *Hérésies stratégiques*; these require to be carefully noted. The majority of the remaining articles in these numbers of the *Revue* are of more particular interest to the Swiss Army, and concern the Swiss people rather than the foreigner.

W.A.J.O'M.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*Nos.* 8 *to* 10 *inclusive*).

The account of the operations of the Belgian Army in 1914 is continued in the numbers of the *Bulletin* under notice; the events of October 4th being dealt with therein. The principal preoccupation of the Belgian High Command at this time concerned the measures necessary to secure the safety of the lines of communication of the Belgian Field Army then at Antwerp. In a written communication sent by the Belgian War Minister to the British First Lord of the Admiralty, it was stated that the Belgians would offer resistance at Antwerp to the extreme limit of their power, and it was suggested that, if, in addition to the Royal Marines already taking part in the defence of the fortress, any further British reinforcements were to be provided, it was preferable they should be directed on Ghent rather than that they should be pushed into the fortified zone of Antwerp. Incidentally, the narrative discloses the fact that the views of Lord Kitchener and F.M. Sir John French, as to how best the Belgian request for help was to be met, were widely at variance. Eventually the British Government decided to make an attempt to reinforce the Belgians without delay, and the 7th Division and the 3rd Cavalry Division—the only troops immediately available in Great Britain—were detailed for this purpose and ordered to Belgium. At this time, the II Corps of the B.E.F.

was in process of being relieved by the French at Soissons and was being transferred to St. Omer; simultaneously, the Germans were pushing their artillery attack on the detached works in the southern sectors of Antwerp. The quality of the Belgian fortress troops detailed for the defence of Antwerp was poor, and the knowledge of this fact was undoubtedly causing the Belgian High Command considerable anxiety. Fortunately, the Germans still had a wholesome respect for the Belgian fortifications and were acting with considerable caution; they were not for risking an assault on the fortified zone until their heavy artillery had had full opportunity of making its weight seriously felt. However, whilst the big guns and howitzers were pounding away at the forts and intermediate works on the banks of the Nethe, von Beseler, who had been reinforced by the 1st Ersatz Brigade, carried out a reconnaissance in force in the direction of Schoonaerde, in order to ascertain the dispositions of the Belgians along the banks of the Scheldt. The Belgian 4th Division had by now taken up positions along the river with a view to barring the enemy's advance on Ghent. The Belgian Cavalry was so impressed by the German operations along the Scheldt that (on the evening of October 4th) it was convinced the movements of the enemy all pointed to an immediate attempt being made by the Germans to force the passages of the Scheldt along the line held by the Belgian 4th Division and reported to Headquarters accordingly.

Captain Kuntz has contributed an article entitled *Stratégie et opérations dans le Nord* to the *Revue militaire générale française* of May 15th, 1923; therein he finds fault with the handling of the Belgian Army in the early phases of the Great War, and, in particular, questions the wisdom of the decision taken by King Albert to withdraw his Army from the Gette on August 18th, 1914, instead of accepting battle in that position. These criticisms are resented by Colonel A. E. M. Nuyten, who contributes to No. 10 of the *Bulletin* an article entitled *Ce fut-il une erreur de replier l'armée belge sur Anvers au mois d'août* 1914; therein he warmly defends King Albert's strategy. In his examination of the operations of the Belgian Army, Captain Kuntz lays emphasis on the fact that the Germans were held up for eight days only at Liége; he alleges that a mere threat on the part of the German VII Corps caused the Belgians to abandon Namur; he suggests that the shelter of Antwerp proved mischievously alluring to the Belgian Field Army; he regrets that the advice of the French High Command was not sought before the decision was taken to withdraw the Belgian Army into Antwerp, and expresses the opinion that, in retiring to the famous fortress, the Belgian King was not acting in consonance with the plans matured by the French High Command in the period immediately preceding the outbreak of hostilities. Colonel Nuyten contests the views of Captain Kuntz in relation to each of the points mentioned above *seriatim*, and gives the reasons why the Belgian Army retired on Antwerp instead of endeavouring to join up with the Allies at Mons or Lille. The Belgian Army certainly ran the risk of being cut off from the Anglo-French Armies by taking the northern route to the coast, but the fact remains that it managed to get away from Antwerp and joined up safely with the Allies on the Yser, after having succeeded in drawing five German divisions—some 75,000 men—and the German heavy artillery, which was very powerful, to Antwerp; it thus prevented this force from reinforcing the German Armies during the Battle of the Marne. Captain Kuntz is not impressed with the value of the sorties made from Antwerp by the Belgians and suggests that it was not until the end of November, 1914, that they took an effective part in the battle line. In his reply to Captain Kuntz, Colonel Nuyten points out that during the period October 15th to 31st inclusive the losses of the Belgian Army amounted to 16,000 out of a total of 48,000 infantry; further, at this time it was the Belgian Army that barred the northern approaches of Dunkirk and Calais and prevented the Germans from crossing the Yser. Colonel Nuyten quotes statements made by von Kluck, von Falkenhayn and others in support of his view that the strategy adopted by King Albert was sound, and that the retreat of the Belgian Army to Antwerp served the interests of the Allies as well as meeting the particular needs of the Belgian people. The original article deals in an able manner with a highly controversial subject, and is, in consequence, a contribution of considerable value to students of military history.

