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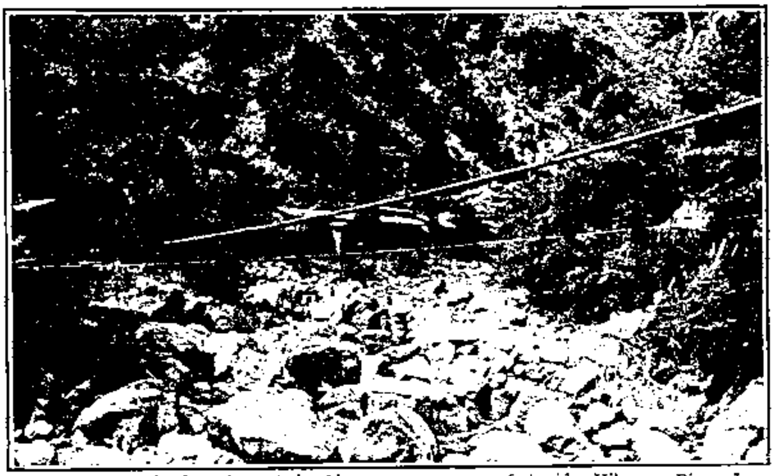

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A Lecture delivered at the S.M.E., Chatham, on March 6th, 1930, by LIEUT.-COLONEL H. E. MEDLICOTT, D.S.O.

I MUST preface my remarks by asking you to remember that I am not a technician. I propose to deal with the general history of the Anglo-Persian Oil Company from its infancy to the present time, when it has taken its place among the most important commercial undertakings of the world. It is beyond my powers in describing the progress of the Company's activities to enter into a detailed discussion of the minutiæ of refining processes, or to venture into the turbulent and controversial arena of geology and geophysics—these are for the experts and specialists—and so, having made my apology in the first place, I hope that those of you who expected a scientific discussion will still find interest in what I have to say.

The Anglo-Persian Oil Company's concession in Persia was obtained in 1901, by William Knox D'Arcy, and is commonly referred to as the D'Arcy Concession. It gives the Company an exclusive right to search for and exploit petroleum throughout the whole of Persia with the exception of the five northern, or so-called Caspian provinces, Azerbaijan, Mazanderan, Gilan, Astrabad and Khorassan, which were regarded as being in the Russian sphere of influence.

From the earliest days, use has been made of the oil seepages in Persia and Mesopotamia; we know that bitumen was used in cementing the bricks of Ur and in mummifying the royal dead in Egypt, where, on account of the distance it had to be transported, it was a luxury only available to the richest in the land.

There is reason to suppose that the Zoroastrians, those early Persians for whom fire was the symbol of the purity of the all-powerful spirit whom they worshipped, have built their temples round a spot where the inflammable gases from the oil beneath the ground have been ignited by lightning or other natural source.

There are various stories regarding the manner in which D'Arcy's attention was first directed to Persia as a possible field of riches, but there is no doubt that anyone who had travelled at all extensively either in Khuzistan or in the region of Naft Khaneh field could have told him of the numerous seepages.

It does not necessarily stand to reason that the place where the oil comes out of the ground is anywhere near the source of supply; dependent upon the geological formation, the oil might travel almost any distance before finding an outlet, and in these days when we know so much more, though by no means all there is to be known, about the structure of that portion of the earth's crust, the presence of a seepage is not necessarily regarded as evidence that there is any prospect of finding oil in commercial quantities in the vicinity.

D'Arcy started drilling in 1903 at Kasri-Shirin, reasonably near the present rich field of Naft Khaneh, where seepages were reported; he had made a considerable fortune in the Broken Hill Mine in Australia and he proceeded to devote most of his capital to the furtherance of his new oil schemes. Drilling is an expensive business at the best of times and, as can be easily understood, the cost per foot drilled varies enormously according to the hardness of the strata to be drilled and the distances over which the machinery has to be transported. No doubt, having regard to the fact that surface indications of oil were plentiful, it was hoped that the reservoir was not at any great depth. The first well drilled at Chia Sourkh, however, reached a depth of over 2,300 feet before oil was struck in anything like useful quantity, and altogether two producing wells were brought in, in January and May, 1904, one of which flowed at the rate of 30 tons a day. The remoteness of the field, some 600 miles from the Persian Gulf, made its proper development both difficult and expensive. Some more accessible and more productive district would have to be found if the venture was to be a success.

In the meantime, the expenses of operation in so remote and undeveloped a country as this part of Persia were becoming appalling to contemplate. When I tell you that the cost of drilling a well in such an isolated position may easily rise to £30, £40 or even £50 per foot, it is not difficult to understand how quickly even the large amount of capital at D'Arcy's disposal was swallowed up in the first few years; £300,000 of his own money was expended and it says a great deal for his pluck that he had not given up altogether when, at the end of 1904, he had nothing to show except two small wells in a remote and inaccessible part of the world.

In the course of this talk, I shall have occasion to mention one or two men to whom Britain should certainly be grateful for the services which they have wrought for her in securing an independent and safe supply of that now so vital commodity, oil. First and foremost in this list must stand William Knox D'Arcy.

When, at the stage I speak of, he was hard pressed for money, he was approached by a German group with a proposal to relieve him of the concession; in the light of subsequent events it was not difficult to appreciate the significance of this move on the part of the nation whose attention was even then concentrated on the project of a Berlin–Baghdad Railway, which would have wrested the trade of a hemisphere from Great Britain. D'Arcy refused the offer of the Germans, forgoing the opportunity of turning his losses into profits, although he had naturally gone into the business principally for commercial reasons. It was, indeed, a fortunate decision for Britain.

Even so early in 1904, the problem of converting the Royal Navy to oil fuel had been exercising the minds of those at the Admiralty. The advantages, as regards design and economy and welfare of personnel, were manifold, higher speeds and greater radius of action could be attained, fewer men employed and the fuel could be fed from places remote from the boilers, making it possible for naval architects to effect great improvement in the fighting value of the ships.

Further, an oil-burning fleet could refuel at sea from tanker vessels with far greater facility than could ever be done with coal. Against these advantages was one terrible disadvantage, viz., source of supply. All the coal we needed was at our hand in British mines, secure from any blockade from an enemy. Not so the oil. The world, at that time, depended almost entirely upon the American Continent for its supplies, and requirements on the scale of those of the British Fleet would probably have been unprocurable from any other source, and the width of the Atlantic made it impossible to consider this source as a secure one in every eventuality.

A Committee was appointed, with the Right Hon. E. G. Pretyman as Chairman, to discuss the matter of supplies; on this committee was Sir Boverton Redwood, who knew D'Arcy well and had a high opinion of the importance of the Persian field. Partly as a result of the intervention of this committee, the Burmah Oil Company and Lord Strathcona were induced to come to D'Arcy's assistance, and in 1905 the Concession Syndicate, financed principally by the Burmah Oil Company, was formed at Glasgow to take over the further exploitation of the Persian concession.

This was the first occasion upon which the British Government extended a helping hand to the A.P.O.C. There was to be another more important one, of which I shall have more to say later.

The first step taken towards the search for a new and more prolific area was the removal of the scene of operations from Chiah Sourkh to Marmatain, not far from Ahwaz on the Karun River. Here drilling was recommenced and hopes ran high, since the locality was easily accessible from the Gulf and presented no difficulties. The results, however, were unsatisfactory and a further search became necessary. It is realized now that drilling was not carried deep enough to provide a real test, but at all events the attention of the Syndicate was next directed to a new area in the Bakhtiari Hills, about 145 miles from the head of the Persian Gulf. The story goes that D'Arcy's attention was first drawn to this locality by Monsieur De Morgan, a French archæologist, who had been engaged for many years on excavations in the neighbourhood of Shushtar. He is supposed to have remarked on some occasion to D'Arcy that if surface indications of oil were any guarantee of the presence of petroleum in large quantities in the neighbourhood, then there was a spot on the caravan road between Shushtar and Malamir which might be worth looking at.

The spot referred to was a desolate valley called Maidan-i-Naftun, which means the Plain of Oil. This name now applies only to the original small plain where the earliest wells were drilled. As the limits of the field were extended and other localities were included, the name of Masjid-i-Sulaiman was taken to cover the whole area. The name means "Temple of Solomon," and refers to the ancient Zoroastrian ruin, which is a central feature of the district. It had, of course, nothing whatever to do with Solomon, but in common with many other places in Persia has been attributed to him by the local population. I do not know whether any of you have ever seen the country of which I am speaking. You will have an opportunity to judge of its appearance from the film which will be shown after I have finished talking. The strata in these hills have been so twisted and pressed together that the whole landscape presents a most fantastic appearance, with the strata for the most part standing on edge instead of lying flat. Indeed the whole appearance of the country round the oilfields beggars description, and I am reminded of an extract from the diary of a young officer in the Indian Army, who had made the journey to Maidan-i-Naftun. His descriptive powers were perhaps not his strongest point, but having kept an excellent account of his journey until he arrived in the neighbourhood of the oilfields, he evidently felt compelled to continue his notes, and accordingly made the entry "quaint hillocks," a description which by its very inadequacy is almost impressive.

The indication of which De Morgan spoke was a small oil spring which bubbles up in the bed of a salt stream running through the valley. Long before the Anglo-Persian Oil Company came on the scene, the Persian tribesmen had collected the oil by skimming it from the surface by roughly damming the stream. The oil so collected was used for burning purposes or for application to wounds both in man and beast.

I might mention that these oil springs are common enough throughout all the mountain ranges extending from the Caucasus, on the north-west of Persia, to the Indian Frontier on the south-east.

As you may imagine, the task of moving the heavy drilling equipment to the new site of operations was an arduous and expensive one. It would be difficult for anyone visiting the oilfields to-day to realize that the area occupied by that highly modernized community, with its railways, roads, motor-cars and residential and industrial buildings, was less than 25 years ago a howling wilderness, and it would be difficult also to realize what hardships the pioneers were called upon to endure. As everybody knows, the climate of the Persian Gulf region is not a pleasant one, and in the summer, shade-temperatures of 128° are not unusual. Although the oilfields are situated some 500 feet or so above sea-level, the gypsum hills which surround them hold the heat to a very marked degree, so that the welcome drop in temperature at sunset, which is a feature of the alluvial plain below, is absent in the case of the oilfields, and in spite of their greater altitude, the summer nights are often more trying than in Abadan, which is practically at sea-level.

The inhabitants at that time were wild nomads, few of whom had ever seen a European before. Organized labour conditions were quite unknown, and although the Persian Government were, according to the terms of the concession, under obligation to give the Company any necessary protection, the isolated position and primitive conditions of the country made the efficacy of any available protective measures very problematical, nor was the authority of local tribal chiefs of the most certain kind.

Drilling proceeded slowly, money vanished rapidly and in May, 1908, the fresh capital provided by the Concession Syndicate was nearly exhausted. At the headquarters of the Syndicate in Glasgow, depression and anxiety reigned, even D'Arcy, whose optimism had carried him through so much to victory, was beginning to flag. Then on May 26th, 1908, oil was struck, and D'Arcy's hopes were realized and vindicated, since the strength of the gusher which wrecked the derrick and nearly killed the drillers when it came in, left little doubt as to the richness of the store that had been tapped.

A year later, in 1909, the Anglo-Persian Oil Company was formed, with a capital of £2,000,000 sterling, which was increased by further issues of debentures and preference shares in 1910 and 1912 to £2,900,000. Lord Strathcona was the first chairman.

It was in 1912 that the liquid fuel problem became even more pressing at the Admiralty. Mr. Winston Churchill was then First Lord and he set up a Royal Commission on Oil Supply, over which Admiral Lord Fisher was asked to preside. I do not propose to trace the steps by which this Committee reached its decision, as Mr. Churchill himself has told the story in his own vigorous and inimitable fashion in the first volume of the *World Crisis*. Suffice it to say that the famous and much discussed Anglo-Persian Oil Agreement was the outcome of Mr. Churchill's action, and now the Government are the owners of the controlling share in oil properties and interests which are at present valued, I am quoting Mr. Churchill, at "scores of millions sterling." Thus was secured for the Navy a sure source of supply completely independent of America, and capable of enormous expansion to meet any demands likely to be made upon it.

This was in 1913. In the interval, the productivity of the oilfield had been amply proved by the striking of a particularly prolific well in 1908. Developments were extended and in the nearby field of Maidan-i-Naftak, a further abundant yield was obtained at a depth of 1,875 feet. Once assured of the supply, the immediate problem was the work of its transport and treatment. A site for a large refinery was selected on the Island of Abadan ; launches, barges and stern-wheeler shallow draught vessels were placed on the lower and upper reaches of the Karun River. A short railway was laid to overcome the obstacle of the rapids at Ahwaz, and an up-river terminus was constructed at Dar-i-Khazineh, which means the "Door of the Treasure House." A motor road was constructed from there over the remaining 30 miles to the oilfields, running up through the foothills where previously only a mule track had existed.

To lay a pipe line across the alluvial plain, which runs back for about 150 miles to the foothills, was simple enough, except when the winter rains reduced it to an impassable waste of mud, but from the edge of this plain the hills rise abruptly in superimposed ranges until the high plateau of Persia is reached. To reach the fields two ranges have to be crossed, and at one point the pipe line attains an elevation of 1,300 feet. A mule track wide enough for two mules to walk abreast had to be blasted through the mountains, and each section of pipe, weighing 820 lb., was carried up by four mules, and laid into position. The sections were then screwed together, until some 1,500 tons of pipe had been laid in this manner. This weight, of course, only represents a small fraction of the total amount laid and refers only to the section which traverses the mountain range, a distance of only about 30 miles out of a total of 150 miles. The total length of the present main pipe line which is duplicated and composite represents altogether a length of over 500 miles.

Although the gas pressure in the fields was amply sufficient to force the oil out of the well mouth and into the flow tanks, the oil could not, of course, flow under its own pressure over such altitudes and for such a distance as to take it to the coast. A huge pumping station was constructed at Tembi, at the head of the pipe line ; and other pump houses or "boosting stations" at intervals along the line, while at the other end of the pipe line, the preparations for building Abadan Refinery were in full swing. On October 1st, 1912, the first delivery of refined products was made to local markets, and the capacity of the refinery reached 6,000,000 gallons a month. It was at this stage that the need for further capital became apparent. Though much construction work had been done there remained a great deal to do, and it so happened that the oil industry was passing through one of its bad periods of poor returns. This, coupled with the fact that the Company had only just reached the stage of development necessary for the earning of dividends, would have made it impossible to raise further capital in the open market on favourable terms, and it was therefore decided to seek the necessary financial assistance of the Government, who were at that moment engaged upon the solution of the problem of oil supplies for the Navy, of which I have previously spoken. At this period, the Chairman—Lord Strathcona—was succeeded by Mr., afterwards Sir Charles and now Lord, Greenway, who during the next seven years combined the duties of Chairman and sole Managing Director, and in 1917 William Knox D'Arcy, the real founder of the Company, died too soon to see the full flowering of his enterprise.

With the War, the pressure of the work of development in Persia was increased to the greatest possible extent, the capacity of the Refinery at Abadan was doubled, further pipe line was laid down to meet the increased requirements of crude oil, and arrangements were made for the construction of a number of tankers.

Naturally, the importance of these operations was not lost on the enemy powers. One of the first acts of the Turks on the declaration of war was to endeavour to lay mines at the mouth of the Shatt-el-Arab, so as to make access to Abadan impossible by sea. The fortunate and unexpected arrival of the Indian Expeditionary Force, which fought its first action at Sahil, almost opposite Abadan, prevented the carrying out of this design and also a projected shelling of the Refinery. It is significant that the mines were sent across by land from Constantinople some months before the outbreak of war.

The next step was the invasion of Persia from Amara by way of Hawaizah, with the object of cutting the pipe line. The enemy approached within striking distance of Ahwaz, but were unable to dislodge the small British Force holding the right bank of the Karun River. Their emissaries, however, were successful in persuading some of the tribesmen to co-operate by cutting the pipe line above Ahwaz. After the battle of Shaiba, however, the Turks withdrew, closely pursued by the 12th Division under General Gorringe. Order was quickly restored in Southern Persia and the Company was free to carry on its operations, which had now become of vital national importance. All the Turks had succeeded in doing was to hold up work for about four months and cause the loss of 144,000 tons of oil, representing over £400,000. No further trouble was experienced.

Since that time, the record of the Company's operations has been one of continuous and rapid expansion. All through the War years, every nerve was strained to meet the enormous needs of the Mesopotamian Expeditionary Forces for petrol, kerosene and fuel oil, and the ever-increasing demands of the Admiralty. This necessitated constant additions to the Company's plant—additions made exceedingly arduous by the inevitable restrictions and difficulties of the period. Vast quantities of material were required. English foundries and factories were already overwhelmed with war orders, and it was almost impossible to obtain freights for the long voyage to Persia. There was the further difficulty of recruiting the extra European staff made necessary by these developments.

The face of the world has changed much since the date when the first gusher was struck at Maidan-i-Naftun. Everywhere the old order has given place to the new and unfamiliar, and nowhere is the change more apparent than in Persia itself. With the disappearance of the Qajar Dynasty from the throne of Persia, a new movement swept across that country. I have said earlier that law and order held but insecure tenure in the south, but that is no longer true. The present Shah, a man of great character and individuality, has succeeded in consolidating the power of his Central Government, so that instead of being a place of lawless tribes and feudal states, Persia is rapidly becoming a modern democracy.