An article has been contributed to the *Bulletin* by Colonel A. E. M. Fastrez wherein it is shown how important it is that a General Staff should, when framing a plan of campaign, give the fullest consideration to the several political considerations that may be involved. The quarrels between Germany's military leaders and her professors on the subject of the violation of Belgium's neutrality have provided Colonel Fastrez with ample materials for his article, the first part of which appeared in No. 7 of the *Bulletin*. It would appear that so little did the Great General Staff value the opinions and advice of those outside its own immediate circle that officials so highly placed as German Ambassadors and von Tirpitz, the Minister responsible for Germany's navy, were not consulted in relation to certain matters of a political kind concerning which one would certainly have expected a General Staff to seek their views. In his Memoirs von Tirpitz goes so far as to aver that it was not until war was actually declared that he first had knowledge of the intention to march German Armies through Belgium. Colonel Fastrez's article is concluded in No. 8 of the *Bulletin*; he there asks the question: "Was it not possible to avoid the political obstacle?" In examining the situation, Colonel Fastrez points out that the German plan of campaign had serious disadvantages, which were partly political in their nature and partly military. Of the difficulties which the German General Staff was creating for itself, the most important among them was that arising from the projected invasion of Belgium, since such a step would with almost absolute certainty draw Great Britain into the conflict. It may be that the German High Command felt confident that it would be possible to knock France out of the ring before any intervention on the part of Great Britain could become effective. Nevertheless, before taking the decision to march the German Armies through Belgium, the German High Command should have carefully weighed the effect of the possible resistance of the Belgian Army on the operations of the German Army in the event of any part of their plan miscarrying. If it is really the case, as is alleged by the German General Staff, that it was not expected that Great Britain could, in any circumstances, have been induced to remain neutral, it became particularly important that Germany should at least, by diplomatic means, have secured a benevolent attitude towards herself on the part of Belgium. Speed and surprise were the two elements most necessary for ensuring success for the German plan of campaign. It was with a view to satisfying the first of these requirements that, according to the German General Staff, the decision to invade Belgium was taken and a plan adopted whereby Germany was, from a political standpoint, placed in the worst possible position; the result was that developments followed which proved fatal to the strategic needs of the Central Powers. Colonel Fastrez examines the conditions existing in the autumn of 1914 along the eastern frontier of France and shows that, with the powerful siege artillery possessed by the Germans they would probably have found the French fortified zones quite as vulnerable as the Belgian defences at Liége, Namur and Antwerp actually proved to be. The fortifications designed by Séré de Rivière in 1875 were quite obsolete in 1914 and no longer met the needs of the situation; their armament also was much out of date and would have been no match for the German siege artillery. In view of this condition of affairs one is justified, says Colonel Fastrez, in asking whether the frontier of France immediately contiguous to Germany was really so redoubtable as the Germans have alleged? The suggestion is made in the original article that the Germans made a great deal of the supposed strategic difficulties of a direct advance against France from Alsace-Lorraine for the mere purpose of covering their political designs against the independence of Belgium, and that alone. Should such have been actually the case, then it can certainly be said the German General Staff succeeded in their plan of campaign in harmonizing their strategy with the political considerations. However, a bold strategy was necessary to support an audacious policy embracing wide aims. It was here that the German plan of campaign, in Colonel Fastrez's opinion, failed: finding that the means available for pursuing their political aims were inadequate, the Germans should, in the initial stages of the war, have been careful to narrow down their aims to bring them within the range of their means. Had the course of events justified their doing so, the Germans could, at a later period, have broadened their objectives. Colonel Fastrez deals briefly with the offensive of the French 1st and 2nd Armies in August, 1914; he thinks that, had the Germans launched a counter-offensive in Lorraine after the collisions between the opposing armies in the neighbourhood of Morhange and that of Sarreburg, they would have met with a large measure of success. Indeed, he goes further than this; he is convinced that, had the German Army made a direct attack against France in August, 1914, without traversing Belgium at all, it would have decisively defeated the French Army. In adopting a course such as that last mentioned, Germany would have avoided the political mistake which led to the resistance of Belgium, brought about the immediate intervention of Great Britain and gave rise to all those consequences of a political, moral and military kind which were the proximate causes leading to the defeat of the Central Powers.

Major Jobé deals, in Nos. 9 and 10 of the *Bulletin*, with the Battle of the Marne and the Race for the Sea as studies in the application of the correct principles in the conduct of a modern battle. It was on August 24th, 1914, obvious to all who had knowledge of the facts that the French plan of campaign had completely failed and that the adoption of an entirely new plan was necessary if the war was to be continued to a successful issue. At the same time, events on the Sambre had, to some extent, caused the calculations of the German General Staff to be upset. However, the German High Command was able in great measure to continue its operations on the lines planned for the initial deployment; the enveloping movement against the Anglo-French Armies was pushed on and an attempt was made to exploit the success gained against the French right at Morhange by an energetic pursuit in Lorraine. The directives issued by German Headquarters on August 28th and September 4th, and those issued by the French Headquarters on September 1st and 2nd, with a view to meeting the new situation are set out in the original article. Marshal Joffre's directives provided for the possibility of a retreat to a line as far south as that of the Seine; bitter criticism has been directed against the new plan of the French Generalissimo. Major Jobé defends the new plan; he rightly points out that what Marshal Joffre did was to fix the extreme limit for the retreat of the Anglo-French Armies, which is by no means the same thing as ordering a retirement to the Seine. The French Commander-in-Chief was playing for safety and not disposed to take hazardous risks; in acting thus, he was correctly applying the proper principle in the conduct of a battle, the one without which victory is unattainable. The Germans, on the other hand, by continuing to carry out their original plan of a double envelopment of the Anglo-French Armies had to stretch out their two wings; these both became, in consequence, too weak effectively to crush the Entente Armies between them. The numbers of troops fighting on the two sides at the Battle of the Ourcq are set out in No. 10 of the *Bulletin*; the Anglo-French forces numbered 475,000 men and 1,344 guns (9 Corps), whilst the Germans had only 280,000 men and 1,008 guns (7 Corps). Major Jobé examines in some detail the directive issued by the German Headquarters on September 4th; he is of opinion that it was then impossible for the German Armies to carry out the moves ordered therein and gives his reasons. He also records his conclusions as to the course the German High Command should have followed at the outbreak of war, namely, (1) the Russian front should have been completely neglected until the French were definitely defeated—the adoption of this course would have released four additional German Army Corps for employment on the Western Front; (2) on the Western Front an enveloping movement should alone have been attempted by the northern wing of the German Army; (3) a defensive battle should have been fought by the remainder of the German Army with a view to holding the Entente Armies along the whole length of their front.

W. A. J. O'M.

MILITÄR WOCHENBLATT.

15th March, 1923.—In the issue of 1st March the *M.W.B.* reviewed Dewar and Boraston's book dealing with Earl Haig's share in the Great War. In the issue of 15th is a leading article dealing with the reception of this book by the French technical Press and particularly by *La France Militaire*. The reviewer observes that this paper is especially concerned with the fame of Marshal Foch as a great Commander " and anxiously watches to see that not a twig shall be taken from his crown of laurels." The reviewer says that the credit for the successful allied offensive in August and September, 1918, is claimed by the English book for Earl Haig, while the French claim this for Foch.

The details of the review of the book and of the French criticism are not of particular interest ; they serve mainly for an attack on the French critic, Gen. Fonville.

In dealing with the " decisive " application of the main body of the American forces under Pershing, after the capture of the salient of St. Mihiel, on the west bank of the Meuse, the reviewer says that this, according to the English book, was to be ascribed to Haig's plan, while Foch would have wished to attack on the east bank in the direction of Briey. " According to other sources " on the other hand, Pershing favoured the attack west of the Meuse, and this plan was selected. " Now there can be no doubt that the direction of attack east of the Meuse, that is to say, the prosecution of the successful offensive of St. Mihiel and its extension, had been the most favourable for operations and would have caused the greatest difficulties to the Army group of General Gallwitz. On that account the Germans reckoned that the attack would be continued there. To meet these dangers, most of the available German reserves were applied in this direction." The reviewer then goes on to say that Foch was right to act as he did, for he could not tell what success would attend the simultaneous attacks west of the Argonnes and in Champagne where the French were without American aid, adding that on this portion of the great battle-front the French had to thank the " dashing spirit of attack " of the Americans between the Meuse and the Argonnes almost entirely for their successes.

The reviewer then compares Foch's strategy of " Une poche qu'on bossèle à coups de poing " and the " Buffalo strategy " of Ludendorff as criticized by the French, finding a similarity between the two ; he defends Ludendorff against the accusation of the French critic that he never, in his strategy, conceived anything but the attack straight to his front by referring to Tannenberg, the Masurian Lakes and Lodz. He finishes with the observation that, but for the Americans, Foch would have been miserably beaten, and that the French, " particularly chauvinists of the calibre of M. Fonville," do not like to hear this.

The question of the best anti-tank weapon for infantry is evidently of much concern to the German military mind. The ball is thrown in by a writer in this issue, and play is continued in several later issues. In this the writer begins by defining the task of the " Infantry gun " : " From the beginning of the fight in co-operation with the other heavy weapons of the infantry to help in breaking down local resistance and to subdue single machine-guns, machine-gun nests, trench mortars, guns and tanks." The need of rapid effective action, before hostile artillery fire has been drawn on to them, is stressed, while the difficulty of ammunition supply is referred to. "An army, which must defend itself against hostile tanks, whilst itself deprived of both tanks and fighting aeroplanes—which can take on a part of the tasks of the infantry gun—has need more than any other to study carefully the question of the infantry gun." The war proved that projectiles of small calibre have not sufficient effect; the guns which the allied armies now favour are then named. While these appear more or less to agree, it is necessary to be quite clear as to whether the infantry gun is to be used in conjunction with, or against, tanks. In the first case, if necessary, a light trench mortar can be made to suffice; in the second case, however, a comparatively heavy cannon is required capable of opening fire rapidly, and strongly constructed. An anti-tank gun for short range only is a contradiction in terms and a sheer impossibility.

The writer then goes on to say that while it would be very nice to have an anti-tank gun as well as the "infantry gun," there would be the difficulty that a special anti-tank weapon is ill-fitted to deal with other objectives and at the critical moment would not come into action at the right moment or in sufficient numbers. "For German conditions —weak artillery—this way is not open to us, even if we were allowed to develop artillery."

For an infantry gun that will be effective against tanks the writer requires:—

1. Sufficient effect against living targets and tanks, in so far as this can be attained with a flat trajectory.
2. Adequate provision for ammunition supply.
3. Light mobility, particularly of the weapon when prepared for firing, and the offering of a small target.
4. Accuracy.
5. Great rapidity of fire.
6. The ability to fire from concealed positions.

Each of the above desiderata is then discussed, and finally certain experiments in other countries are commented upon.

In the same issue appears a review of a book entitled *The German Tanks in the World War.* It begins by observing that the Great War has been described as the war of lost opportunities, and adds that this must, at any rate, be admitted so far as the German tanks are concerned. The value and the danger of tanks were greatly underestimated. This applies not only to the measures for defence against enemy tanks, but especially to the construction of German tanks, which "unfortunately" was undertaken too late. Of war experience in actual fighting with the German tanks but little was gleaned. The author of the book reviewed belonged to the German tanks and gained practical experience in the war. Each tank carried the enormous crew of 23 to 26 men, with one gun, 6 heavy and 1 light machine-guns as well as large quantities of ammunition. Each track was driven by a separate motor. The chapter on "The Tank of the Future" is said to be most instructive.

At the end of the war the Germans had only 3 German and 6 captured tank detachments, each of 5 tanks; that is to say, 45 tanks in all;

their first efforts at tanks in the field came at the beginning of 1918. England, on the other hand, started in with tanks in September, 1916, and in October, 1918, disposed of 6 Brigades with 18 Tank Battalions, while France in November, 1918, had over 27 Battalions (1215) of light tanks. "This start in the construction of tanks could not, unfortunately, be caught up by Germany in consequence of the already excessive overstraining of all her forces in the last two years of the war."

In the column giving snippets of news of foreign armies and navies, the following appears under the United States: "The Court of Appeals has acknowledged the sinking of the *Lusitania* as a justifiable act of war. It accepted the transport of munitions on the ship as proven."

1st *April*, 1923.—The leading article in this issue, on "The French in the Ruhr Territory and Germany," is from the pen of Lieut.-General von Cramon, who has fairly let himself go. The first paragraph runs: "When to-day one takes up the newspapers and reads of the wrath of the French in the Ruhr, or hears the tales of inhabitants of the occupied territory, eye-witnesses of the terrible goings-on there, one believes oneself to be not merely set back into the hoary Middle Ages, but into those former times when savage peoples, who knew neither right nor law, gave unrestrained play to their passions and impulses." Further on, England gets the benefit of quite a long paragraph of the General's abuse. She ostensibly took the part of "our enemy" because Germany infringed Belgium's neutrality, yet to-day she suffers the occupation by France of the peaceable Ruhr although she disapproves of this outrage. Italy is next dealt with; she is seeking only her own advantage. Whoever counts on America is building on sand. "When it was a question of saving the milliards at stake in the Great War, a *casus belli* was soon found; to-day, when it is only Germans who are being tortured in this inhuman way, one can remain cool even to the heart and consider it better not to get oneself mixed up in European affairs." The General then has a go at General Nollet and the Military Commission of Control, and ends up with the exhortation to oppose all the demands of the French with "no," "and, if we are driven to extremes, with our ancient Germanic force to fight and win our place in the sun."

Three whole columns of this issue are devoted to a reply to the article in the last number on the question of the "infantry gun." This article defends the claims of the 3·7 cm. gun, which displayed an apparently striking superiority over the German, French and English light trench mortars in some extensive trials against machine-gun nests at ranges of from 800 to 1200 metres; the report on these trials was not published, but the writer claims to have been given all the information by a friendly neutral. The article is interesting but too long to review in detail. The point he makes at the end is: "Has it really been quite forgotten what it means to the morale of the infantry and their power of resistance if the anti-tank defence is fought by guns withdrawn on the average 1200 to 1800 metres behind the front line, or by weapons from the very middle of the infantry line of resistance? Before everything in the grey of the morning, with artificial or real mist, or in high corn as on 18-7-1918?"