Although the growth of nationalism in any country is bound to be accompanied by a certain amount of feeling against foreigners and foreign undertakings, there is little doubt that the security and prosperity resulting from the development and reorganization of the country's administration outweigh in advantage any inconvenience that may be caused by nationalist feelings. The Persian Government and public realize the great financial and other advantages they derive from the presence of the great oil industry in their country, and though agitators cry out against what they call the stream of liquid gold which is flowing from their country into the pockets of the foreigners, responsible people do not pay much attention to this type of propaganda, and moreover know that they would be quite incapable of carrying on the work themselves. Incidentally, the royalties which the Persian Government obtains from the Oil Company represent the greatest and most secure economic asset the country possesses.

The importance of the oilfields to the British Navy has already been stressed. Their importance to the British Empire is no less vital. Petrol, which has become a human necessity, is used in such vastly growing quantities that all the ingenuity of our chemists has been turned to the problem of increasing the percentage of petrol obtainable from any given quantity of crude oil, with the result that, in the last few years, the proportion of petrol ultimately recoverable per barrel of crude oil has risen from about 11 per cent. in 1909 to about 36·7 per cent. in 1929. I need not stress the point which must leap to the minds of all of you: "How shall this vital supply be kept secure for Britain?" This question not only applies to the Persian oilfields in the south, but equally to the comparatively undeveloped but exceedingly rich fields of the Khanaqin Oil Company, which lie on the borders of Iraq and Persia, part being in either country, some 150 miles north-east of Baghdad, and also to the vast oil resources of the Mosul area and the rest of Iraq which are exploited by the Iraq Petroleum Company, in which Great Britain has a quarter share. The outlet for the Iraq and Khanaqin fields will, of course, be to the Mediterranean, and no doubt you have seen many references in the papers to the vexed question of the point where the pipe line is to debouch.

In South Persia the Company has three main centres, *i.e.*, the Refinery at Abadan, the pipe line headquarters at Ahwaz and the fields themselves. The Refinery at Abadan is on the Shatt-el-Arab, a confluent of the Tigris and Euphrates, some 50 miles above the point where it debouches into the Gulf. This Refinery represents the latest developments in all the processes of refining, with a capacity of about 4,500,000 tons p.a., and is still increasing. To the jetties of this oil port come a continuous stream of tankers to load and carry their cargo to India, Australia and Great Britain. The fleet of the Anglo-Persian Oil Company now numbers 86 vessels of an average tonnage of 9,000 tons, including 6 being built.

Europeans, many of whom have their wives and families with them, are housed in the residential quarter of Abadan, in excellent bungalows built by the Company and standing in gardens which the persistent desire of the Briton for flowers has caused to blossom in what is, I suppose, the most unfavourable soil in the world. The Island of Abadan, some 60 miles in length, is formed by the Shatt-el-Arab on the west side and the Bahmashir on the east, joined at the top by a short channel on which Mohammerah, some 8 miles north of Abadan, is situated. The island itself is completely flat and at its highest point perhaps 10 feet above sea-level. It is practically devoid of vegetation except for a fringe of date palms, and at its southern extreme it degenerates into mud flats which for many miles are covered at high tide or when there is a southerly wind. On this inclement spot, a quagmire in the rains and a burning desert in the summer, this flourishing town has sprung up round the industry which employs some ten thousand Persians, who live on the south side of the Refinery, while the European quarter is to the north. In spite of the natural disadvantages of the place, the Company has succeeded by the introduction of any amount of amenities, such as clubs, swimming pools, squash courts, tennis courts, cinema theatres, football grounds, and even an 18-hole golf course, which can be said certainly to consist of 18 holes and nothing else, in making the lives of the employees very pleasant ones. As I have said, there are gardens around the bungalows, and an astonishing variety of plants can be induced to grow.

From this refinery town runs the pipe line inland towards the fields with watchmen's huts every few miles along it, where pressures, etc., are taken at stated intervals. Upon it also are the boosting stations, of which mention has already been made. These form in themselves a small community of about seven Europeans and a large number of Persians, whose function it is to look after the powerful pumping machinery which maintains the pressure in the pipe lines.

At Ahwaz, some 75 miles from Abadan, there is a centre of considerable importance with a large *sief* or wharf and considerable storehouses for material destined for fields. It is at this point that all material which has come up the River Karun has to be unloaded and carried up a short railway round the rapids, to be reloaded on a shallower draught vessel to complete the journey to D.I.K. Here, too, resides the Governor-General, who is the senior Persian Government official in the Company's area, with whom friendly and close contact is maintained. It may be interesting to note here that it is at this point that the southern section of the railway, which is being constructed by the Ulen Company of America, crosses the River Karun on a bridge of steel piers carrying a single line. This section of the railway runs from Dizful to the new Persian port of Bandar-i-Shapur, on the Khor Musa.

This port has a special significance for Persia. When the Perso-Iraq Frontier was delimited, the usual practice of fixing the frontier down the middle of a river was for some reason not followed, and the Iraq Frontier actually begins at low water mark on the Persian side of the Shatt-el-Arab, so that we have the anomaly of the tanker vessels being in Iraq when they are alongside the jetties at Abadan.

The new port is wholly Persian and has the advantage of being situated on a creek of great depth, without a bar which constitutes a serious obstacle to shipping, and above all, in which there is no silting in progress.

The creek in question almost undoubtedly was once upon a time the old mouth of the Karun, before it changed its course and broke through into the Bahmashir and the Shatt-el-Arab.

In the event of the trans-Persian Railway being completed, the new port will play an immense part in the opening up and development of Persia. It is practically the only place on the whole Persian coast where a sheltered anchorage and opportunities for the discharge of cargo to jetties is possible. Even now with the railway only reaching as far as Dizful, its importance is very great and the possibility of its substitution for Abadan as a port of call for a certain number of the Company's oil tankers must not be lost sight of.

But I have digressed. To return to the oil pipe line: we now follow it across the plain till it reaches the foothills and mounts up to cross the Imam Reza range, descending on the other side to the main pumping station at Tembi.

The motor road follows the Karun to a point where a break in the hills formed by one of the tributary streams gave the engineer an opportunity of building the railway and road to fields. On the banks of the river is the Company's wharf and storehouses at the railhead. This is the Dar-i-Khazineh, and here the material which has been brought up the river from Mohammerah and Abadan, transshipped to smaller steamers at Ahwaz, is unloaded and taken by lorry or rail to the oilfields.

On the way up by the motor road, one catches a glimpse of the snow-capped Bakhtiari Hills to the north, and I can tell you that when in August one can see the last vanishing traces of the snow, so near-seeming and yet so inaccessible, it makes one's mouth water, with the temperature at about 110° in the shade.

It is a very strange sensation after driving through a fantastic wilderness of gypsum-veined hills, bare of all vegetation but for a month in spring when they are a mass of flowers, to come suddenly

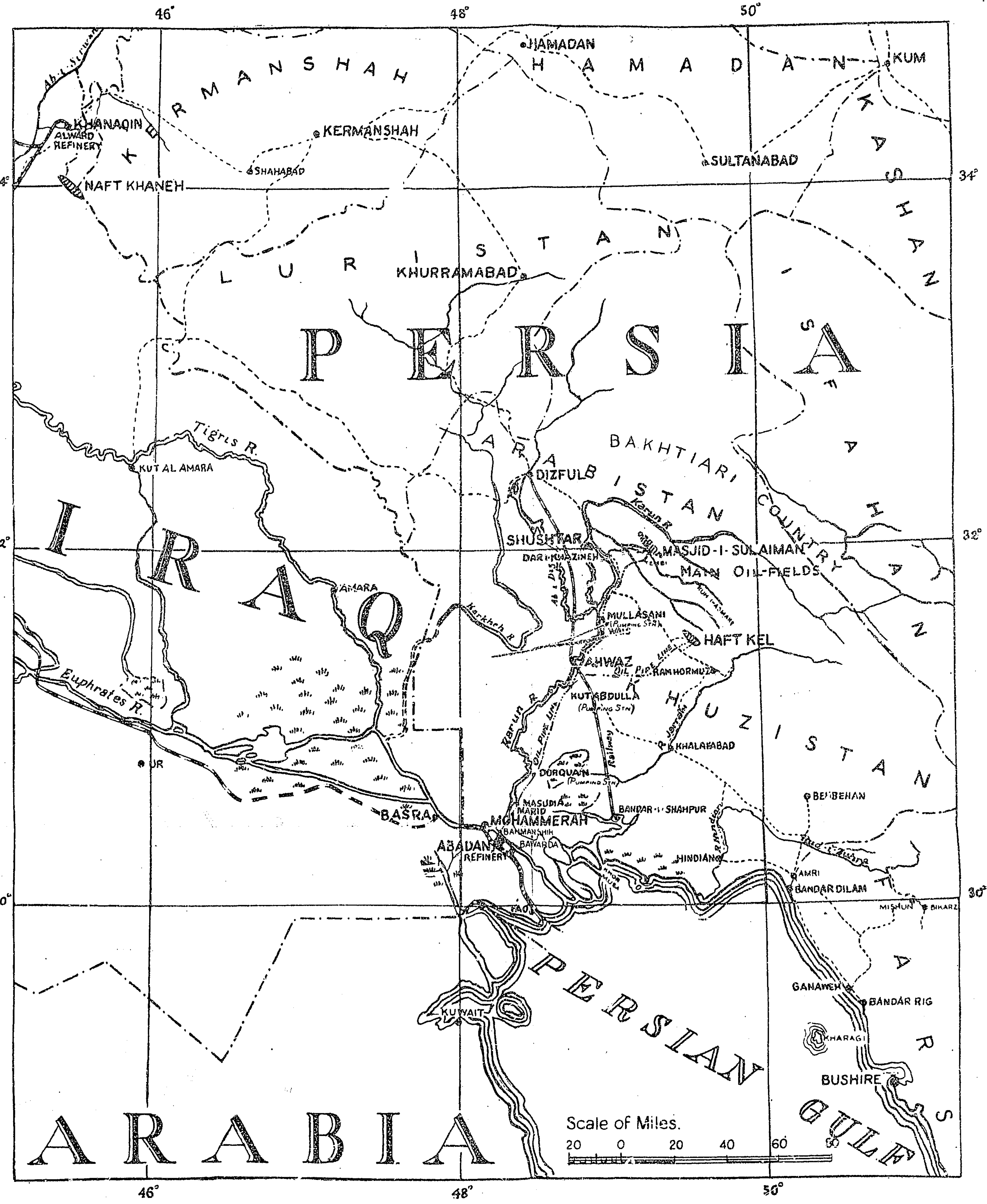
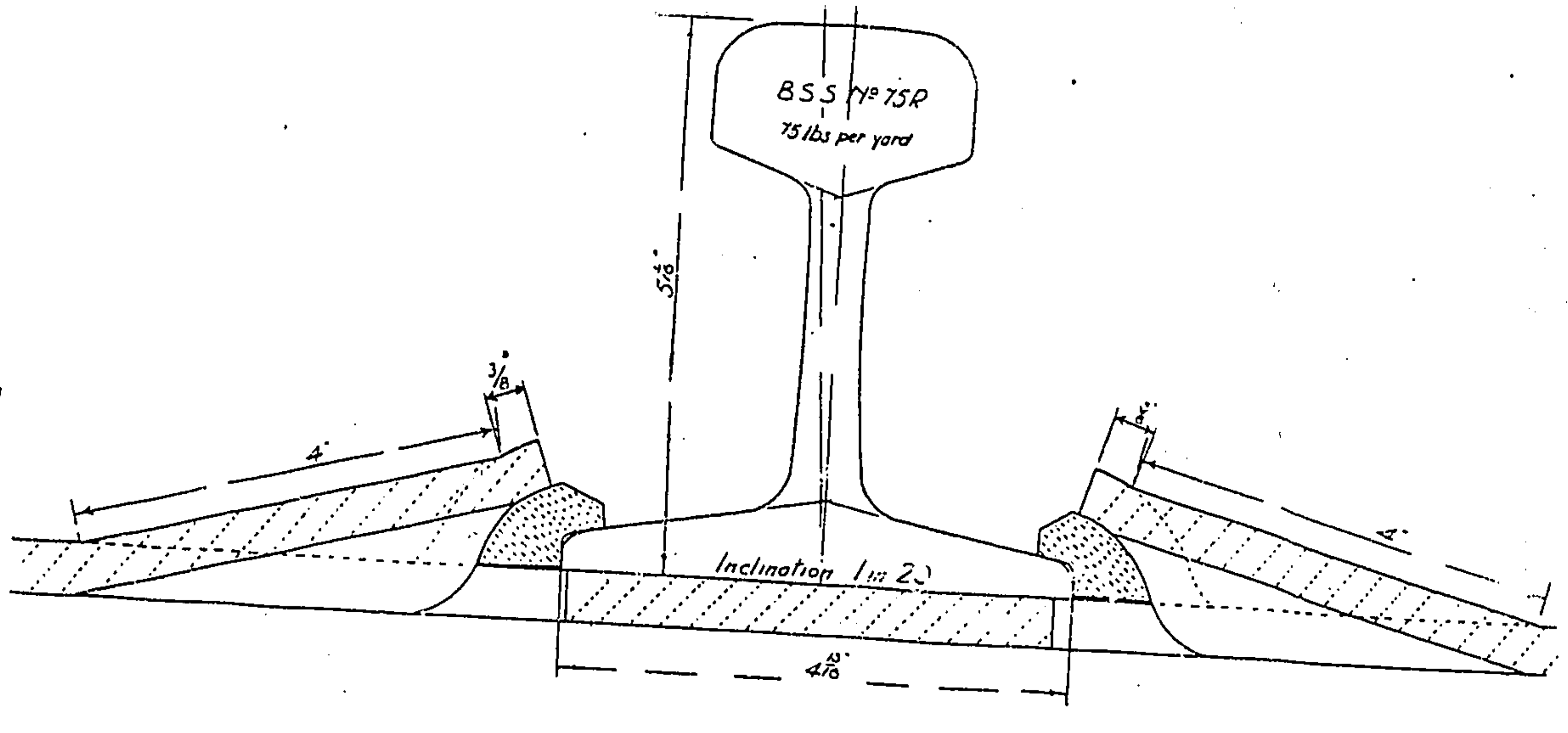
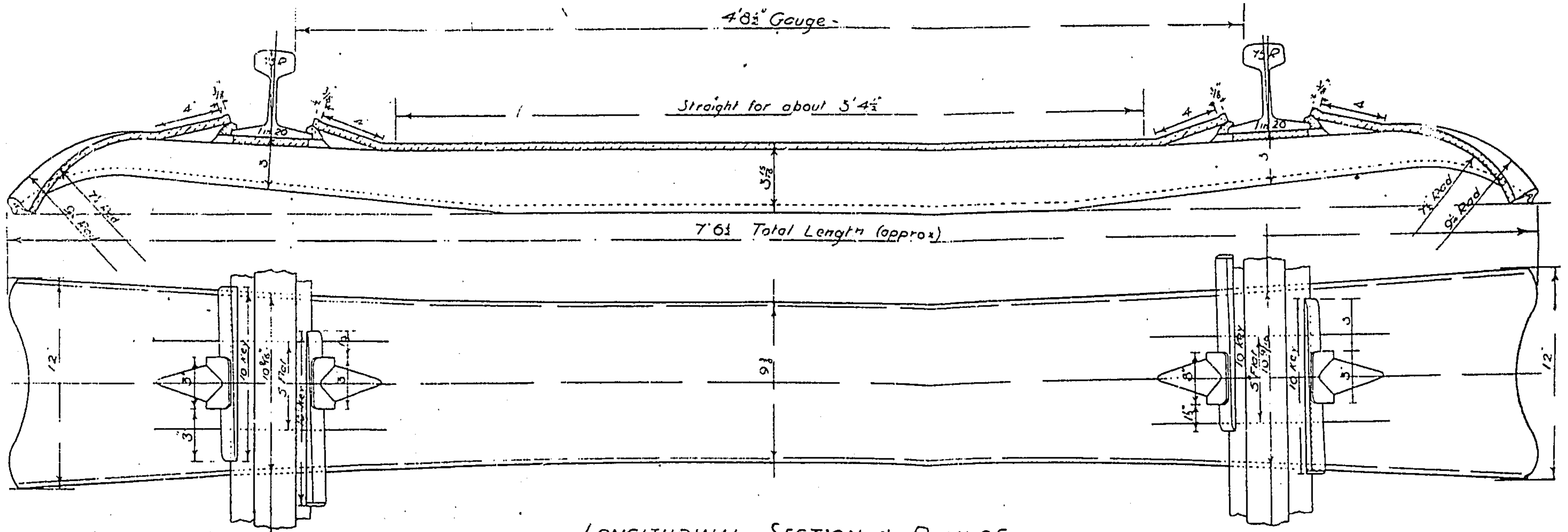

46°
48°
50°
34°
32°
30°
HAMADAN
H A M A D A N
KUM
K E R M A N S H A H
KHANAQIN
ALWARD REFINERY
KERMANSHAH
SHAHABAD
SULTANABAD
NAFT KHANEH
KASHAN
L U R I S T A N
KHURRAMABAD
PERSIA
ISFAHAN
ARABISTAN
BAKHTIARI COUNTRY
Tigris R.
KUT AL AMARA
DIZFUL
Karun R.
SHUSHTAR
DAR-I-KHAZINEH
MASJID-I-SULAIMAN
MAIN OIL-FIELDS
IRAQ
AMARA
Karkheh R.
MULLASANI
(Pumping Stn)
WAIS
HAFT KEL
AHWAZ
OIL PIPE LINE
RAM HORMUZ
Euphrates R.
KUT ABDULLA
(Pumping Stn)
HUZISTAN
Karun R.
Oil Pipe Line
Railway
KHALAFABAD
UR
DORQUAIN
(Pumping Stn)
BEHBEHAN
MASUDIA
MARID
BANDAR-I-SHAHPUR
BASRA
MOHAMMERAH
BAHMANSHIR
ABADAN
REFINERY
BAWARDA
HINDIAN
R. Hindian
AMRI
BANDAR DILAM
FAO
MISHUN
BIKARZ
PERSIAN GULF
GANAWEH
BANDAR RIG
KUWAIT
KHARAGI
FARS
BUSHIRE
ARABIA
Scale of Miles.
20 0 20 40 60 80

FIG IV.