E.G.W.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.
September–October.

THE battles on the Carpathians, from the middle of January to the end of April, 1915, are described by Colonel d. R. Mayern in this Austrian Journal. Operations were to take the form of an attack over the Carpathians from the Rumanian frontier to Czeremcha–Strasse in three sectors—on the right (East) v. Pflanzer-Baltin with 6 Infantry and 1 Cavalry Divisions, centre v. Linzingen with 6 Infantry and 2 Cavalry Divisions and left v. Boroević with 14 Infantry and 4½ Cavalry Divisions —v. Boroević was to keep 5 Russian Infantry and 1 Russian Cavalry Divisions, on his left, busy with 4 of his own Infantry and 2 of his Cavalry Divisions, while he attacked 9 Russian Infantry and 4 Cavalry Divisions with the remainder of his group. V. Linzingen had but 1 Infantry and 2 Cossack Divisions opposite him, and v. Pflanzer-Baltin had 2 to 3 Russian Reserve Divisions and 2 Cossack Divisions opposite. The Russians were surprised, but, helped by the weather (a temperature of −20° Centigrade is quoted), soon brought the advance to a standstill. A Russian counter-attack made little progress against v. Linzingen, but its chief weight fell on Boroević and forced his line back by 20 kilometres or so. The XVII Corps from the IVth Army and the VIII Corps from Serbia were sent up to reinforce v. Boroević, and relieved some of the pressure, but the Russians continued to attack with heavy reinforcements, and made it impossible to relieve worn-out 3rd Army divisions. The attack on the right wing, however, prospered. The Bukovina was cleared of Russians and, with right shoulder up, v. Pflanzer-Baltin reached the line Stanislav–Kolomea–Czernowitz by the 20th of February. Meanwhile a new Russian Army was concentrating west of Stanislav: it was impossible to push reinforcements up to v. Pflanzer-Baltin fast enough to guarantee, against fresh troops, the exploitation of his original success and a renewed offensive in the centre was therefore arranged for by pushing in a new Army (2nd) under v. Böhm Ermalli on the night of the 3rd. On the 27th the new 2nd Army attacked in the direction of Baligrod with the idea of relieving Przemysl, but made little progress. Attacks developed along the whole line and from the 1st to 15th of March the casualties of the 2nd Army rose to 51,000. On the 15th the attack was broken off, having done little but draw in the Russian reinforcements destined to counter-attack v. Pflanzer-Baltin. The 2nd Army had drawn upon it the principal Russian forces on this front and now bore the brunt of their counter-attack. Ground had to be given, but the Russians were fought to a standstill as much by difficulty of supply as by opposition, and by the middle of April the battle ceased nearly on the line of January. In this area 1,000,000 Germans and Austrians had held 1,500,000 Russians, whilst further west and north 263,000 Germans had held 608,000 Russians. The sketch diagrams illustrating this article are excellent.

Major Kaiser, whose name in connection with Artillery Intelligence, and the German Artillery School at Wahn, was well known to us during the war, contributes an interesting article on the surveys of targets and of the guns which engage them. Unfortunately it seems to be the concluding part of a series which would repay study. He recommends that location units (flash-spotting, sound-ranging, etc.) should be kept separate, whilst the domestic survey—the survey of gun positions, the determination of " line " or bearing, and accurate " ranging "—should become one of the normal duties of the artillery. He advocates ranging on a high burst, and considers that it can be made part of a regimental routine by arranging for chains of surveyed O.P.'s after the manner of a flash-spotting section. The flash-spotting section and sound-ranging section of a division should be put in the advanced guard, and should be ready with surveyed targets for the divisional artillery on arrival—a most ambitious programme. Wireless should be used for both sections (under a common command) and, to facilitate the survey, light cars (in what proportion he does not say) should be provided for the officers of the section. He, very properly, condemns the common practice of referring to these questions as a species of " black magic " and maintains that they are exceedingly practical and usable methods which gain in importance as the supply of ammunition falls off. The deduction is that, valuable as they were in stationary warfare, they will be of increasing importance in mobile operations. Like other gunners, he condemns reliance on field survey units and would set them free for triangulation and mapping. Meteorological personnel are included in the artillery survey units. The ideal is that of a divisional artillery survey unit, directly under the orders of C.R.A., and, to gain this ideal, the observation of the individual battery must suffer. The unit should consist of aeroplane and balloon observers, survey or trig. section, location section (flash and sound) and meteorological section. The social standing of the survey unit is of importance and so it is recommended that staff employ, high command, and success generally, should be conditional on a well-reported-on year in the section.

The first number of a series of articles by Ludwig Pengoo on the operations at the Col di Lama in 1915–1916 does little more than describe the topography. A capital map is provided on which the bastion character of the Col di Lama is clearly brought out. Both Austrian and Italian communications were under close artillery fire, possible only by night. Two forts, or rather blockhouses, armed with machine-guns and old patterns of field-guns and howitzers, existed in the Col di Lama sector and were garrisoned by the Austrians in 1914. War with Italy had, of course, been thought possible, but had not been studied in connection with a simultaneous Russian and Balkan War. The disappearance of the Italians from the Tirol in August, 1914, and the warning sent to English folk in Cortina by the intermediary of an Italian courier, indicated the probable trend of affairs to the Austrian outposts and the sector was quietly but continuously strengthened. Old men and women began the construction of strong points under sapper supervision. Late in the autumn two labour companies were sent up. Guns were taken out of the forts and placed in the open. The Italians kept a close watch on all these preparations.

There is a highly technical but apparently valuable article on aerial tramways, and two others of minor interest on the Psychology of Discipline and an Anti-aircraft Defence.

H.St.J.L.W.

HEERESTECHNIK.

(July, August and September Nos.)

CAPT. JUSTROW'S articles on the theoretical conditions affecting the life of barrels are continued through these numbers. His aim is to reconcile theory and practice; to find out exactly what the wear and tear is due to; and to express the various factors in formulæ which will correspond to practical experience. In the past much more discussion has been published dealing with the trajectory than with the conditions which obtain within the gun. In the September number he begins to sum up on the "life" of the barrel. Each article is crammed with equations, however, and no summary review can deal adequately with his matter.