SECTION AT CENTRE OF RAIL SEAT



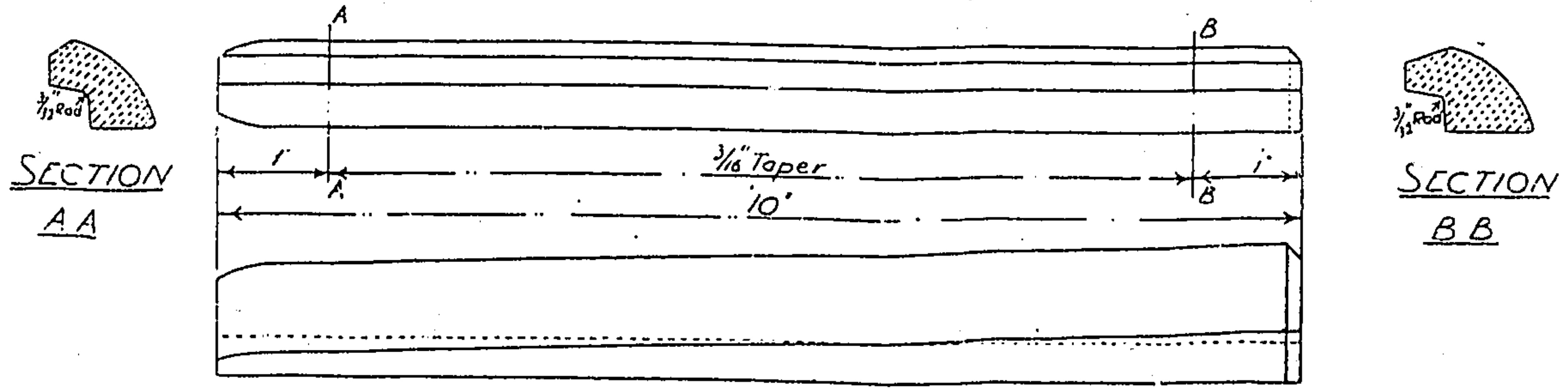
LONGITUDINAL SECTION & PLAN OF

STEEL SLEEPER

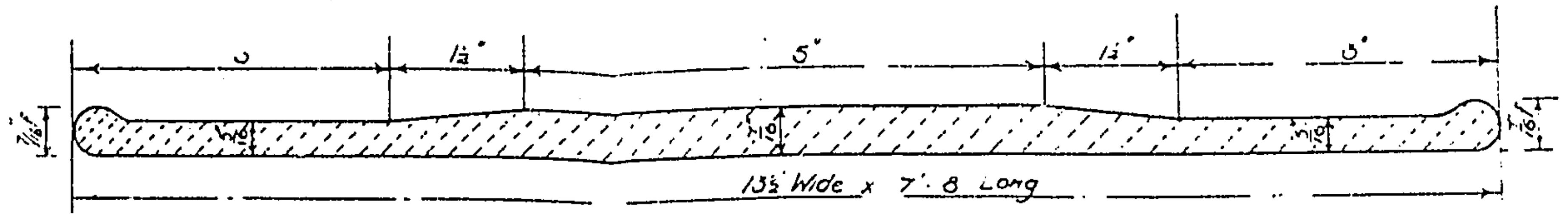
Weight of Steel Sleeper about 130 55 lbs

Weight of 4 Steel Keys 10 long 5 76

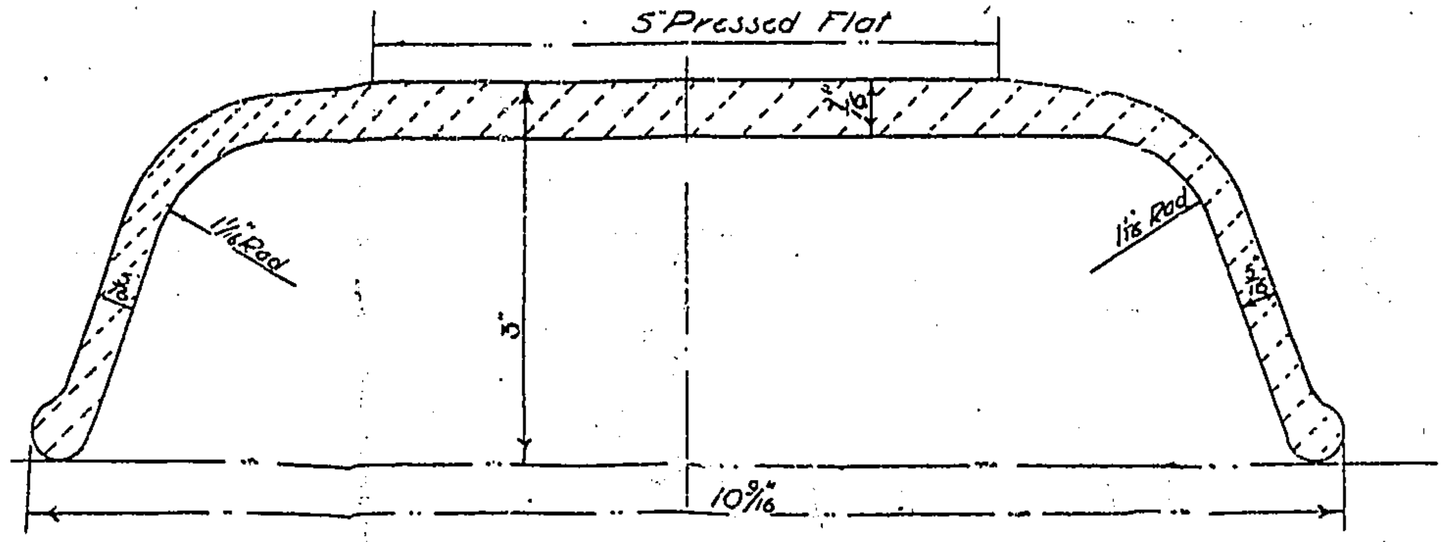
Total weight 136 11 " (approx.)



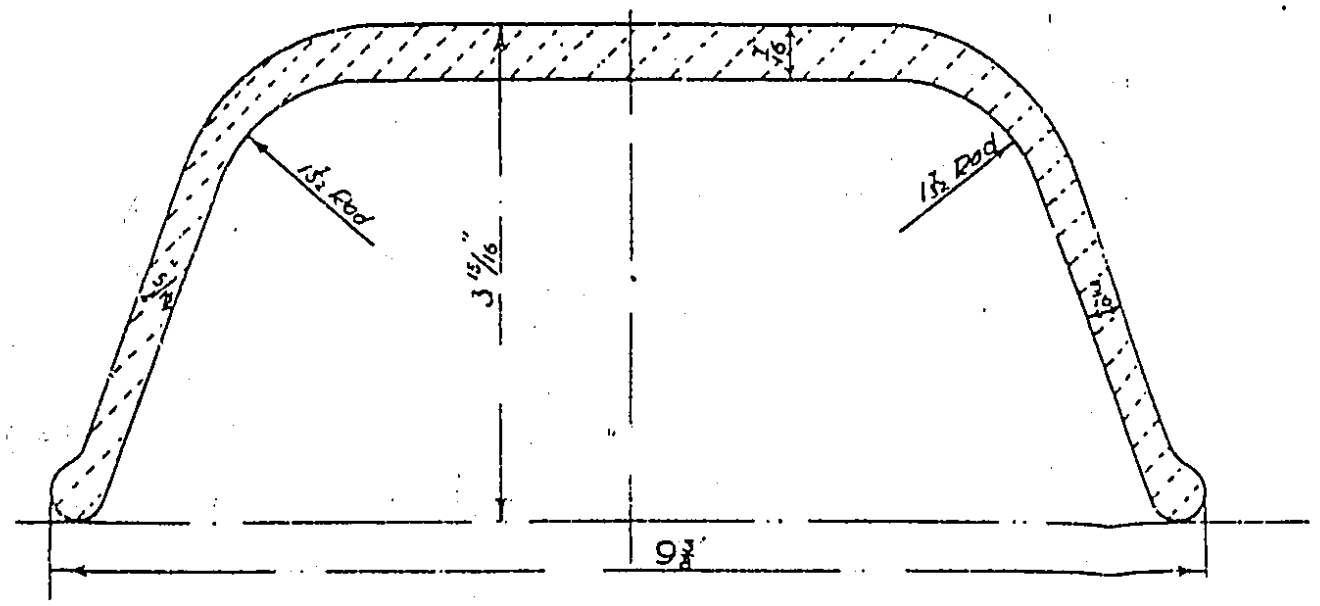
STEEL KEY



SECTION OF PLATE (UNPRESSED)

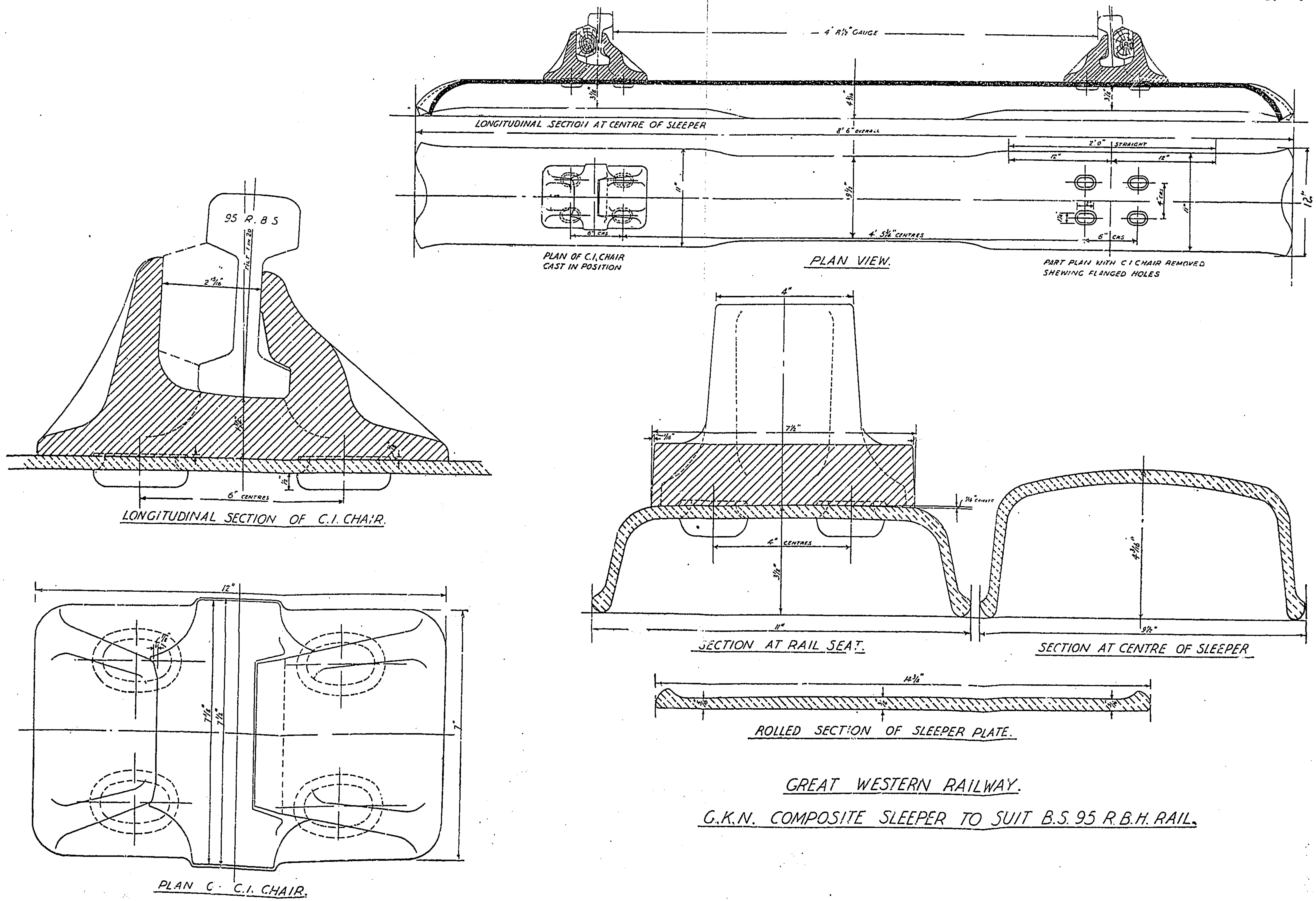


SECTION AT CENTRE OF RAIL SEAT



SECTION AT CENTRE OF SLEEPER

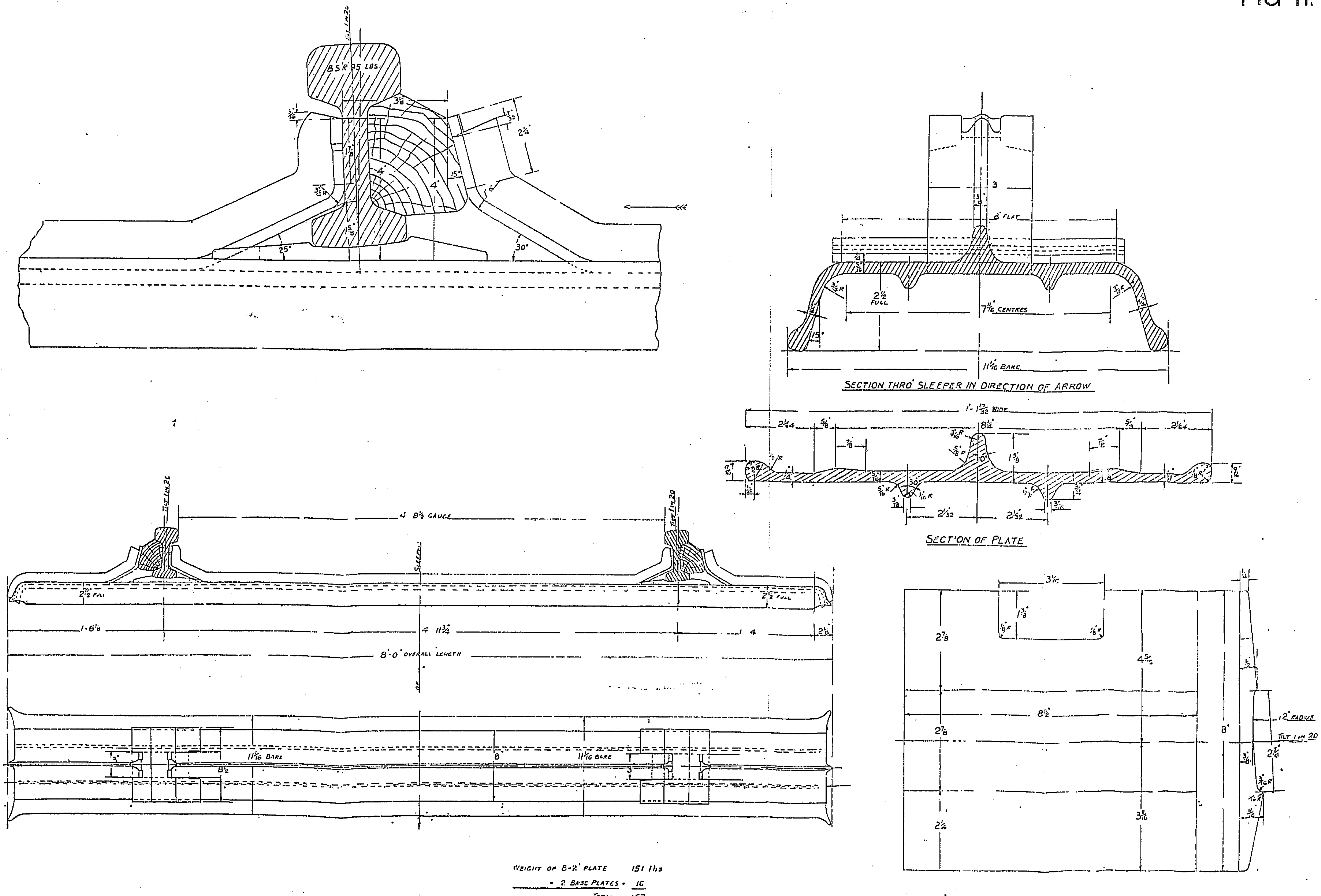
FIG I.



GREAT WESTERN RAILWAY.

G.K.N. COMPOSITE SLEEPER TO SUIT B.S. 95 R.B.H. RAIL.

FIG II.



SANDBERG'S STEEL SLEEPER

upon a tarred road, an iron gate set in the buttress of a rocky defile, a uniformed Persian servant of the Company who presents a book for signature, and then to find oneself as the road turns into more open country, in the middle of a thriving modern community, with electric lamp standards along the roads, huge workshops echoing to the clang of machinery, rows of neat bungalows set each in their own garden, fleets of cars and lorries and not one drop of oil to be seen.

Gone are the days of exciting but somewhat dangerous methods which permitted the new well to spout its contents over the countryside until it could be got properly under control, or when the uncontrolled gases, as the night grew cool, inundated the gullies and low-lying spaces, bringing death to the skulking hyenas and jackals, and sometimes, sad to relate, to belated human wanderers. All now proceeds "according to plan, securely and with danger to none."

There was a time when the picturesqueness of the fields was materially added to by the presence of numerous enormous flares; real "pillars of smoke by day and pillars of fire by night." These represented what was formerly the only method of getting rid of the vast volumes of gas which are always present under pressure together with the oil. This gas in the early days became a very grave menace to the lives of the personnel in the oilfields. It is invisible, heavier than air and very deadly, and it used to collect in valleys and hollows, where it was a lurking menace to any who passed that way. Something had to be done to get rid of it, and it was decided to build great six-foot conduits leading up to several vast burners on the tops of the surrounding hills. These were ignited by shots fired from a Very light pistol, and for years poured their columns of smoke and flame hundreds of feet into the air, giving the place a most infernal aspect by night. Now, however, millions of gallons annually of benzine are extracted from the gas by a new method of compression and absorption, and the number of the flares has consequently dwindled to, I think I am right in saying, about two or three very inferior ones.

About 7,000 Persians are employed in the oilfields and altogether, one would not be far out in estimating in round figures the number of Persians employed by the Company in all its centres at 20,000, which, of course, does not include the enormous number of tradesmen and others who depend indirectly upon the Company for their living.

At the period immediately after the War, it was an accepted practice, almost an axiom, to build a refinery at the nearest possible point to the source of supply. It seemed to the Company, however, that for many reasons it was desirable to create another great refinery in addition to the one at Abadan to serve its British and European trade, and accordingly Llandarcy was built, incidentally providing work for thousands of Britishers. Llandarcy Refinery, like Abadan, represents the last word in the development of all refining processes and has helped to make the port of Swansea one of the most progressive in these Islands.

THE GERMAN ENGINEER AND PIONEER CORPS.

(INGENIEUR=UND PIONIER=KORPS.)

By COLONEL G. H ADDISON, C.M.G., D.S.O.

PART II.

Reorganization during the Course of the War.

Three separate problems had to be dealt with during the war :—

(*a*) the provision of newly-formed Corps and Divisions with Pioneer units ;

(*b*) increase of the number of Pioneers in every division, so as to improve the ratio of Pioneers to infantry ;

(*c*) creation of additional units to cope with the new weapons and technical methods that grew up with the war.

To a great extent, all three had to be faced simultaneously, and as will become apparent, the claims of (*a*) and (*c*) continually conflicted with those of (*b*), which, in the eyes of the Pioneers, was of first importance. Floods of keen but raw recruits streamed into the depots,* there to be first trained individually, and then kneaded into new units. At the same time the heavy losses in the early battles raised a continual cry for reinforcements ; while scarcely less urgent were the demands of civil industry for tradesmen. Amid these conflicting claims nothing could be done to help the original divisional Pioneers, on whom increasingly heavy calls were made. The shortage was just as bad among the army companies, many of which were tied up in the attack of certain fortresses, notably Maubeuge, Longwy and Antwerp. The remainder were quite insufficient to deal with all the semi-permanent bridging wanted as the advance went on.

Example of Overwork of Field Companies.

A typical case of the strain imposed on divisional companies is given. The 1st (Reserve) Company of the 3rd Pioneers was the only company with the 6th Reserve Division. About 6 p.m., on the 4th October, 1914, after several days of continuous fighting, they reached the River Nethe, over which assault bridges of improvised material were thrown. These had to be launched under heavy fire, and the Pioneers crossed them in company with two battalions of the 35th (Reserve) Infantry Regiment to the assault of Lierre. As soon as

* Lt.-Col. Augustin says that, whereas France had in peace 2·1% of the population with the Colours, Germany only had 1·2% ; a very poor proportion of the possible effectives.

the southern part of the town had been cleared they repaired the existing road bridges under artillery fire, and then took part in the storming of the northern area. Here the attack was held up by barricades and broken ground. During the night the divisional bridging train came up and the company threw pontoon bridges over the two southern branches of the river, whereby artillery was enabled to advance and deal with the barricades. At 7 a.m. next morning, assault bridges were made south-west of Lierre for a battalion of the 26th (Reserve) Regiment. The infantry hesitated to advance over the water-logged meadows, so the Pioneers led the way, cleared the opposite bank by rifle fire, and then launched the bridges, by which the position was stormed. In Lierre the heavy traffic over the bridges necessitated constant repair work, and an additional bridge was built in the south part of the town over which, in spite of continual damage and interruption by enemy fire, reinforcements of infantry and artillery were able to go forward. By this time the company had worked and fought continuously for over 50 hours, without a single pause; neither rest nor relief was possible.

Beginning of Trench Warfare.

When, after the battle of the Marne, the war gradually took on the appearance of a siege, new demands were quickly made on the Pioneers. The fighting arms were quite unprepared for these conditions and depended more than ever on technical assistance. Fortunately, some of the fortress Pioneer battalions had taken part in extensive siege manœuvres during peace, and the field companies soon learnt the tricks from them. Many divisions improvised infantry Pioneer companies, but this only left the regiments themselves the more helpless and increased their calls for skilled assistance. The first trench mortars and flame-projectors came into use, and were manned by personnel withdrawn from Pioneer units. It is not surprising that the autumn and winter of 1914 passed away without any improvement in the ratio of Pioneers to infantry.

Developments during 1915.

Further delays occurred at the beginning of 1915, when bridging trains had to be raised for the new formations that were created by withdrawing fortress troops from the Eastern Front. Then mine warfare came into prominence, for which fresh companies were continually needed. A new form of Pioneer assault tactics in conjunction with flame-projectors was introduced in the Argonne by Lieut. Beumelberg, after whom it was named,* and this was followed by an increase in, and proper organization of, flame-projector troops. In March, a special "assault" detachment was formed, consisting

* The German official monograph *Argonne* says, "In the rolling-up of enemy trenches, which was later developed as a special method of fighting, Lieut. Beumelberg (Walter), 2/Pi/30, early exhibited an exemplary mastery."

of headquarters, 2 Pioneer companies, and a gun section with 20 3·7-cm. guns; and at the same time the 3rd Guard Pioneer Battalion was organized as a flame-projector unit, with headquarters, four companies and a workshop detachment. The assault detachment tried out new methods of attack and, at first, made much use of portable shields and body armour; the personnel were employed both as instructors of the infantry, and as the nucleus of specially selected assault parties. At last, in April, sufficient new units became available to provide every division in the field with two field companies. This was only a beginning. The need for field companies on a scale of one per infantry regiment was generally recognized, although an alternative proposal to increase the establishment of existing companies from 250 to 300 men met with some support. Both plans were rudely checked by the scheme of army reorganization, by which all divisions were gradually reduced from four to three regiments; the regiments thus released being grouped into fresh divisions, which again had to be furnished with technical units.

At the beginning of this year, intensive experiments had been carried out with disinfection and breathing apparatus (*Desinfektionsgerät und Luftfläschen*) by two special Pioneer companies under Colonel Peterson; and in April and May, the 35th and 36th Pioneer Regiments, each of two 3-company battalions, were established as gas-warfare troops.

About the same time the first Pioneer park company was formed in the Sixth Army area; eleven more for the other armies following at intervals during the year.

In June, the first detachment of Pioneers, equivalent to about one company, departed for Turkey.

For the Austro-German crossing of the Danube in October, a Pioneer "landing" company, for which an establishment had been prepared in peace, was brought into being, and was provided with special landing equipment based on English experiences.* A Pioneer "ferrying" company was also formed for the rafting operations at Semendria.

During the autumn the increase in enemy air activity required a systematic organization of anti-aircraft troops, and the Pioneers were called on to man the anti-aircraft searchlights; the first detachment, equipped with 90-cm. lights, was assembled in September.

All this time, trench mortar units were in a constant state of reorganization and expansion, and their requirements brought a steady drain on the Pioneer resources.

Complaints as to the recruiting position in Germany, and delays in sending reinforcements, led to a demand for field training depots at the front. At first the War Ministry objected strongly, fearing lest unauthorized units might be formed and Pioneer reserves used

* Presumably at Gallipoli.

up too quickly. However, in October, permission was granted to establish a Pioneer training depot in the XVI Corps area, where the personality and experience of the Commander (Gen. von Mudra, late Chief of the Eng. and Pi. Corps) provided a guarantee against misuse, and where the conditions in the Argonne offered peculiar facilities for training. Thus the year 1915 did produce a certain measure of improvement in the unsatisfactory position created by inadequate peace establishments; it was, however, no more than a meagre approach to what was really needed.

1916.

During 1916, the process of forming new divisions went on simultaneously with the reduction of four regiments to three within the division. The number of divisions in a corps was increased, and the heavy casualties and need for relief of exhausted divisions had the effect that the divisions in a corps were constantly being changed. This only served to accentuate the difficulties of the Pioneer situation, and to increase the urgency of continuity in technical control. The result was that selected Pioneer officers were gradually detailed by G.H.Q. to take command of all the Pioneer units in divisions, and were given small staffs for the purpose. The normal organization of divisional Pioneers began to be recognized as: headquarters, two field companies, searchlight section, trench mortar company, bridging train. Parks, or other special units attached to the division were put under the Pioneer commander. Some divisions, particularly at Verdun and on the Somme, improvised additional units; for instance, the 56th Division at the Mort'Homme, in July, formed a third field company by taking one section from each of the others, putting the senior subaltern in command; this division had found it necessary to form a mining company from each infantry regiment some time earlier. Even six units were not enough at the height of a battle, and eight companies (field and mining) were employed in mining operations under the Pioneer commander west of Givenchy-en-Gohelle during August. When mine warfare reached its zenith, between 40 and 50 special Pioneer companies had been formed, besides a number of improvised units.

During phases of the Verdun fighting it was found necessary to allot a field company to every battalion, although the infantry were better trained in field works than ever before. In fact, it is said that the infantry-man at this time would rather have been without his rifle than his spade.

The drain on Pioneer reserves continued to be very severe all through this year; for, in addition to the heavy battle losses, trench mortar and flame-projector units were still further added to, and a number of fresh searchlight units formed. Two Pioneer recruit training depots were established behind the Verdun front; also one in the Balkan theatre, which was called for not only by the distance, but by the need of allowing reinforcements to become acclimatized.

Other developments during this year were a "Water Transport" (No. 310) Pioneer Company, used for canal traffic in Alsace-Lorraine, under the director of railways; the appointment of an Inspector of Gas regiments; and the inauguration of a Pioneer training establishment at Maubeuge, to which resting battalions were sent for refresher courses, or for special instruction and training in schemes for the break-through.

1917.

The year 1917 was ushered in by an administrative measure that was long overdue. On January 24th, formal approval was given to the establishment of a Pioneer battalion headquarters with every division. In many divisions there were still only one or two field companies;* unfortunately, also, some divisional commanders did not yet know how to make use of the new organization. But, at all events, divisional Pioneers had recovered the tactical unity of which mobilization had deprived them. At the same time, Pioneer staffs with Corps Headquarters were regularized; but the position here remained unsatisfactory, for only one staff officer (a captain) was allowed. Junior officers could not be expected to possess either the authority or the experience that were needed, and during the summer they were replaced by Pioneer lieut.-colonels.

Further developments occurred during the first half of the year. The recruit training depots had proved so successful that they were established behind every army. A Pioneer officers' training school was opened at Maubeuge for the Western Front, and at Kovno for the Eastern. Searchlight detachments were reorganized in consequence of the introduction of a portable electric light, which was so much simpler in use than the delicate oxy-acetylene pattern, that it became possible to hand it over to the fighting arms, only retaining small care and maintenance parties of Pioneers.† A special trench-warfare Pioneer park organization was set up, comprising four battalions, each of three companies, a trench mortar park inspectorate with five companies and a trench mortar instructional detachment. The role of this organization was to administer the vast quantity of trench-warfare weapons in corps and army parks, to inspect and test supplies before delivery from civil firms, and to run the newly-built home depots. Finally, Pioneer units were raised to accompany the so-called "Pasha" expeditionary corps to Asia.

* A British G.H.Q. Intelligence pamphlet dated Jan./17 says: "The number of pioneer companies (exclusive of mining companies) now formed allow of 3 Pioneer field companies for every German division in the field." This was never true, and only approximately so if all available companies had been allotted to divisions, to the complete exclusion of Army Troops, L. of C., etc. The confusion no doubt arose from the German universal ("Einheits-") Pioneer Company system.

† Apparently the small type was taken over by the infantry and the heavy (A/A) by the Air Force, though this is not actually stated.

The development of the Corps had now reached its zenith. Increasing difficulties in finding reinforcements compelled the War Ministry to issue instructions for retrenchment towards the end of September. The abnormal increases in trench mortar units had drained the Pioneer reserves. L. of C. and home establishments were combed out, all fit men being replaced by those unfit for service. But such measures no longer sufficed. Shortage of men and even more noticeably of horse-flesh brought about a reduction of Pioneer establishments before even the process of building up could be completed. Divisional Pioneer battalions were to remain short of their three companies. "The Nibelungs' hour of doom had struck." Divisional and Corps bridging trains were handed over from Pioneer battalions to ammunition trains and columns, whereby the Pioneer detachments were saved to the benefit of the Pioneer reserve. A little later, 7 Corps and 24 Divisional bridging trains were disbanded, and reductions made in many others; there remained 14 Corps and 30 divisional trains at the disposal of G.H.Q., 22 Corps (5 without horses) and 79 Divisional under Corps and Army Headquarters. The result of these measures was that the equipment, insufficiently cared for by non-technical personnel, steadily deteriorated; and the Pioneers, with restricted opportunities for practice, lost their skill in the technique of bridging; so that, before the 1918 offensive, selected Pioneer units had to be put through intensive courses of training. But, worse still, Pioneer battalions lost the bridging vehicles on which they had been accustomed to depend for the forward transport of trench stores and tools. Night after night drivers and teams had given devoted service under conditions of indescribable difficulty and danger; now they were no longer available.

1918.

The process of retrenchment gradually spread. In February, three divisions had to be disbanded; in June, one; in August, nine; in September, ten; in October, four. The Pioneers of these 27 divisions were retained for the most part as G.H.Q. reserves, only a few companies being used to fill existing gaps in other divisions. The Pioneer staffs were placed in charge of sectors of rear line construction. The total number of Pioneer units was, therefore, not decreased; but, in order to maintain them, the establishment of companies had to be reduced to a nominal 220. Reductions in the infantry could, to some extent, be offset by increases in the number of machine-guns; but it was very difficult to find similar means of replacing Pioneers by machines. No. 421 Pioneer (boring) Company was formed in February, No. 422 (compressed air) Company in April, and No. 423 (mechanical trench-digger) Company in July; but subsequent events put an end to experiments of this kind. There is little more to be said. Three extra gas battalions were formed in 1918, making a total of seven active and one reserve battalions under the commander of gas troops. Finally, trench mortar companies were transferred from Pioneer battalions to infantry regiments, but too late to bring any relief to the Pioneers.

In all, during the war, 425 Pioneer companies of various kinds; 176 searchlight sections; 42 divisional, 17 Corps and 11 Army bridging trains; and 4 Pioneer siege trains were newly formed. The number of Pioneers in the German Army rose to roughly 170,000, all ranks, with 8,000 m. length of bridge equipment. Thus the total strength was more than doubled in the course of the war. None the less, the strength within divisions never arrived at what had been asked for, had been shown to be necessary by technical experts before the war, and was proved to be absolutely essential by the War itself. A further 240 companies were required, which means that the total Pioneer strength should have risen to 220,000; *i.e.*, three times the mobilization strength.

Technical Services Not Belonging to the Engineer and Pioneer Corps.

Some mention must be made of certain units which were outside the Pioneer formations and did not draw their personnel from the Pioneer depots; although their work was certainly technical, and ought to be recognized as functions of the Engineer and Pioneer Corps in any future organization.*

The first to be considered are the electrical detachments. Improvised units were formed by some armies in the winter of 1914–15, to take over captured power stations, from which power for workshops and light for billets were distributed about army areas. Later, light was also taken up into the front line. In places, power was used to electrify wire obstacles, but, with the great increase of artillery fire, these were abandoned. Forty-one companies and 76 independent detachments had been formed by March, 1917, when official sanction was given for a regular electrical unit in every army. The commander of this unit belonged to the General Staff of the Army, which led to the interests of the fighting troops being subordinated to those of back areas. In the Seventh Army, sections were attached to divisional and corps Pioneer units, an arrangement that worked well. Personnel of searchlight sections, set free by the reorganization referred to earlier, proved especially apt for this work. With the increasing use of electric power that the future will surely bring, it seems essential that the electrical detachments should be incorporated in the Engineer and Pioneer Corps.

Labour Battalions.—At the beginning of the war, labour detachments of Landsturm were formed into military construction units of various strengths and designations, and distributed among the German fortresses. Numbers of them were soon sent to the front

* It must be understood that in this and similar cases the opinion expressed is that of the German author. See Introduction to Part I in June number *R.E. Journal*.

for work on rear positions, roads, and billets; and later into the forward zone, where they performed varied and arduous tasks; in fact, within an army area, they came to be regarded as universal constructors, providing for needs that varied from mineral water factories to heavy steel shelters. In the spring of 1915, these mixed formations were reorganized into regular labour battalions, of which there were ultimately 217. When the construction of rear positions was systematically undertaken in 1915 and 1916, directing staffs were formed of officers from all arms, principally staff, Pioneers, and artillery. A number of battalions were allotted also to divisions and were generally placed under the Pioneer commander. The tremendous achievements in field fortification during the latter half of the war owed much to this measure, and to the heroism and devotion of the men of the labour battalions, whose work, carried through without proper officers, organization, or equipment, can never be forgotten by the specialist—the Pioneer. These battalions must have a place in any future scheme of mobilization; their affiliation to the Pioneers will come about, in greater or less degree, of itself.