Continuing the account of the attack on Nowo Georgiewsk, General von Schwarte begins by stating that the infantry advance on the night 14–15th August was soon brought to a standstill by Russian artillery and machine-gun fire. On the 15th the bombardment was renewed. The heavy howitzers failed to secure the actual effect, which had been hoped for, on the forts; but the moral effect was important and the Russian artillery was silenced during the afternoon. The infantry pushed forward, and opposite Fort XVA (reckoned to be the most formidable of all) they had reached the edge of the wire entanglement before they were stopped. On the 16th, a foggy morning, the bombardment was taken up again at 9 a.m. and an hour afterwards attempts were made to storm forts XVA and XVB. The attempts were premature, but a lodgment was made in a subsidiary earthwork to the south of XVB. The bombardment had to be reopened and, though directed by artillery officers from the front line, occasioned serious casualties amongst the leading infantry. Two hours later XVB was captured, and held against counter-attacks from XVA and from the thick woods in rear. In the evening XVA fell in its turn. Meanwhile Russian troops were massing in the woods behind for counter-attack. It was reported afterwards by Russian prisoners that 11 battalions were sent forward for this attack, but the larger number never arrived, which may have been due to the fire concentrated on the woods by the German heavies. The attack on XVIA and XVIB (the extreme left on the bank of the Narew) fared worse. The artillery devoted to the purpose was too weak. On the 16th the attacking infantry were brought to a standstill some way from the wire. On the 17th renewed attempts brought them to the forts but could not affect a lodgment, in spite of reinforcements drawn from the front opposite XVA and XVB. But on the night of the 17th in pouring rain the Russians acknowledged defeat and retired, leaving XIV (on the extreme right and not, so far, attacked) empty, and clearing out from the dense woods which run parallel to, and behind, the forts. A general advance to the Wkra encountered small opposition, but a crossing was impossible until Fort III had been bombarded. Meanwhile, Russians were seen digging in on the front Fort XII–Fort II–Fort III and were immediately engaged by field-guns from the south edge of the woods. An attack south of the Narew against an outlying earthwork had, meanwhile, failed, but had had considerable influence on the defence. On the 19th all guns were concentrated on II and III and on an intermediate horn-work. In the afternoon a general advance began and by six o'clock had broken the last resistance and captured the whole northern sector. In the course of the evening an unconditional surrender was signed by the Russian Commander. No particular technical lesson is to be drawn from these operations, but they exemplify what can be done with comparatively inferior forces against a supine and demoralized antagonist.

In the *R.E. Journal*, September, we left a German field survey company just as it arrived on the Salonika front. The maps were found very bad; and the Austrian 1/200,000 (the best of a bad lot) showed errors of seven kilometres or so. A printing press was secured after long official wrangles and the new survey begun with the Zeiss photogrammetric camera and with a "Mester" panorama camera (similar, it is presumed, to that used recently in Alaska). Captured maps (presumably British or French) formed the basis for a 1/25,000 series along the front and the country was found exceptionally suitable to stereophotogrammetry.

Capt. Fries describes a commercial "large surface" lorry, or combination, which consists of a 40–45 h.p. 4-ton lorry taking a 10-metre-long trailer. The trailer fits on behind in such fashion as to put about half its weight on the rear axle of the lorry. The combination is easy to turn, and the following advantages are claimed for it:—

1. Weight carried, 8 to 10 tons.
2. The surface is so large that very bulky goods can be carried (or 80 men).
3. The heavy weight on the driving wheels (rear axle of lorry) grips a slippery road.
4. The lorry can be used separately, by detaching trailer.
5. Economy of personnel.
6. The floor of the trailer can be lowered for loading.
7. The length of a column could be lessened by 60 per cent.
8. The greater weight on the axle and slower speed spare roads.
9. Smaller carriage weight than a number of independent lorries.
10. Economy of petrol.

There is an interesting account of the map policy which follows on the change in German survey organization.

All surveys are now in civil hands and a sub-department of the Home Office ("Reichsministerium des Innern") is entrusted with the task of laying down, and presumably enforcing, common policy upon all the individual states. There is a council of 46 which reports to the Home Office and which includes representatives of Army, Navy, transportation and of the various State Surveys. The programme they have decided on will prove of considerable national value. They have decided, unanimously apparently, to introduce a general system of reference analogous to our military grid on all maps. It is a matter of wonder that other nations do not do the same. After all, the military grid was introduced in order to facilitate administration, and to make the way plain to all. It offers the same advantages in peace as it does in war. The 1/50,000 is to be pushed on with when funds permit, a 1/5,000 cadastral is to be made universal, and, for the benefit of topographical and cadastral mapping. Gauss conformal co-ordinates are to be based on a new, 3 degree, meridional strip, an arrangement which will prove a wonderful simplification. These changes are all in the direction of facilitating home defence and it is strange to see them assented to by a body of men which includes a service representation of about 4 per cent.

The ninth volume of Schwarte's history of the 1914–18 war deals with the organization of the "Versorgung" of the German Army. Here we have an expression rather hard to translate, and I am afraid we should generally use that abominable term "ancillary services." Medical and Veterinary matters, clothing, equipment, auxiliary water transport, postal and telegraphic services, and supply generally are included. A short notice of its appearance is given in the July number.

A continuation of the article on railways during the French offensive on the Aisne (1917) deals with the metre-gauge Montcornet–Rethel line. Its importance during the battle is illustrated by the fact that as many as 47 supply trains (28 of them with ammunition) ran in a day and the average was not far below this figure. Diagrams of the stations at which the meter-gauge trains were loaded up are given. Much of the line was under long-range fire and on one occasion the Laon station was out of action for 12 hours. The author concludes with the statement that a well-organized railway system is indispensable to a successful defence.

Anti-Aircraft Defence.—This article deals with the defence of national centres and not with that of an army in the field.

It is divided into :—

(*a*) Measures which are purely military—such as the organization of scout and fighting squadrons, anti-aircraft guns and machine-guns, searchlights, balloon and "sausage" screens, etc.

(*b*) Measures of co-operation between civil and military authorities such as the organization of a good system of warning, the camouflage of important centres, of the approaches to them, instructions for the behaviour of civilians during an attack, etc.