Railway Units.—Finally, a word about railways.* The permanent peace establishment was three regiments and one Bavarian battalion, the latter always retaining close connection with the Bavarian Pioneer Corps. Every modern means of locomotion and transport was employed in the war. Railways played a part of great tactical as well as administrative importance. Without them, Tannenberg, the Masurian Lakes battle, the breaks-through at Gorlice and on the Isonzo, the campaigns in Serbia and Roumania, and many great battles on the Western Front would all have been impossible. The mobilization scheme provided for 56 construction companies and 4 auxiliary battalions. These proved to be quite inadequate, and very early steps had to be taken to mobilize the personnel of the civil railway and bridge-building industries, whereby a veritable technical transportation army was created. At the end of the war, there were 164 construction companies of various categories, 125 operating companies, 71 labour companies, besides a large number of light railway, ropeway and special units, and 7 armoured trains.

Lessons of the Great War.

Reasons for Shortage of Divisional Pioneers.

If the question is asked, why was it never possible to furnish divisions with the Pioneer units that were recognized as essential, the answer can be given in one word: trench mortars. The Pioneers were the protagonists of this weapon. During siege manœuvres in

* This is not referred to by Lt.-Col. Augustin, but in the historical section of "Der Pionier" there is a brief summary dedicated "To the memory of the German railway troops," which is of interest. As already explained, although originally one with the Pioneers they had been entirely independent since 1875.

1913, a special Pioneer trench mortar troop had been organized, and the use of mortars in the infantry mobile battle practised; so it naturally fell to the corps to sponsor the weapon in war. But once it had become a going concern, the whole business should have been handed over to the infantry and artillery; and this was, in fact, discussed by the Higher Command from 1916 onwards. The Pioneers themselves were loth to give it up, and the staff feared lest development on sound lines should be checked. Consequently, it was not until the complete exhaustion of Pioneer reserves made it unavoidable that the transfer was ordered; and then it was too late. The organization of trench mortar units underwent many changes. At the period of maximum strength of the army, the trench mortar company comprised three sections; one heavy (4/25 cm.), one medium (8/17 cm.) and one light (6/7·5 cm.), with an establishment of roughly 200. The total strength in the field was thus between 40,000 and 50,000, almost exactly the numbers required to complete every division with three field companies. From first to last, some 200,000 Pioneers and 17,000 mortars passed through these units.

Correct Proportion of Pioneers to Other Arms.

Opinion as to what was the correct proportion of Pioneers with an army had pretty well crystallized by the end of 1916. The Commander of the German First Army, General Fritz von Below, in a paper dealing with the experiences of the Somme Battle, dated January, 1917,* gave his views in full. A little later, the General of Engineers and Pioneers at G.H.Q. issued a detailed scheme, which embraced and amplified Below's proposals; to which he appended a suitable peace establishment. In July, 1918, the War Ministry officially specified Pioneer requirements based on the experiences of the war, as follows: A number of higher staff officers (Generals); with every Army Group, Army, or Army Corps, a Pioneer regimental commander and staff; for every division of three regiments, a Pioneer commander and staff, one battalion of four companies, a field searchlight and anti-aircraft searchlight section, and a divisional bridging train; to every three divisions, one Pioneer battalion as G.H.Q. reserve; to every six divisions, one Pioneer park company, and a Corps bridging train; for each cavalry division, a light Pioneer detachment with light bridging train; as special G.H.Q. troops, one Landing Company, three Gas Regiments, and one Flame-Projector Regiment. The corresponding peace establishment was laid down as: 64 Pioneer regiments (one per division)† comprising 128 battalions, one Gas Pioneer Battalion, one Flame-Projector Pioneer Battalion, an experimental and instructional regiment of two battalions. Except that the Pioneer general proposed a rather larger

* A translation was issued soon afterwards by British G.H.Q. (Intelligence).

† An interesting indication of the size of post-war Army that was then being looked for.

proportionate peace establishment, there was little difference between his scheme and that of the Ministry. Owing to the result of the war, nothing, of course, came of these proposals. Lieut.-Colonel Augustin sums up by saying that nothing can alter the following conclusions: that a large modern army needs Pioneers in far greater numbers than anything contemplated by Germany before the war; that the peace strength must be large enough to ensure that existing formations do not have to be broken up on mobilization; that units should be organized in the largest possible formations, at least battalions.

Need for a Technical Head of Pioneer Units.

The war proved conclusively the importance of a technical chief of Engineers and Pioneers in the field, and the absolute necessity of regularizing his position at G.H.Q. The Minister of War, von Stein, the Chief of the military cabinet, Freiherr von Lynke, Ludendorff and Hindenburg, all at different times expressed their conviction on these points. But it was only towards the end that official action was taken to improve a state of affairs that had been incredibly bad. Relegated to the 2nd echelon, attached to the Chief of the General Staff, but with no recognized position or authority, the Chief of the Engineer and Pioneer Corps, in the early days of the war, remained in ignorance of the progress of events and with no indication of the intentions of the higher command. Experience proved the need for technical advice and co-ordinating authority, which were gradually made use of by the General Staff, to their own great benefit; in particular may be quoted: Verdun, the "Alberich" (March, 1917) retirement, the 1918 spring offensive especially on the Marne and at Rheims, the construction of the Meuse position, the final Rhine crossing.

Pioneer Stores and Tools.

In 1914, each field company had four tool wagons, carrying wood- and metal-workers' tools for improvised bridging and for demolition work. Three wagons were loaded identically, each carrying the tools of one section, while the fourth held the company reserve and special articles. Various bridging tools and accessories were held in divisional and corps bridging trains; the latter also carried a reserve of explosives. During the war, extra vehicles were added for trench warfare contrivances such as grenades, lights, signals, etc. The original technical vehicles with companies proved unsatisfactory and were replaced by G.S. wagons, otherwise the organization worked well. But care had to be taken not to increase the first line transport of field companies unduly, six tool vehicles per company being regarded as the maximum. Horses for every Pioneer officer in the field proved indispensable for reconnaissance work; equally necessary was a light lorry with every divisional Pioneer battalion H.Q.

Explosives, Grenades, etc.

The supply of explosives presented difficulties owing to shortage of certain raw materials, and all sorts of makeshifts had to be adopted. The chain of supply in mobile operations was: munitions trains to artillery munition columns; thence to corps bridging trains and so to field companies. In trench warfare, supplies were sent to companies direct from Pioneer parks. Economy in use was insisted on, but for certain operations (*e.g.*, "Alberich") requirements were so large as to necessitate the formation of special explosives columns.

Much difficulty was experienced in producing suitable lights and signal devices, and the end of the war left a number of points undecided. Hand-grenades early assumed importance, as was to be expected from the experiences of the Russo-Japanese War. A small supply of ball (*Kugel*) grenades had been stored in German fortresses, and immediately war broke out the Pioneers began to experiment with new types. The stick (*Stiel*) grenade was considered to be the best produced during the war, and it was copied by all other armies.* It was noteworthy that the British and French preferred the "egg" grenade, designed for defensive use from under cover, while the Germans and Russians favoured the more handy "stick" type, and employed it offensively. Consumption by all arms of the German Army reached the astounding figure of 9,000,000 in one month, a large proportion of which must have been wasted. Every unit carried hand-grenades in its first line transport; supplies were consigned direct from home to Pioneer parks, and thence to the troops. In the great 1918 advance, divisions were followed by light Pioneer columns carrying supplies of grenades, which were replenished from special columns ordered up as necessary by G.H.Q.

Rifle grenades, which were designed by the Engineer Committee in the early days of the war, came into some notice again in 1918; but there were always difficulties in manufacture, mainly as regards raw materials; and there is still much scope for improvement in this weapon, which has particular interest for infantry, cavalry and pioneers. A stick-bomb-thrower became popular, but was unsuited to mobile operations and was superseded by the light trench mortar.

The flame-projector diminished in importance towards the end, the heavy type being immobile, while the light type had a short range and small effect. This weapon, of which the origin dates to pre-war days, has its definite uses as a close-combat accessory. The details of gas-warfare are beyond the scope of this work; its increasing importance is recognized, particularly for artillery, trench mortars, tank units, Pioneers, and above all, the air service.

* Lt.-Col. Augustin's views on these points are open to question.

Bridging Equipment.

The pontoon equipment proved highly satisfactory and met all requirements. The galvanized steel pontoon was of two types; uni-partite, weighing 1,102 lb.; bi-partite, weighing 661 lb. and 683 lb.; the buoyancy of the complete boats being identical. Corps bridging trains were equipped with the former, one boat and one bay of superstructure being drawn by a six-horse team. In divisional trains, a half pontoon and half a bay of superstructure were carried on four-horse vehicles, which were as mobile as field artillery. The value of the extra mobility was, however, neutralized by the delay caused in joining up the two portions of the boat; the heavier vehicles of the Corps train always came up in time, and, with their complete pontoons and bays, were much to be preferred.* In normal bridge (3½-ton total load, but no lorries) the baulks were gunwale loaded on four boats; in "heavy" bridge (11-ton total load; single line metre-gauge railway) on six boats, with extra baulks and double chessing. A strengthened four-boat bridge to carry 5-ton total (empty 3-ton lorries) could be made by doubling the baulks under wheel tracks. The cavalry had a special steel boat equipment† which was a failure, mainly owing to the high centre of gravity of the vehicles, which caused most of them to break down and be abandoned. A special heavy equipment, which proved entirely successful, was designed for the middle and lower Danube, where heavy seas were liable to be encountered. For the "Pasha" Asiatic Expeditionary Force, a camel transport equipment, composed of light superstructure carried on air-filled rubber floats, proved very successful. There was no assault bridging equipment, and all such had to be improvised. Its importance was emphasized many times, particularly at the crossing of the Nethe and at the battle of the Marne (1918), besides many other occasions (*e.g.*, La Fère, 1918); and French and Belgian experiences confirmed this. The use of such equipment is often preferable to ferrying, and every Pioneer battalion ought to be equipped with 300 m. of bridge; the rubber float type mentioned above would seem suitable.

The requirements of improvised bridging were well catered for by the tools and material carried in special wagons with bridging trains; but the heavier loads, that have since been introduced, demand more heavy timber, heavier pile-drivers, and mechanically-driven circular saws. Motor transport for all bridging equipment is also clearly indicated; the mechanical maintenance would be a normal task for the personnel of the Pioneer electrical detachments.

Although the pontoon equipment met all requirements during the

* The bi-partite boat has apparently been discarded since the War.

† The pontoon was bi-partite, of mild cast steel on a framework of wrought-iron ribs. A cavalry regiment had two 6-horsed wagons, each of which carried two half pontoons, one above the other, and superstructure. See footnote on page 252.

war, the careful observer cannot ignore the fact that substantial changes are bound to be introduced by the greatly increased weights of modern armament. In considering this, it must not be forgotten that ferrying is much less sensitive to enemy fire than bridging; the crossing of the Marne, in 1918, is a conspicuous example, but for purposes of easy rowing the weight of the pontoon cannot be increased. Again, although motorization of the transport is desirable it should be by a system of tractors, so that in the final tactical advance the vehicles may still be capable of being drawn by horses. And lastly, whatever increases in weight of equipment may become necessary, the available length of bridge, which proved so suitable in the War (35 m. per divisional train, 120 m. per corps train, normal bridge) must not be reduced.

Supply of Technical Stores.

The supply of technical stores, both before and during the War, was directly controlled by the Pioneer Inspectorates, and its smooth working was chiefly due to the fact that experiment, design and provision were all under one head, though the wonderful results that were achieved met with scant recognition at the time. The Engineer Committee, which consisted of three small sections before the War, was employing a staff of over 900 by 1916. General trench-warfare stores were at first all handled by them, but were later taken over by the Ministry of Munitions. This Committee was not unlike the R.E. Board. Anyone could send in inventions or ideas direct to it. It carried out experiments with new devices of every kind and finally settled patterns.

POST-WAR PERIOD.

General.

By the Treaty of Versailles, the Pioneer Corps was limited to seven battalions; *i.e.*, one per infantry division; the battalion to consist of headquarters, two field companies, a bridging column, and a searchlight section. Whether the organization that was mooted in 1918 would have actually been put into force in different circumstances must remain a matter of conjecture. The training of the post-war Pioneer is dealt with in *Der Pionier*, the chief points being summarized in the introduction as follows: the principal feature of Pioneer training is its remarkable many-sidedness. The technical knowledge and skill of officers and men must be such that they may be able to respond to every call for help, wherever or whatever it may be. This implies full knowledge of the tactics and organization of other arms, thorough infantry training being indispensable. But helping others is only one part, and not the most important of the Pioneer's duties; primarily, it is his business to do technical work that is beyond the powers of others. Modern conditions make it necessary for all arms to do far more for themselves than in the past; but more than enough is left over for the Pioneers.

Training of Other Ranks.

The recruit is trained during his first six months exactly as an infantry soldier. Pioneer battalions inherit the traditions of their forerunners, especially of the storm-battalions, and they must be fully trained in the tactics of assault troops, understanding the construction, working and handling of all close-combat weapons and devices. Physical training, too, is of outstanding importance to the Pioneers. Besides infantry training, the recruit is practised from the start in the use of entrenching and artizans' tools; the elements of bridging, watermanship, and use of explosives also form part of the early training. At the end of the first period, recruits, still in special squads, take their place in a company, where they learn the handling of the machine-gun and various other duties; they complete their training as mates to older soldiers, the whole period amounting to two years. For special branches and employments (*e.g.*, boatmen, wood and metal-workers, electricians), those most advanced in general training, and best suited, are picked out and given special extra training. The greatest possible number are expected to become specialists in some line; this being particularly necessary for those who aspire to non-commissioned officer rank.

Training of Officers.

The Pioneer officer requires wide knowledge, both tactical and technical; the former so that he may be able to appreciate instinctively the needs of other arms, the latter so as to be in a position to meet those needs. The post-war army makes heavier demands than ever on the Pioneer officer, and very careful selection is, therefore, needed. Aspirants join a Pioneer battalion as volunteers, and do the usual recruit's training, at the same time working methodically for the officer candidate's examination. This examination, which is taken after a school period varying from 1¼ to 3¼ years, takes place annually in Berlin, under instructions from the Pioneer Inspectorate. A successful candidate waits three months and then does the first year's course (actually 10½ months) at the infantry school. After another examination and a few weeks' interval, which is spent doing duty in the Pioneer battalion, and during which he is gazetted *Fähnrich*, he goes to the Pioneer school at Münich for about a year. Theoretical and practical scientific courses are given there as well as advanced military training. Yet another examination must then be passed, after which the candidate returns as *Oberfähnrich* to his unit, where he does duty until his turn arrives for appointment as an officer. The whole training period thus varies from four to six years, depending on the candidate's general educational qualifications.

Duties of the Post-War Pioneer Officer.

It is impossible in a few words to give any idea of the weight and range of the tasks that lie before the Pioneer officer of to-day. The following notes are concerned with some of the more common :—

River crossings assume more and more importance. Practice is equally necessary with equipment and with improvised material; the latter being especially called for by the tendency of loads to go on increasing in weight.

Explosives of all kinds and their use.

Mine warfare in all its aspects.

Field fortification must always have a prominent place.

Camp construction combined with concealment from aircraft.

Road-making.

Survey has come into some prominence.

Searchlights have produced a whole technique of their own and technicians.

Electric power line work becomes steadily more important, as agriculture, industry generally, and railways are electrified.

The foundations of general *mechanical engineering* are taught at the engineer school, assisted by visits to civil firms.

For employment on *fortress construction* officers have to specialize.

Conclusion.

The circumstances of the German Engineer and Pioneer Corps have always differed in so many respects from those of the Royal Engineers that exact comparisons have little value. None the less, the general course of development during the war in both Corps had many features in common, which will be apparent from the table appended. The story may be not inaptly concluded with one of the many quotations that embellish Lieut.-Colonel Augustin's pages; it is attributed to Frederick the Great.

> "Think of the future and forget the past.
> What is past is done; it is for the future that one has to prepare."

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UNIT.	BRITISH.	GERMAN.
Engineer Park Companies.	Authorized, February, 1915; 1 per Army, and at Base.	First authorized April, 1915. 1 per Army added by end of year.
Electrical and Mechanical Companies, etc.	One formed in September, 1915; 1 per Army authorized Autumn, 1916. Boring Section added to each Company end of 1916. Airlifts added to each Company during 1917.	Improvised in 1915. 1 Electrical Power detachment per Army authorized March, 1917. 1 Boring Company formed February, 1918. 1 Compressed Air Company formed April, 1918. 1 Mechanical Trench-Digger Company formed July, 1918.
Workshop Companies.	Improvised beginning of 1915; 1 per Army authorized June, 1917.	Nil.
Labour Battalions.	June, 1915.	Spring, 1915.
Training Depots at Front.	February, 1917.	First in October, 1915. Generally extended to all armies.
School of Instruction (Officers).	Towards end of 1916.	Towards end of 1916.
Total peace establishment.	7,000.	20,000.
Total strength after mobilization.	14,000.	120,000
Maximum strength during war. Excl. transportation.	250,000.	} 170,000.
Maximum strength during war. Incl. "	330,000.	

UNIT.	BRITISH.	GERMAN.
Divisional Engineers. Headquarters.	Attached before war: mobilized with E.F.	Unofficially formed during 1916; formally approved January 24th, 1917.
Divisional Engineers. Field Companies.	2 per Division on mobilization: all Divisions raised to 3 from beginning of 1915.	1 or 2 per Division on mobilization raised to 2 per Division by middle of 1915. Later new Divisions sometimes only had 1.
Bridging Trains, etc.	60 yd. normal bridge per Division (with Field Companies). 250 yd. normal bridge per Army (in Pontoon Parks). Special steel spans of all sorts from Base Park additional.	35 m. normal bridge per Division (in Divisional bridge train.) 120 m. normal bridge per Corps (in Corps bridge train). Special heavy bridge train additional.
Army Troops Companies.	On scale of 1 per Division in the field, from middle of 1915.	Originally available on scale of roughly 1 per Division. Gradually reduced to 1 per 6 Divisions. No regular scale or allotment.
Searchlights. Hand. Anti-aircraft.	Small detachments attached to Field Companies at end of 1914, but soon disbanded. Asked for in March, 1915; first unit in the field, April, 1916.	At first 1 section per 2 Divisions. Gradually raised to 1 per Division. First detachment September, 1915. Gradually added to all Divisional S/L. sections.
Mining Companies.	Improvised, December, 1914; first regular Company early 1915. Total of 35 Companies employed in France.	Improvised winter, 1914. 30 Companies raised during 1915. Total employed—between 40 and 50.