As regards military measures, the strength and organization of air-defence units is discussed generally in the spirit of placing them so as to cover as many points as possible, whilst anti-aircraft guns must be more or less stationary. Scouts must go for bombing planes and on no account for their escort. Anti-aircraft guns have to think of three classes of target—bombing planes, fighting escort and those whose job it is to go for anti-aircraft batteries with machine-gun and small bomb. Anti-aircraft batteries are therefore of four varieties :—

(*a*) Heavy and high velocity—height of trajectory at least 7,500 m.
(*b*) Medium calibre—height of trajectory 5,500 m., 20 rounds a minute.
(*c*) Small calibre automatic 3 to 3·7 c.m.—height of trajectory 2,200 m., 150 rounds a minute.
(*d*) Machine-gun—heavy and light.

The anti-gun aeroplanes may succeed in coming down low enough to knock out heavy and medium anti-aircraft batteries unless the latter are protected by machine-guns. The day bomber will be smaller than the night bomber and will be at a height of some 6,000 m., flying at 200 km. an hour, but will hardly carry bombs heavier than 200 kg. Night bombers are bigger, slower and carry much heavier bombs. But it is probable that day bombing will be thought more paying than night bombing—at any rate, at the start of a war. There will be two or three medium-calibre guns for each heavy. Both heavy and medium will be stationary, but the small-calibre will be mounted on lorries. Six *Tables*, which follow, give the radius of full and of medium effects at various heights for heavy, medium, and small-calibre guns, for heavy and light machine-guns, and for searchlights.

Major Klingbeil, in the September number, starts an article on rivers in battle. The increase both in the weight and size of military vehicles (tanks, etc.) and in the range and precision of heavy artillery have added much difficulty to the question. In fact, the crossing of a river under effective heavy artillery fire can hardly succeed by day, or at any rate a complete bridge can hardly be constructed, by day. Probably the first troops must be rafted over. In the first place all preparations must be camouflaged to escape air observation. Rafts will be prepared away from (probably up-stream from) the scene of action, and more men and stores, and better river-reconnaissance than in former times, will be necessary. Weight to be carried will reach at least 12 tons. German pontoons are of war period pattern and the "Ganz" pontoon will take 8 tons. Baulks and road-bearers must be strengthened and experiments in coupling must be tried. The manual which deals with the subject says much about the collection of intelligence under the headings of reports from air-observers, air-photographs, river or canal plans, charts or sections to be found in water transport offices, etc. Emphasis is laid on the breadth of front—one bridge is but a hostage to fortune—and particularly so with the advanced guard.

An interesting and very technical summary of the influence of wind and temperature on the movement of sound waves in the atmosphere began in July and is still unfinished. It is a valuable, if not an original, contribution to the subject and will be reviewed as a whole.

An article on Geology in the world war, which appears in the August number, is a translation of one published in Spanish on the centenary of the university of Buenos Aires. It was, however, prepared by the German scientific society of that town. The first official German geological staff was employed in Flanders in 1915. The work lay mostly in planning and supervising the construction of dug-outs and in advising mining engineers. Gradually they were found a place in every theatre of war, mostly either to find, or to get rid of, water, but also to assist in securing road metal and, indeed, in many ways to be the handmaid of engineering. The total staff to be employed was 250 and a headquarters of 40 in Berlin, under the direction of the survey, provided maps and stores and formed a staff of lecturers. Reference is made to a "Geological Atlas of Flanders" of which over 5,000 copies are said to have been in stock at the end of the war. Wytschaete and

Professor David are quoted as having given the Germans a costly object lesson. The German engineer seems to have been more dependent on professional advice on this matter than we were. Perhaps because he was a pioneer.

H.St.J.L.W.

VOINA I MIR.

The fourth number of this Magazine was reviewed in the March number of the *R.E. Journal*; the sixth number maintains the same high standard as its predecessors. It is interesting to note that the old Russian orthography has been preserved.

"The Problem of the Mechanical Conduct of War" by Captain Ritter of the German General Staff is a transcript of Colonel Fuller's article on the subject in the second number of the third volume of the *Army Quarterly* and ends up with a criticism of Colonel Fuller's remarks so far as the use of tanks in a big war is concerned. Whilst acknowledging the general interest and value of Colonel Fuller's article, he disagrees profoundly with many of his assumptions and deductions. For instance, Col. Fuller assumes that an army, otherwise of the modern pattern, would take the field along with mechanical weapons of a new and advanced type, which would, in the author's opinion, be as illogical as if in the late war men armed with pikes had been accompanied by automatic guns, fire-sprinklers and mine throwers.

Colonel Fuller assumes that the war of the future will begin with the collision of squadrons of tanks acting in the same way that cavalry used to. He does not admit the possibility of other branches of the service taking part in these preliminary encounters, infantry and artillery merely acting as interested spectators. He considers that all advance in the construction of armaments will be confined to tanks, and that no improvement will be made in other weapons. The author holds that the experience of the last war is all against this; though on the first appearance of tanks the Germans were helpless, in 1918 they possessed a very formidable anti-tank gun which would doubtless have been perfected if the war had lasted longer. Why should not an anti-tank gun be invented capable of being carried by a single infantry man? Colonel Fuller supposes that the qualities conferred by strong armour and great swiftness can be combined in a tank, though it is well known from the analogy of destroyers that they are incompatible. He discusses the decisive battle between two armies and apparently assumes that tanks will be distributed along the whole front, like skirmishers in a firing line. At Cambrai on November 20th, 1917, the English had 36 tanks distributed over a front of 1,200 metres; on the system enunciated by Colonel Fuller no less than 100 tanks would be required for a frontage of one kilometre; hence, for a battle on the scale of the Marne, about 25,000 tanks would be employed, an obviously impossible number. Colonel Fuller appears to underrate the difficulties to the progress of tanks caused by rivers and forests. He does not do justice to the power of infantry and artillery in dealing with tanks, forgetting that in the fighting in Flanders between October 14th and 19th, 1918, they accounted for nearly 50 per cent. of the tanks in action.

Infantry will always be the "Queen of the Battlefield" and though its action will, in future wars, be supplemented by some form of light armoured machine-gun, a miniature tank, the successful issue of all fighting at close quarters will ever rest with the infantry and not with a machine.

As regards cavalry, the author agrees with Colonel Fuller that, generally speaking, cavalry attacks are now a thing of the past, with the exception of minor actions between cavalry patrols. Assuming the possibility of constructing the tank scouts envisaged by Colonel Fuller, as a substitute for cavalry, possessing high speed and consequently weak armouring, they would be extremely vulnerable to infantry armed with an anti-tank weapon and would therefore be unsuitable for action in the neighbourhood of large hostile columns. In future wars there will be separate regions of reconnaissance. The areas in which columns are marching will be dealt with by aircraft; cavalry will reconnoitre the no-man's land between the two armies, where detailed examination of the ground is required and where opposition would usually be met with from the enemy cavalry or from hostile inhabitants; but in the case of serious opposition, such as that afforded by an advance guard of a column or cavalry supported by guns, there would be a distinct opening for the use of swift lightly-armoured machines, taking the place of the "striking battalions" of a cavalry division or of a single reconnoitring squadron, but not of a single cavalry patrol as Colonel Fuller suggests.