THE ABOR MILITARY AND POLITICAL MISSION, 1912–13.

(Continued.)

Compiled from the Diary of the late Capt. P. G. Huddleston, R.E.

2. The Siyom.

Jan. 17. Main advance up right bank of Dihang fixed on. Trenchard arrived by pony about mid-day and gave me my instructions, as we may not meet again for two to three months. To-morrow I walk through to Rotung in one day, 24–6 miles, and the Siyom party, including myself and one surveyor, start on the 23rd, our object being to explore and map all the basin and tributaries of the Siyom River, which joins the Dihang from the west. So I am in luck again!

Jan. 20. Non-stop run to Rotung (exclusive of halts of 5, 10 and 45 minutes), 5 hours, 40 minutes. Not a bit done. Porter and Hore delighted about going to the Siyom and, indeed, we are in luck.

Jan. 24. Yambung, where the main body and headquarters of the great Abor expedition sat for 3 months last year. Got off much better than I expected, about 9 a.m. Got rather excited for a moment, as I thought somebody else was going to bag my coolies. Reached here about 1 p.m. and fished in the Yambung Pool. Our party consists of Capt. Hore (Political officer) in charge of show, Capt. Porter in charge of escort, self, Hamid Gul, surveyor, 1 doctor baboo, 49 rifles, 12 survey khalasies and 65 coolies to carry the kit, also a month's rations from the day we reach Kombong. Carter and 25 sepoys and 285 coolies accompany us as far as Kombong where they return to the main advance up the Dihang. It remains to be seen if the Galongs will carry our loads from Kombong on.

Jan. 25. Camped in jungle on banks of Yambung River. Climb of 1,800 ft. up, and by the time the last coolie reached the top it was like a mud slide. Rained for 2 hours.

Jan. 27. Camp Tadung, a Galong village, visited by white men for the first time, though Dunbar last year, in his dash to Kimbong, passed fairly close. Off 7.15 a.m. to top of pass. Complete mist on top, so started pacing by steps and time and compass bearings, and heights by barometer. By the time we got into the valley below, it cleared and then, climbing a small hill and cutting jungle in two places, got an excellent view of the Sipu valley and the main Subansiri-Siyom divide (11 000–13,000 ft. hills) in the late afternoon.

Jan. 28. Kombong at last, with its 200 houses "beetling on a crag" as described last year, goodness knows why, there's nothing like a beetle about it, though it is certainly a very fine site and like a small town. Up in the dark, off at 6.30 to hill we had cleared. Only 3,000 ft. Thick mist suddenly started and snows disclosed themselves above a sea of fog and mist; then, worse luck, it came on to rain and the mist came down again; but luckily not before I had got readings with 3 in. from 6 of the peaks, and Hamid Gul had proved some more. Till 1 p.m. occasional peeps through the mist, and amusing the Galongs; then had to come down in disgust. After coming down the hill from Tadung, there is an expanse of sloping fields for the last 3–4 miles all about 1,600 ft. above sea-level, a unique feature for the Himalayas. Streams with low banks, in fact, a most happy valley which it will be delightful to fill in on the world's map, together with the other valleys running up into the snows. Reception by villagers fair. We should have no trouble.

Jan. 29. Went up to the village and to hill above it, where, after clearing, waited till the mist rose about 12.30, disclosing the Siyom with villages. At 2 p.m. dashed back through the village and up another hill about 3 miles off, and back to camp just after dark, really quite a successful day. Hore and Porter in camp diplomatizing with the *gâms* and found it no easy matter. The tribe naturally wants to know why we have come, and is suspicious. No wonder, as it is the first time there is any question of their coming under British suzerainty. One little difficulty is they will at present only take whole rupees and won't look at our 4-anna pieces. In clearing, got the Galongs to work by promising to let them have a look through my binoculars and by firing off my shotgun for them. What a lot of dog-eating shirkers they are! Any excuse for *bakshish*.

Jan. 30. Late rise. No use going off before 10 a.m. as mist did not rise till 11.30. Hore and Porter's diplomacy most successful. Meeting with *gâms* satisfactory. Villagers very pleased with us. Sepoys swapped a pig for a blanket, and chickens for brass buttons are a very ordinary swap. Hore and Hamid Gul to go to Doji and Nomdir, then to Basar on light kit. Porter and I with main force, loads to be carried by Galongs to Along at the junction of the Sipu and Siyom, from where I shall probably do some 2- or 3-day *chukkas*.

Feb. 1. Off 7.30 to Lupum hill, cleared for 2½ hours, got filthy dirty with *ringalls* (small bamboos), had to wash my hands in my cold tea before I could touch my plane-table. Talking of swopping, yesterday I got a flint and steel bag for a box of matches: most of the hill tribes along the Himalayas use these of one pattern or another. The Galongs grow their own tobacco and always have a pipe in their mouths. It would be interesting to know where this tribe originally came from. They must have been here for at least

200 years, but they say they don't know. The surrounding tribes of Abors look upon the Galongs with great contempt as "dog-eaters" and remain quite separate. From the hill did a most satisfactory day's work for the country ahead.

Feb. 2. Camp at the junction of the Sipu with the Siyom, a junction that we had (all being fishing men) had in our imaginations for some time, though, of course, no *sahib* has ever been near. And we were not wrong either, as after finishing my plane-tabling, and while the camp was being finished, I took out my rod and had two 10-pounders and a 22-pounder in half an hour just before dusk, which could not very well have been better, considering the lowness of both streams. Thanks to Hore's and Porter's diplomacy, the Kombong *gâm* duly produced 121 of his villagers, who by 9 a.m. were carrying our loads through Pankam to Along, which we reached at 1 p.m. They were then paid off at 8 annas each, and to Porter's delight, took the 4-anna pieces. The Kombong *gâm* is evidently a character, as he keeps most unquestioned sway over his villagers and neighbouring villages. The Along folk are fishermen, using long bamboo rods with a line of fibre and a row of nooses and stone. They then float down the Siyom on bamboo rafts and chucking the noose in front of them pull it up. As they float 6–10 of the rafts together, fishing is a very pretty sight. A crowd assembled when I started fishing and they evidently looked on me as a worthy brother angler. To complete a most delightful day, a Galong brought our letters in.

Feb. 4. Found some fishermen with their bamboo boats; they, after some hesitation, agreed to lash 5 together into a raft and take us across. This they did most successfully, 5 at a time in 7 trips in about 1½ hours. The country up the Siyom is now disclosing itself and it is very exciting now that every day opens up new country. The river here splits round many islands and is evidently very low at present. Got two fixings *en route* and one in camp (Jomlo) which we reached at 3 p.m., giving plenty of time to make the usual perimeter and build our *bashas*.

Feb. 5. Set out 7.30. In 7.30. Very nearly bit off a piece more than I could chew in one day, but luck was with me, as the Sirit River is extraordinarily simple, with from 6,000–3,000-ft. slopes running down to a ravine at the bottom, and the villages standing out clear on the slopes. I had a lot of trouble as regards villagers, who are Minyong Abors up this valley, and it would have been better if I had given them more notice and got the headman of the biggest village to come along with me. The Minyongs are most democratic and do nothing without a council in their village town hall, called a *moshop*. The Jomlo *gâm* put in a very late appearance, making me wait for him, but though he sent his brother as a guide, he refused to come himself, and only brought me *apong* as a *salami*. This I refused to drink. Mori also gave me a guide but no *gâm* put in an appearance. Same at Jomoy. Plenty of *apong*, but they seemed a most undisciplined crowd, though a big village, and with plenty of young men looking fine in full war kit or *shikar* trim. Road to Rengkhu behind Mori over hill down into the head of the Sirit again and then over the watershed. Wonderful weather when once the mist clears, and snows brilliant at noon till after 2 p.m. Sometimes the whole valley hillsides are blocked out by the *jhum* fires which they are now burning ready for their fresh fields this year. I was asked continuously to-day by single Abors, putting a leaf over their nakedness, to give or sell them cloth. Such is one of the first unnecessary needs of civilization, reminiscent of the Bible though it is.

Feb. 6. Camp opposite Along. The Jomlo villagers seemed desirous of giving the customary presents of eggs and drink, etc., and dissatisfied with their *gâm*. However, I did not take them, and after enduring half an hour's discussion as to the best route, got off. Sent 6 sepoys off with baggage to the Pebu junction and climbed up from 750 to 3,250 ft. up the Rolging fields, but on getting back, suffered a most anxious 15 minutes, as there were no signs of camp. However, by chance, we saw it a mile ahead and I had a few words to say to the *havildar*.

Feb. 7. Along camp. The *havildar* and the Miri *kotoki* (interpreter) made an excellent raft out of three small Abor raftlets we found on the bank, and they ferried us across before 9.30. This bucked me up considerably, as now we can always cross the Siyom, independently of the Abors or Galongs, as long as bamboos are available from the jungle. Completed area east of Along and got back to main camp at 3.30. Galongs well in hand, and ready to do anything for us. Tea, and then to fish with an enormous, greedy crowd watching, which luckily was not disappointed: 3 fish in an hour, 19, 9 and 5 lb., and it would have been more if we had not eaten too long a tea.

Feb. 8. Inked up all day. Filling 250-ft. contours over about 100 sq. miles takes longer than I expected. Fished after tea. Three fish again, 25, 12 and 4 lb. Magnificent sport.

Feb. 10. News that Hore and Hamid Gul are ahead, having evidently worked round as I asked them to. This is great. I am very excited to see what they have turned out.

Feb. 11. Hore and party in. Successful. Hore at Basar was asked to decide in a case of a wife who had been captured by that village from a village of the foot-hills, which are now under our control. Both sides were present, so he asked the woman who promptly said she would not return to her old husband, and was perfectly happy in Basar. So Hore decided they might keep her, but were to pay the deprived husband a heavy fine of 5 cows, 10 pigs, etc., and 15 rupees, which satisfied all except the husband himself. A curious but excellent punishment, like our stocks in the market, was a man in Kombong, who had been condemned by the head *gâm* to wear a heavy wooden log on his leg for 3 years. His leg was through a hole in the middle and he could only get about by supporting it at each step by two ropes at each end, which he held in his hand.

Feb. 12. Hamid Gul inked in his work and I plotted some more points. As it was my last day at this junction, I fished and caught first a 6-pounder, and then, what do you think? A 40-pounder! This beats my 38½-pounder at Pasighat. This was most cheering. Porter is now opening wider and wider the mouths of the Galong *gâms* with some very clever conjuring tricks.

Feb. 13. It was arranged that I should go ahead with half the rifles and we started up the valley of the Siyom, which continues open except for a magnificent crag round the face of which the path wriggles, and from a jutting-out ledge of which a magnificent Abor cane bridge spans the river, here at least 100 yards broad. If for nothing else, these Abors and Galongs ought to be noted for their wonderful cane bridges. After Beni, the Siyom runs through a narrow gorge with several rapids till Wak. Reached camp at 1.30, and leaving the most capable *subadar*, Gang Singh, to mark out and build camp, went off to fish. Apparently my Along reputation had also arrived, as I was accompanied by a crowd of rather sceptical villagers. First few casts near in landed me in a fishing trap, from which an obliging villager detached me with his raft. Changed to a No. 8 spoon, the size of a soup spoon, so as to get right out. Tug. Rush. Bust and a line, minus trace and spoon, came back to me. Villagers interested but disappointed. Spoons being a bit short, changed to a No. 10., size of a gravy spoon. Tug—missed him. A few more throws. Got him! Yes, got him! And in 20 minutes he had been cut on the head by an Abor and was scaling 26 lb. A 15-pounder followed and then some small fish. Abors quite satisfied.

Feb. 14. Could we be having a more fascinating time and experience, especially coming through this more fertile portion of the Siyom? I could not help thinking as one eyed a fishing junction, how comfortable Alexander and his soldiers must have felt when first seeing and marching through richer portions of Persia and Hindustan. Our sepoys are always saying, in their own way, "Top-hole land," and our old head coolie told me how comfortable and rich he could make himself if the Sirkar (Government) would give him a small bit of a hillside in this part.

Feb. 16. Camp at Kambang, at junction of Hirit River. Rained practically continuously all day. In fact, the mist has not risen properly above 4,000-ft. hills since the 9th. Beastly.

Feb. 17. Rain all night and rain all day, till the afternoon, and now we pray that a break in the weather may have come. Our coolies went back to-day and brought up some more rations, but only 19 Abors came. Hore writes that the Wak *gâms* are giving trouble also. An awful shock! Some of the rations have gone bad, having been found fermenting in their bags. So our troubles are beginning, which will add zest to the work. Porter fished in the Hirit junction, but no luck, so I crossed over 200 yards above and in 2 hours caught 7 *boka*, 56 lb. in all. Coolies are most enthusiastic over getting fish nearly every day.

Feb. 18. No high hills clear yet. To our delight, 75 Kambang men went back to Wak to bring the remainder of the stuff and Hore up here, much to the Wak men's disgust. Weather looks more hopeful.

Feb. 19. Waited for guides, who did not turn up, so went off along the river and after much shouting and patience a Galong man came over the Siyom on a raft, and after offering him a cigarette and chatting a bit, suggested he should tie another small raft to his and come over again with his pal and ferry us (15 in all) over. This struck him as a good idea, and back he went, but when the raft was ready a *mithun* turned up which they wanted to take across, so we had to wait till after many struggles they got it into the river. They then condescended to come back and take us across, but it was too late to go up the higher hill, so we went up about 1,000 ft. and then at 2.30 the snows gradually began to disclose themselves and we got by the evening one of those magnificent views that one gets in the Himalayas after a week's rain. Several of the hills that before had only been tipped with snow are now covered much lower down. Every day opens up new valleys, and the survey work is so interesting that I forget to tell the numerous amusing and quaint incidents which occur daily with the savages in the villages around. I don't quite know what constitutes a savage, but each march the tribe —generally a group of 3 to 4 villages—gets more jungly; wants money less but clothes and salt more, and gives louder exclamations of wonder at the things one shows them. They, however, remain just as suspicious of what we want. I am off to-morrow for 6 days to the west, to the foot of the 13,096 range.

Feb. 20. Below Sholing village. Started along left bank of Hirit and reached the bridge opposite Kambang village of 50–60 houses, situated round a wooded knoll alongside a most lovely long pool above which we had to scramble. The path had given way in two places and we had to cut down small trees across the gap to make certain of the coolies getting over safely. Then over a hill and round a corner and we suddenly got a view of part of the head waters of the Hirit and several Karkang tribe villages. The country, with the snow range immediately behind, is much more like the usual Himalayas with the villages high up the hillside and the rivers far down in a ravine below. Very nice for surveying quickly. The people also suddenly changed to long-haired creatures dressed in skins. However, to my surprise, they seemed delighted to see me, and I hope we shall have a friendly exchange of presents in the village to-morrow which we could not reach to-day. Weather splendid and Hamid Gul filled in another little bit of this old globe. Villages up here absolutely not known before.

Feb. 21. Half-way up the hill to Sholing, several of the headmen and women met us with drink, eggs and chickens. Yesterday's Kambang guides (of another tribe) were with them and they were evidently *badmashes*, as they said they would not take the salt and cloth as payment, and then again, not the 1s. 8d. in 4-anna pieces. They were, of course, only wanting more, so I gave their salt and cloth to the Sholing villagers, with a bracelet to the old woman who had brought the drink. They were evidently delighted, so it only remained to leave the money in the Kambang men's hands and angrily eye them into silence. As they moved on, we were much amused to see the Galong *kotoki* produce some cloth of his own and do a most profitable deal for the money the men had pretended to disdain. Of course, they see we have more, and, like spoilt children, so to speak, cry if they can't get it. The *kotoki* discovered a lost female cousin among these Karkang Galongs and they were most friendly, giving me more drink and eggs, in return for which I with some ceremony presented him with a pair of cheap scissors, to his intense pride and delight. During this pow-wow, Hamid Gul was sketching in the country from a knoll near, from which, only 2,860 ft., he got a magnificent view of the head waters of the Hirit coming straight down from the 12,000–13,000 snowy range, the top 4,000–5,000 ft. of which are a sheer drop. Weather glorious, the proper sniff of the Himalayas in one's nose. The pleasure in the lovely scenery is rather diminished by a beastly little fly (*damdin*) which swarms in the fields and small jungle, and insists on exchanging, wherever the skin is exposed, its own poison for your blood. The poison is most irritating, waking you up two or three times at night to insist on being scratched.

Feb. 23. Along a nasty path, above the Hirit up to Boru village. Hamid Gul who went ahead had a most lucky escape. His foothold slipping, he fell a few feet, and then, turning several somersaults fell sheer, he says, 50, probably 20–30 ft., into the river below, by the grace of Providence into a deep pool, and not on to rocks. Hence, instead of killing himself, he merely bruised his knee and got a bad ducking. He is an enormous, fair-complexioned Pathan, as strong as a horse, with an insatiable and untiring desire to survey-in more and more country, and makes it a point of honour not to be done by rain or mist or the many daily difficulties that occur, so is first rate for this sort of work. Went over the 4,400 pass at the back. Rain all day and had to camp in the rank jungle. Extraordinary how quickly the Gurkha sepoys, khalasies and coolies make you and themselves comfortable.