An article entitled "The Control of Masses in War" by S. Dobrodsky discusses the difficulties met with by commanders who had, of necessity, no experience of the control of the vast multitudes employed on the various fronts in the Great War. In 1914, 2,000,000 Germans deployed against 2,000,000 French and English, and 3,000,000 Russians against 1,800,000 Austrians and Germans, whereas in 1812 Napoleon led 462,000 men across the Niemen; at Leipzig in 1813 the allies numbered 772,000 men and in 1870 the Germans at the end of the first month of war numbered 484,000.

As an example of difficulty of control the author cites the failure of General von Kluck to carry out the orders issued by G.H.Q. at 21 hours on September 4th, and received by him on the morning of September 5th, he being ignorant of the general situation on the whole front and thinking that G.H.Q. was alike ignorant of the frontage of his army which had already crossed the Marne. The author discusses at length the results of this want of mutual understanding. The German leadership in 1914 was based on the same principles as in 1870. A plan had been worked out and elaborated in peace time and had to be carried to a successful issue. When once the working of the plan had been started its fulfilment was supposed to follow automatically. Hence, when the German High Command found that the execution of their plan was being frustrated by an enterprising and well-found enemy, it preferred to withdraw its troops behind trenches to risking the improvisation of a new one.

In the second part of the article the author describes how, at the beginning of the war, the French were similarly handicapped by a lack of experience, but by degrees method in the control of masses was forged out. He traces at length the steps by which success was eventually obtained in 1918.

In the third part the author discusses the questions of reserves, of adapting plans to meet unexpected situations, of manœuvring troops rapidly by means of trains, lorries, taxicabs, etc., and of the necessity of close contact between a C.-in-C. and his troops. The article ends with a eulogy of Marshal Foch.

An article by Colonel Kolossovsky, of the General Staff, on coast defence, includes a transcript of an article by Lieut.-Colonel de Watteville in the *R.A. Journal*, and a description with illustrations of the guns used by the United States for coast defence; also a short account of the organization of coast defence in France for which the Navy has been responsible since December, 1917.

"Ideas of Officers of the American Army on Infantry Tactics," is a discussion of two articles on infantry tactics recently published in American journals and is preceded by a lucid dissertation on the subject by the editor of *Voina i Mir*, General Professor A. Kelchevsky. He considers that the French have been unduly influenced by four years of position warfare in arriving at certain conclusions regarding infantry formations and armament. He sums up the question of attack *versus* defence. Since the appearance of fire-arms the defender has always had an inherent advantage over the attacker, owing to the greater facilities he enjoyed for the efficient use of his weapon. The problem of the attack has always been to combine forward movement with efficient fire effect. The first method adopted in solving the problem was the use by the attack of masses of artillery, as practised by the Germans with success in 1870–71. The efficacy of this method was neutralized twenty years later by the introduction of the magazine rifle and quick-firing artillery, leading, in turn, to the use of concentrated artillery fire by the attack. The Russo-Japanese war confirmed previous experience whilst it showed that the employment of machine-guns, though of great advantage to the attack, was even more advantageous to the defence. The "radical question" of the attack—forward movement without the slackening of fire—was still unsolved. The Germans, ever trying for a solution, had recourse to the heavy artillery for field warfare, and their successes at the beginning of the Great War must be largely attributed to the splendid work of their heavy guns. Position warfare with its labyrinths of trenches, led to the vast increase in numbers and range, of heavy ordnance used by the attack for protracted preparation at long range, a method which, to a great extent, defeated its own end by abolishing the element of surprise. Hence the adoption of another method, in which a larger number of guns was employed for a short period to crush the defender on the portions of the front destined for attack. The reply of the defence was the position in depth, which tended to deceive the attack as regards the main position of resistance, facilitated counter-attack on his flank and drew him beyond the supporting range of his artillery. The problem of the attack still remained unsolved, but human ingenuity rose to the occasion. In 1916 tanks made their appearance; the problem was nearly solved, but not quite, for the artillery of the defence, profiting by its range and comparative invulnerability, continued to inflict losses both on infantry and tanks. Tanks could not work alone, but had to be accompanied by infantry to occupy and make good the ground passed over. The dispersal of the defending infantry in depth in small centres of resistance necessitated the dispersal of the attacking infantry in groups. Arguing from this special form of warfare, a peculiar outcome of the war of position, the French have adopted formations and armaments suitable for it, but ill adapted to open warfare. The true solution of the problem lies in the use of tanks and caterpillar artillery. The whole of the divisional light artillery, which should be self-propelling and provided with armour for the engine as well as a shield, having co-operated with the other forms of artillery in the preparation for the attack, must advance with the infantry on a level with the battalion reserves and take part not only in the initial barrage but continue its fire in the form of a moving barrage. The artillery must keep close visual connection with the infantry and help it to thrust its way in, overcoming by its fire everything which the tanks have failed to deal with. By such methods, after a century of efforts will the problem of the attack, advance without slackening of fire, be solved.

An article on the effect of heavy artillery by Colonel Bauer, of the German General Staff, has some good photographs showing the result of heavy shell-fire in armoured turrets and brickwork at Liége, but does not appear to contain any very striking conclusions.

A.H.B.

THE MILITARY ENGINEER.

September–October.

The Military Map of the Future.—The author describes the production of the "pictorial relief map" which is obtained by super-imposing on a topographical contour map a high-light photograph of an equally accurate relief model of the same area. Being produced by mechanical means from an accurate model, the map presents a truer interpretation of the hill features than has hitherto been possible with shaded and tinted maps dependent on the skill of the artist. The value of the relief model map is unquestioned; production in sufficient quantities has always been the difficulty. The pictorial relief map appears to provide an efficient substitute.

The Coast Artillery and the Engineers.—Soon after America's entry into the war, the Coast Artillery Corps sent heavy artillery personnel to France. The material was furnished by the Allies, and simultaneously the United States undertook the manufacture of its own heavy guns. The Armistice, however, intervened before quantity production was attained, but America now possesses a good supply of railway and tractor-drawn artillery.