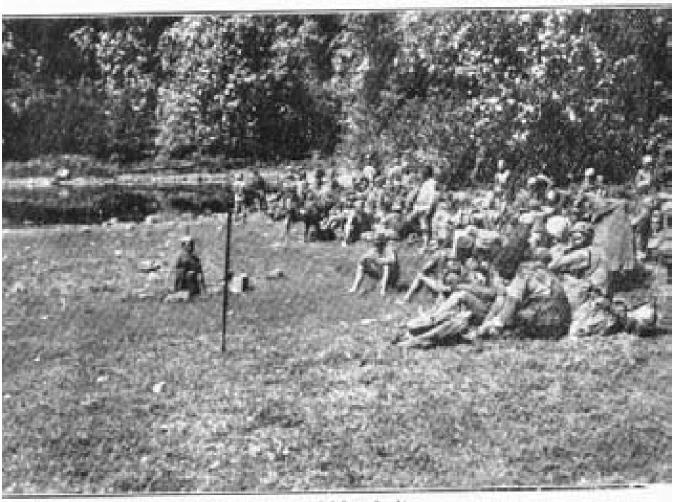
Feb. 24. A most dreadful day. Rained hard all night and most of the day and then harder. The road could not have been worse. A vertical mud slide up or down or along which we and the poor coolies slithered and cut steps in places. Up 1,000, down 450, up 400, down 600, up 700, down 650. Bridged the Siyom River, up 1,700 and down 1,600 to the Kebung River, below Yangking, which we waded. Leaving 4 rifles with the coolies, took the rest and just finished a footbridge in 2 hours. By the time the coolies came up, they could not have waded safely. Yangking villagers most friendly, brought up firewood and helped in making the camp. Very bad day. Survey work out of the question.

Feb. 25. Left Yangking and, to our delight, struck Hore, at the advance camp at Puitgong junction. Kaying is just ahead, a Minyong village, the *gâm* of which told Hore he thinks the Bori tribe, 3 villages ahead, will fight us. However, we have heard that story before. Hore wishes they would, as we could then insist on help as terms of peace. In Kambang some 100–200 were just going to carry our loads, when a young buck stepped out and harangued them not to. Hore immediately had him and another seized, and, kicking hard, placed in camp under guard. The rest had, meanwhile, bolted, but returned slowly when they did not hear their pal being shot. Result miraculous. They carried our loads without a word, and the haranguer was released next day when all the loads had arrived. Extraordinary how trusting they are. Last year, they would allow themselves to be disarmed of their own will, and be taken into an armed camp, though they had never seen a *sahib* before and had only heard of him by report. It surprises me that women and children don't bolt when we enter a village with our sepoys with fixed bayonets.

Feb. 26. Nothing but glimpses through mist and rain for 4 days now. More and more news that the Boris mean business and that they have been ordered to stop us by the Mimats behind them, who, it now seems, are an outlying tribe of the Tibetans, and, by report, cannibals. Things are really getting interesting.

(*To be continued.*)

Potung crossing over Dihang.



A midday halt.

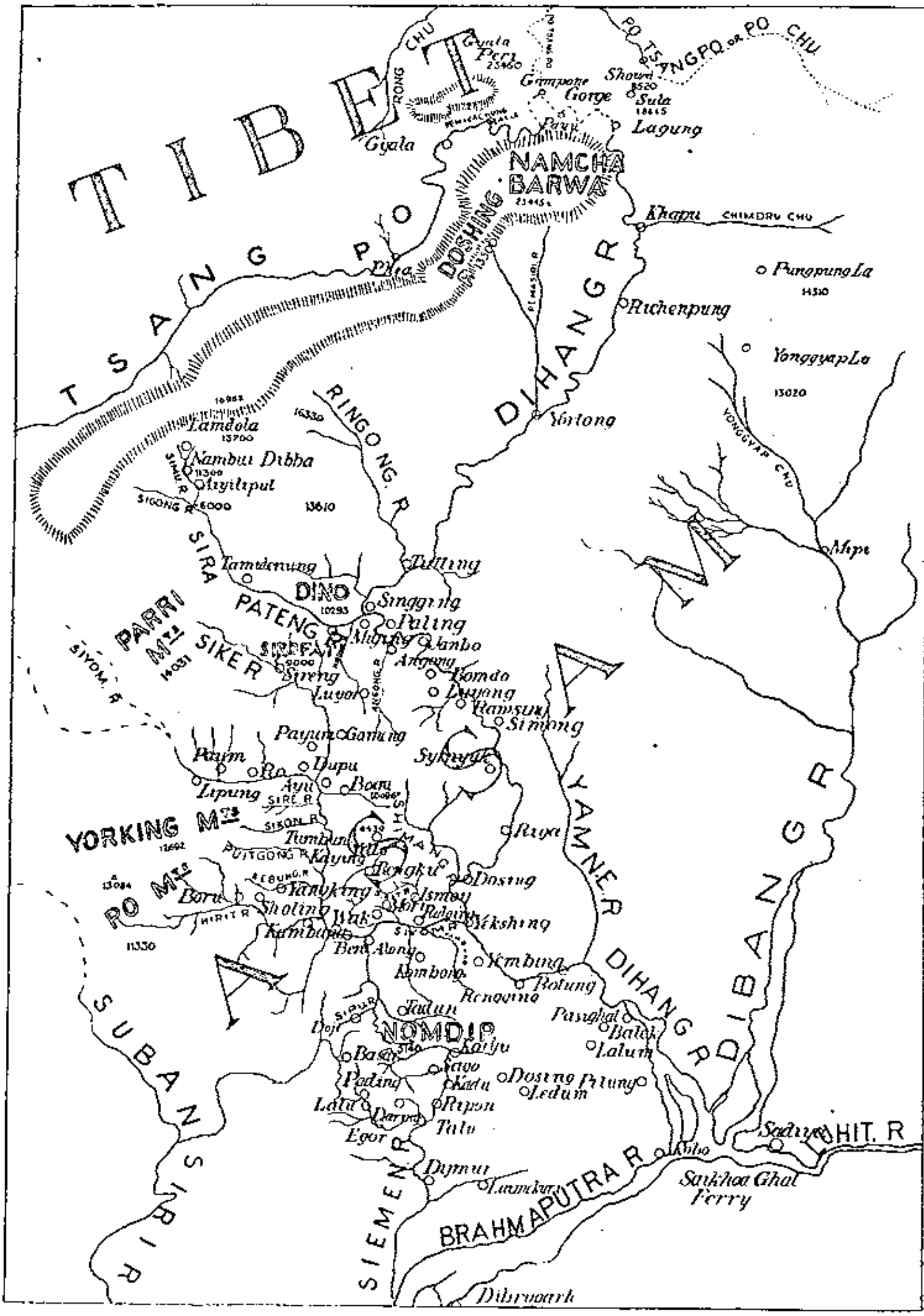
Abor Military & Political Mission.

Fallen tree cut down to span Nigong, with coolies going over it.

Coolies starting off with full loads.

Coolies starting off with full loads

THE ABOR MILITARY AND POLITICAL MISSION, 1912-13.



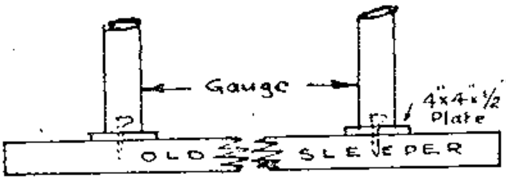
Sketch Map shewing Abor Country, and Gorge of Tsang-Po River.

track when they are withdrawn. The remaining earth can be made good afterwards.

If the bank is over 5 feet high, a gallery can very quickly be made from 3-in. tubular scaffolding (*see photograph facing page* 428).

Since the footings have to remain in the bank, they can conveniently be made out of old sleepers, on which must be placed two small bearing-plates 4 in. x 4 in. x ½ in., to prevent the tubes cutting into the sleepers. To keep each plate central to the sleeper and prevent the tube slipping, or getting knocked off it, a hole is drilled in the middle of the plate, and a dogspike half driven through.

Soft ground may necessitate more than one sleeper underneath to distribute the pressure. Each sleeper provides about 7 square feet of bearing area and the load on the piers, if they are spaced to correspond with axle spacings, is the same as the axle load, or 9 tons maximum with ordinary 4-wheeled wagons. One sleeper is ordinarily enough for each pier.



As the tubes are of fixed length, and the load is applied on the top, great care is needed in levelling up the footings, so that the horizontal tubes may not get bent, owing to the tops of the verticals being uneven.

While the first two footings are being levelled, the first two piers can be assembled, each consisting of two upright tubes and one transverse tube, attached to the uprights by couplers.

When ready, they are lifted by hand on to the footings and kept in position by an intermediate longitudinal tube each side, coupled to the uprights about 5 feet above the ground. These intermediates do not appear in the photograph, but serve as platforms for men to stand on when fixing, by " finial " joints, the top of the vertical tubes to the longitudinal members which tie them together.

When the next pair is ready and lifted up into position (by a rope over the previous pier), it can be kept temporarily in place by the intermediate longitudinal members which are slid along through their couplers on the previous pier. The couplers on the last pier but one can be removed when no longer wanted.

During erection the stiffness of the joints prevents side sway, but to prevent any lateral movement while the gallery is under load, side struts are needed. These are formed from longer tubes, coupled to the top longitudinals, and as near as possible to each pier. At their foot, a half sleeper is let into the ground at right angles to the stay tubes and rammed tight. (One of these sleepers can be clearly seen above the grass on the left of the photo; most of the others are hidden by the grass.) Before being coupled up tight to the longitudinal, the tube is used to ram the sleeper hard against the ground. If the piers are canted about 2 in. towards the beginning of the gallery, this will allow for any forward movement which may be caused by braking the train, and the rails moving in their fish plates.

At the far end of the gallery, fore and aft struts, similar to the side stays, may be fixed as a precaution to minimize any jar to the gallery should the train bump into the stop at the end of the track. This end strutting is not really wanted, because the track cannot move forward more than the full stretch of the fish plates, unless the fish bolts shear, but it has a good moral effect on the unloading party.

The track should, of course, be fully fished up and is held to gauge by gauge ties, as already described. It rests on ordinary sleepers laid over the "finial" joints of the piers.

These sleepers can, if necessary, be held in position by spun yarn, or wire, while the rails are being run out. Alternatively, if the side struts are extended slightly above the longitudinals they prevent the sleepers from shifting forward.

When once the load is applied, the underside of these sleepers crushes on to the finial joints. This fixes them firmly in position.

The rails can be run out in pairs along planks, using tubes as rollers. If no planks are handy, the first two rails are run out just over half their length (after which they would tip up) and laid on the transverse sleepers. They then serve as a runway for another pair of rails to be rolled out to their proper position in the track. The process is repeated until the track is laid over the complete gallery.

When all is ready and the earth train arrives, its wagon doors should be unhooked before the rake runs out on to the gallery (where the door catches cannot very easily be knocked up from below).

Emptying each 10-ton truck takes 3 men about 15–20 minutes, unloading both sides, and when the truck is empty no further shovelling is needed, since the earth has fallen quite clear of the track.

The fall of the earth leaves the joints of the tubular scaffolding free to be withdrawn, even when the earth is piled as high as the bottom of the door flaps seen in the photograph. If the track is raised clear of the gallery on jacks, and slewed slightly to one side to allow the uprights to come out, all the tubes can be withdrawn without dismantling the rails.

The vertical tubes are easily pulled out by three men using a rope, but the side stays take seven men, owing to their greater length, and the fact that there is a good weight of earth above them. For this reason it pays to remove alternate side stays before they are completely covered with earth. It is possible that all the side stays can be removed, when enough earth has been unloaded to reach their underside, but this has not yet been proved.

With the piers out of the way, earth can be shovelled into the central longitudinal cavity and the track re-laid on ordinary sleepers, doubled until the bank consolidates (the extra sleepers not being spiked). It may be necessary to bring up more earth to increase the bank to full width and correct the side slopes.

With practice 20 men can lay 100 feet of such a gallery 10 feet high in 4 hours, provided that levelling the footings can be done in a reasonable time, and that materials and tools are all ready to hand.

Removing 100 feet of a 10-foot gallery and replacing the track takes 20 practised men about two hours.

A 15-foot gallery is about the highest which can be built without cross-bracing the vertical members to reduce their unsupported length. Alternatively, extra vertical members can be provided.

With higher piers, the upper half of the vertical members must be cross-braced in such a way that the cross-bracing can be removed, or gradually raised, when the earth reaches up to them. If the earth is evenly rammed round the legs it will take the place of the bracing while the upper half of the bank is being tipped.

The only drawback to this method of making a gallery is the first cost of the tubular scaffolding, about £2 a foot run for a 10-ft. bank. When, however, it is remembered that only one old sleeper, two 4 in. x 4 in. x ½ in. mild steel plates, and two dog spikes, are lost at each pier (a matter of two or three shillings), and that the remainder can be used over and over again, the ultimate cost will compare very favourably with any other method of making banks over 5 feet high, in Europe or America. (In Asia or Africa the coolie, or donkey, and basket remain without a rival.) Higher banks than 15 or 20 feet would have to be made in two or more layers.

It is an advantage to make any kind of tipping gallery higher than the top level of the bank, since the full amount of earth can be tipped and dressed to level and slope before the gallery is removed. Any deficiency of soil then noticed can very easily be made good.

Many other uses for tubular scaffolding will at once suggest themselves to the practical engineer, such as staging for water towers, landing stages, piers for bridges, falsework for girder erection, etc.

In connection with the last, Indian railways have used "Sullivan staging," a form of tubular scaffolding, for nearly half a century, and it answers admirably for this purpose. It is, however, heavier than the tubular scaffolding described above, and as the lengths of the diagonal bracing rods are fixed, it has not the same flexibility as the tubular scaffolding, the bracing of which is formed of tubes which can be fixed just as required.

From the tables below it will be seen that these tubes are of little value as beams, their greatest strength being developed when they are used as columns.

The speed with which tubular structures can be assembled should make them particularly useful to R.E. Field Companies.

PATENT 3-IN. STEEL TUBULAR SCAFFOLDING (WELDLESS TUBE).

(Made by Messrs. Scaffolding (Great Britain) Ltd., Lansdowne Road, S.W.8.)

Outside diam., 3·00 in. Bore, 2·375 in. Area, 2·64 sq. in. Section modulus, 1·6. Radius of gyration, 0·97 in. Tensile strength per sq. in., 30 tons. Weight per ft. run, 9 lb. Weight per coupler, 22 lb. Weight per base, 22 lb. Coupler slips with a load of 3·5 tons.

LENGTH.	COLUMNS.		BEAMS.	
	Compressive load at which tube would buckle in tons.	Safe load recommended for columns.	Transverse central load at which tube would fail.	Safe load recommended for beams.
6	53·8 tons	13·4 tons	3·2 tons	0·80 tons
7	49·6	12·4	2·7	0·67
8	45·7	11·4	2·4	0·60
9	41·6	10·4	2·1	0·52
10	37·2	9·3	1·9	0·47
11	33·7	8·4	1·7	0·42
12	30·2	7·5	1·6	0·40
13	27·2	6·8	1·5	0·37
14	24·5	6·1	1·4	0·35
15	22·0	5·5	1·3	0·32
16	20·0	5·0	1·2	0·30
17	18·0	4·5	1·1	0·27
18	15·0	3·7	1·0	0·25
19	13·0	3·2	1·0	0·25
20	10·0	2·5	0·9	0·22

PATENT 2-IN. TUBULAR SCAFFOLDING (WELDLESS TUBE).

Outside diam., 1·90 in. Bore, 1·47 in. Walls, 0·21 in. thick. Area, 1·13 sq. in. Section modulus, 0·42 in. Radius of gyration, 0·60 in. Tensile strength per sq. in., 20 tons. Weight per ft. run, 3·75 lb. Weight per coupler, 5 lb. Weight per base, 5 lb. Coupler slips with a load of 1·75 tons.

LENGTH.	COLUMNS.		BEAMS.			
	Compressive load at which tube would buckle in columns.	Safe load recommended for columns.	Transverse central load at which tube broke.			Safe load recommended for beams.
	Tons.	Tons.				
6	14·60	3·65	Span		B.W.	Tons.
7	12·30	3·08	Ft.		Tons.	
8	10·37	2·59	1·0	—	7·50	1·87
9	8·77	2·19	2·0	—	3·75	0·94
10	7·45	1·86	3·0	—	2·50	0·62
11	6·30	1·57	4·0	—	1·90	0·47
12	5·50	1·37	5·0	—	1·50	0·37
13	4·90	1·22	6·0	—	1·25	0·31
14	4·20	1·05	7·0	—	1·07	0·27
15	3·60	0·90	8·0	—	0·94	0·23
16			9·0	—	0·84	0·21
17			10·0	—	0·75	0·19

R.E. CO-OPERATION WITH CAVALRY.

By MAJOR C. J. S. KING, O.B.E., R.E.