The war demonstrated the value of mobility, dispersion, and concealment, and mobile artillery will play an important part in future coast-defence policy. It is considered that only the heaviest guns should be provided with permanent emplacements. The co-operation of Engineers will be required in a still wider field for the design, construction, repair and modification of emplacements and fire control stations, etc., for roads and bridges for heavy tractor material, for the collection of railway data, and the construction of additional sidings.

An interesting system of fire control, based on subaqueous sound-ranging is being developed. This serves two purposes—to locate a hostile ship by its under-water noises and to record the pitch of a projectile by its impact on the water. Work is still in the experimental stage, but is sufficiently advanced to be used in emergency.

R.I.M.

SAPER I INZYNIER WOJSKOWY.

2nd Year No. 2.

On the occasion of the opening of the new Engineer Officers' School in Warsaw, the Polish *Sapper and Military Engineer* devotes most of its space in this number to the education of Engineer Officers, articles appearing on the methods observed in France, Austria and Petrograd past and present. An introductory paper, by Engineer Colonel Ozynski, describes the organization which is being adopted for the new School, mainly based upon that of their victorious Allies, the French. The intention is to give the students the fullest possible technical education both in engineering and military science, while sports and physical training are not neglected. The course will last three full years and in each summer the students will pass 10 weeks in training camps, and be given 5 weeks' leave at their homes. Education, clothing and food will be free of cost. The annual batches will each consist of 100 students, the whole being organized into a Battalion of three Companies. After the completion of the second year's course and passing the necessary examinations, the students for their third year will be commissioned as 2nd Lieutenants. The first Commandant of the School is Engineer Colonel Haller, who obtained his education in the Mikolevski Engineer Academy at Petrograd, and he will be assisted by a Director of Studies, a Commander of the School Battalion and a School Quartermaster. There is also a School Council, with the Director of Studies as its Chairman, which advises the Commandant on all questions concerning the appointment of the Professors and instructional staff, and the Commandant in his turn makes his recommendations to the Staff Department V (Engineers and Sappers), which, in consultation with Staff Department VI (Military Education) makes the appointments. The School is accommodated in Warsaw, in the buildings of the former Chief Artillery and Engineer School, which have been remodelled and considerably added to for this purpose, from the designs of the well-known architect Cz. Domanievski, Professor of the Warsaw Polytechnic.

F.E.G.S.

CORRESPONDENCE.

THE 21ST COMPANY, R.E., AT THE BATTLE OF BETWA.

To the Secretary, Institution of R.E.

DEAR SECRETARY,

I have read with great interest your excellent Memoir of Sir Bevan Edwards in the *R.E. Journal*.

At page 136 you quote Sir Hugh Rose's dispatch. This dispatch was communicated to Chatham by Sir John Burgoyne. I was at Chatham at the time and heard it read out on parade.

My recollection is that Sir John Burgoyne's instruction was that the dispatch should be *read out on parade at all stations where the R.E. were quartered*. Probably you would verify this from the Chatham records.

My object in writing is that I think you might find it suitable to quote in the next issue the instruction I have underlined. The instruction clearly added to the honour which Sir John Burgoyne desired to confer on Edwards.

We all felt very proud indeed of Edwards' feat, and in conversation I have often and often referred to it with pride.

Observe that the enemy were in overpowering numbers, and that the 21st Company absolutely put them to flight.

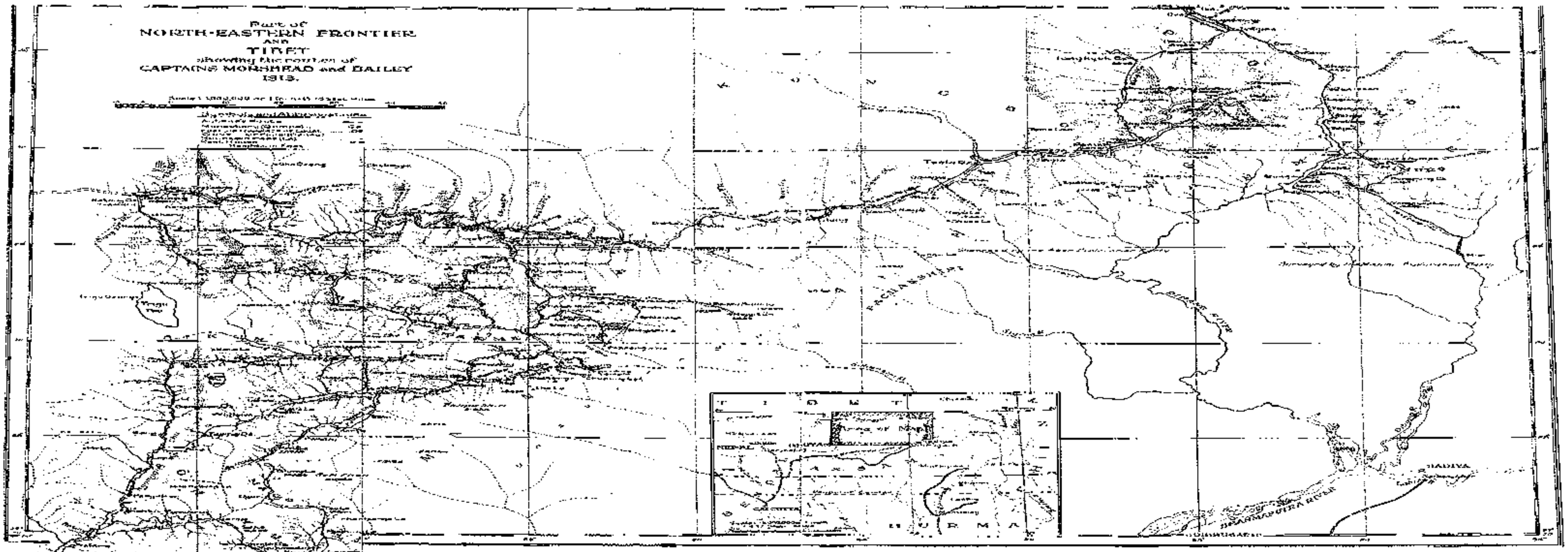
Yours sincerely,

W. SALMOND.

The Secretary regrets that he has been unable to obtain any confirmation of Sir William Salmond's interesting reminiscence, as the Records of the S.M.E. do not go back to 1858. *Possibly some one of our readers may remember the incident?*

ERRATUM.

In September *R.E. Journal*, page 501, the Christian names of Lieut. Dickson should read James Whyte Melville.



NORTH EASTERN FRONTIER AND TIBET