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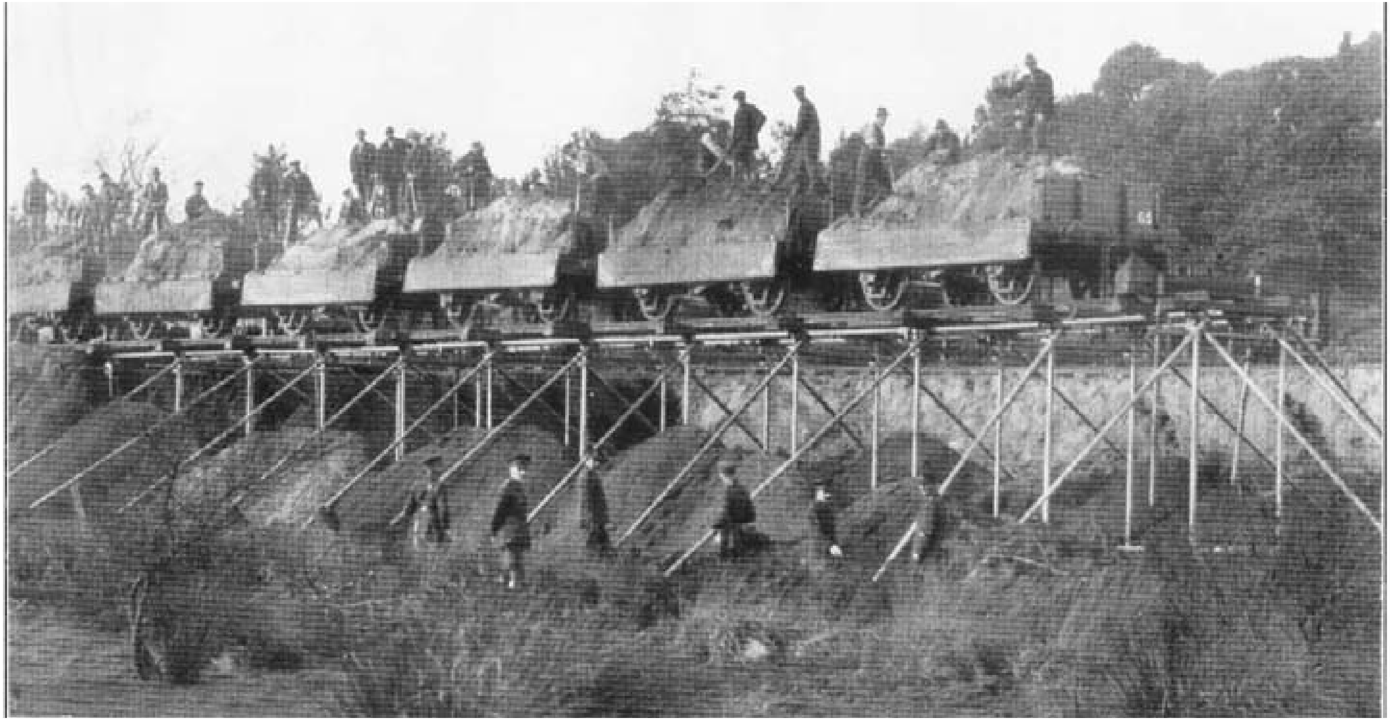
THE recent appearance of a revised *Cavalry Training Manual* offers a suitable opportunity for a consideration of the subject of R.E. co-operation with cavalry. In the manual the amount of space that is devoted to this subject is small compared with that devoted to the principles of co-operation with other arms, and the reason for this is not far to seek. There is not very much to be said on the general principles, and in a *Cavalry Training Manual* it is not possible or even desirable to enter into any great detail of the subject. Such detail would involve technical descriptions which would be entirely out of place and which are available in *Engineer Manuals* for those who are curious enough to investigate.

From this preliminary remark, it might appear that there is nothing more to be said on the subject, as it is all available in *Engineer Manuals*. This, however, is hardly the case, as the earnest seeker after knowledge would find himself in considerable difficulties if he plunged into all the various engineer publications affecting the subject. The basis of co-operation is knowledge, and it is, therefore, essential that the cavalry officer should know what he may reasonably expect from the R.E. unit with the cavalry division, how much the unit can do, how long it will take to do it, what assistance is required from the cavalry units, and finally, perhaps the most important of all, what the R.E. unit cannot do.

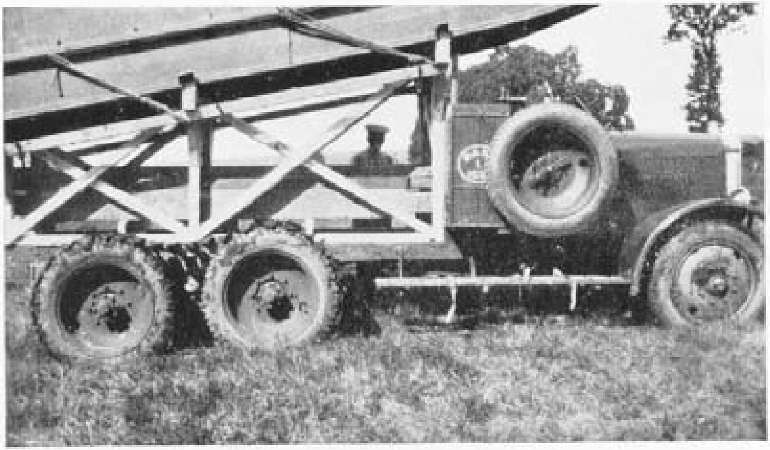
R.E. co-operation with any arm is difficult to practise in peace time, since practically all the work involves either destruction or construction and takes time. The first two cost money and the last may cause an apparent waste in the limited amount of time available for manœuvres; R.E. work is therefore frequently left in the background during manœuvres and false lessons are apt to be learnt.

The Cavalry Division is in a specially unfortunate position, since it does not exist as a formation in peace, and it only functions as such on the rare occasions of Army manœuvres. With the exception of Aldershot, and to a lesser degree at Tidworth, opportunities for co-operation are absent. This article is written with the idea of



Railway bank construction

R.E. CO-OPERATION WITH CAVALRY.



Transport of Pontoon Bridging Equipment.

A complete bay of 21 feet, complete with all the necessary superstructure is carried on the lorry and trailer. For the landing jetty bays, no trailer is required, as all the stores are loaded on the lorry. The lorry is a Guy Medium 6-wheeler.

Transport of Pontoon Bridging Equipment

setting forth the lessons learnt at those two stations in the past three years for the benefit of those who did not take part in them.

Organization.

The R.E. unit with the Cavalry Division is the Field Squadron R.E. It is now on a mechanized war establishment, but it has not yet been mechanized in peace. This has been imminent for some time, but has not yet been carried out. In the following pages only the mechanized establishments are considered.

In war, the Field Squadron R.E. consists of the following :—

Headquarters.
Headquarter Troop.
3 Field Troops.
1 Bridging Section.

In peace there is one Field Troop less. The unit is carried entirely in mechanical vehicles except that the O.C. is mounted and each Field Troop has a mounted reconnaissance party of 1 officer and 6 other ranks, which as its name implies is purely for reconnaissance and should always accompany the advanced mounted troops as a matter of course.

Each Field Troop can produce a working party of about 36 sappers, and it carries sufficient entrenching tools for its own use only ; it also carries artificers' tools to a very limited extent, but sufficient to enable it to undertake small jobs, provided that the necessary material can be found. 1,120 pounds of explosives are carried.

The Headquarter Troop corresponds to the Field Park Company with a Division. It can produce a working party of about the same size as a Field Troop and it carries entrenching tools and a more complete set of technical tools. It also has a mobile lighting set, for the use of Cavalry Divisional Headquarters.

The Bridging Section is a recent addition to the unit and it carries material for the following bridges (*Cav. Tg.*, Vol. II, Sec. 74) :—

Assault Bridge, 208 feet.
Pontoon equipment (medium bridge), 105 feet.

The use to which this equipment can be put is dealt with in the paragraphs dealing with the actual employment of the unit.

This very brief description of the organization and numbers of the unit is given to emphasize the fact that the Cavalry Division has less R.E. personnel in it than a Division. The proportion is about 1 to 4.

Employment.

Cavalry Training, Vol. II, Sec. 74, gives a list of the tasks that will be carried out by the Field Squadron R.E. These can be conveniently classified under three different heads by arranging them in a slightly different order :—

1. Assisting our own mobility.
   - i. Improvement of tracks and roads.
   - ii. Clearance of obstacles.
   - iii. Fieldworks and bridging.
2. Hampering hostile mobility.
   - i. Construction of obstacles, including the use of anti-tank mines.
   - ii. Demolitions.
3. Miscellaneous.
   - i. Water Supply.
   - ii. Washing arrangements.
   - iii. Shelters.
   - iv. Lighting.

Engineer reconnaissance has been omitted as it is a permanent duty, the necessity for which is present at all times whether any of the special duties mentioned above are being carried out or not. It may be considered as more of a "domestic" duty, since without it, no useful work of any nature can be carried out, and the unit would be entirely useless.

It is now proposed to deal with each of these tasks in turn, and to attempt to give some idea of the amount of work that can be expected from the unit. It is, of course, impossible to give exact figures, since circumstances vary considerably, but the amounts can in many cases be given with sufficient accuracy to give a rough guide.

The Field Squadron has three Field Troops which can work independently, but it must not be assumed that the normal method of employ is to attach one Field Troop to each Cavalry Brigade. The Field Troops must be allotted as required for work, and it would be frequently necessary for the Field Squadron to work as a complete unit.

1. *Assisting Our Own Mobility.*

   - i. Improvement of tracks and roads.
   - ii. Clearance of obstacles.

These two can be conveniently discussed together, since circumstances vary so much that it is really useless to attempt to give any figures. Remembering the size of the working party of a Field Troop and the fact that it carries sufficient entrenching and cutting tools for its own use only, it is not difficult to visualize the amount of work that can be expected. Any work involving heavy earth work or the removal of large trees is a slow business, and in rapidly moving warfare it is generally quicker to make a detour rather than wait for a path to be cleared in a direct route.

Cavalry Training, Vol. II, Sec. 13–2, mentions the necessity for this type of work when mechanical vehicles are being used, but it also emphasizes the fact that the improvement of roads is a last resource when efforts to find a more suitable route have failed.

iii. Fieldworks and Bridging.

The word "Fieldworks" is a somewhat loose term used in the Royal Engineers to cover any form of work carried out during the collective training period as opposed to individual training in trades. Its meaning here is not clear, though it implies quite rightly that the unit should be ready to undertake any job that it is asked to do. In the matter of bridging, very considerable strides have been made in the last few years, and it is essential that Cavalry officers should know how much has been done and what is being done to improve the situation.

Up till four years ago, the Cavalry Division carried no bridging equipment of any sort. With the advance of mechanization the necessity for bridging becomes more and more urgent, and with the formation of M.G. Squadrons and Armoured Car Regiments it is of supreme importance.

After experiments, the amounts now shown in the manual were authorized, but the arrangement is not in any way final; experiments are being continued with another and possibly more suitable pattern.

Method of Use of Bridging Equipment.

For rivers up to 105 feet in width, the equipment is sufficient to make :—

(*a*) Two assault bridges each capable of carrying dismounted men.
(*b*) One medium pontoon bridge capable of carrying any load with the Cavalry Division.

For larger rivers, ferrying is necessary, but there is no limit, except time, to the width of the river that can be negotiated. The reason for the arbitrary figure of 105 feet is as follows. It was necessary to put forward some proposal for a definite amount of pontoon equipment. No suggestion could be made which was based on the likely width of the river; it was therefore proposed to carry sufficient equipment to provide a raft and a landing jetty on each bank and to carry sufficient superstructure to join the whole up into a complete bridge. The attached diagram shows the result, which works out at 105 feet of pontoon bridge. The assault bridge is based on this length. It is perhaps worthy of note that in the last two manœuvres, both in the Aldershot and Southern Commands, no river of more than 105 feet wide was met.

The crossing of rivers can, therefore, be considered under two heads.

i. Under 105 feet.

Men cross on the assault bridges. Horses can be swum on a rope or can be led across by men walking on the assault bridges placed about 4 yards apart. This has been tried and found quite feasible. Machine-guns can be carried over on the assault bridge, but no vehicles can cross until the pontoon bridge is built. Launching the assault bridge is a matter of minutes.

Erecting the pontoon bridge depends very largely on the difficulties of the site; with two Field Troops available for the work, under average conditions it can be done in half an hour from the time that the equipment arrives on the site of the bridge. The equipment can be handled by one Field Troop, but work would be much slower. A working party up to forty men from a regiment would be of the greatest help in unloading and carrying stores.

This bridge will take any vehicle on the establishment of the Cavalry Division, including armoured cars; it will not take tanks.

ii. Over 105 feet.

The crossing will be a much slower business. It would be possible to use the complete set of assault bridges to produce one bridge 208 feet long, provided the current were not too swift. If this was insufficient, men would have to be ferried over on the pontoons. As at present authorized, two boats can be made out of the equipment. Each boat will carry 24 fighting men and would be rowed by 8 sappers with a coxswain. The fighting men sit facing outwards with their feet on the handrail and jump ashore as soon as they reach shallow water. The operation is easy and quick, as the boats are easily manageable in even a quick current.

These boats can be ready for use in ten minutes after the arrival of the equipment on site, but, of course, the use of the boats for ferrying men delays the use of the equipment for ferrying over the vehicles.

It is possible to make up small rafts capable of carrying two men from the assault bridge floats. No paddles or oars are carried for this, but it has been found that ordinary shovels are quite effective, and that the two men can get across a river with a current of three knots in a reasonable time. From the equipment carried, 16 rafts can be made up.

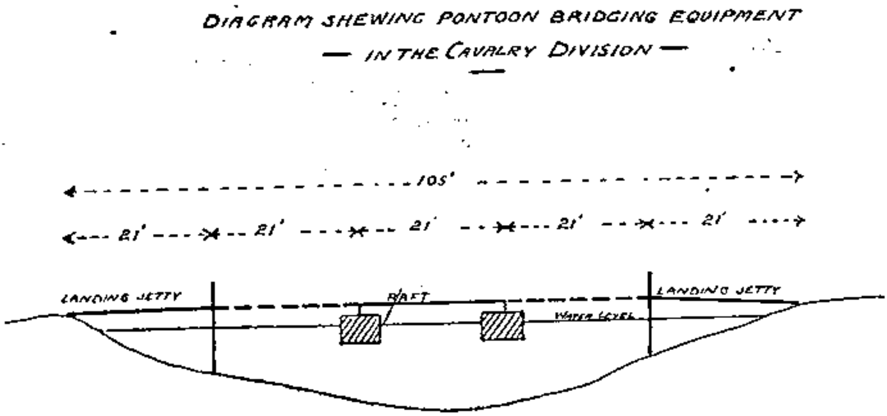
Using all possible means, therefore, 80 men could attempt the first crossing at one time.

For ferrying vehicles a landing bay has to be erected on each bank, and the vehicles taken over on a raft, which can be worked on a wire rope as a flying bridge or pulled backwards and forwards by a rope or, as a last resource, rowed.

As a result of many trials, it has been found that the first vehicle can be got across in about one hour and a half from the time the equipment arrives. The time taken per vehicle after this depends largely on the skill of the drivers coming on and off the raft, but may be taken as about 10 minutes per vehicle for a river 100 yards wide.

If the pontoons are being used to carry men, a certain amount of preliminary work can be done on the landing bays ; the time for the first vehicle after the pontoon had finished carrying men would be about one hour.

The raft can only carry one light 6-wheeler at a time owing to limitations of space. Surplus men and stores can travel on the raft at the same time.



The dotted lines show the superstructure carried to make the complete 105′ of bridge.

This equipment has not yet been supplied to the unit, and it has therefore not yet had a fair trial on manœuvres. A certain amount of equipment approximating to this and carried on M.T. was used last year by a Field Troop with the 2nd Cavalry Brigade, and valuable lessons were learnt, but more experience is required before a final decision on the various difficulties can be given.

The operation of forcing a crossing of a river is undoubtedly one that is likely to fall to the lot of the Cavalry Division owing to its mobility. The river may be only lightly held, but even so it is a tactical operation, and failure to carry out the operation quickly will lead to stronger opposition and the necessity for a far more elaborate preparation. This operation is dealt with at some length in *Engineer Training*, Vol. II, but in no other manual. Some ten pages are devoted to it, and a study of these is strongly recommended.

If we consider the phases of an operation in which the Cavalry Division has been ordered to seize and hold a river line pending the arrival of the main body, we can imagine that the two opposing armies are approaching each other, and that the one who gets the river line will have a big advantage. The Cavalry Division is therefore sent on to seize it; it finds that it is held and that all the bridges have been destroyed. If it sits down and waits, the opposition will become stronger, and it is, therefore, decided to force the crossing. It is a difficult operation and involves the closest co-operation.

The first necessity is information. The mounted reconnaissance party of a Field Troop must be with the leading squadron, the Troop Leader with the Squadron Commander and one sapper with each of the patrols which are sent out. The importance of the reports of these sappers cannot be overestimated. They must send back information to their Troop Leader on the following points :—

i. Possibility or otherwise of using assault bridge.

ii. The width of the river.

To obtain this information, it will be necessary for the patrol leader to assist in every possible way, since the information may be difficult to obtain.

As soon as the Troop Leader has got in the reports from all the patrols, it will probably be as well for him to reconnoitre the most promising one or two with the Squadron Commander and come to an agreement with him as to the suitability of the site from a tactical as well as technical point of view.

It must be remembered that the assault bridge is intended to be used by the cavalry themselves; it is not a technical operation, though R.E. supervision and assistance would be given by the reconnaissance party; the equipment is obtained from the Field Squadron.

It is, therefore, the job of the Squadron Commander to organize the launching of the bridge or bridges and the covering and assault party. *Infantry Training*, Vol. II, deals with this part of the operation in some detail, and a study of the sections is recommended.

Apart from this general assistance, the Field Troop Leader has a most important duty, and that is to ensure that the bridgehead resulting from the crossings made on the assault bridges shall cover a suitable site for the erection of the pontoon bridge. This is likely to be a matter of some difficulty, and the Squadron Commander, with the Field Troop Leader, will have to consider the requirements before deciding on the site for his assault bridges. A good approach on both sides is the chief point to consider, and generally the most difficult thing to find.

As soon as the bridgehead is formed, the Brigade Commander can order up the pontoon equipment and the bridge can be built.

In the light of our present limited experience, the following appear to be the chief difficulties :—

i. Organization of crossing on assault bridge.

A large number of men are required, and it is difficult to get them up quickly. It is suggested that a definite regiment should be made responsible for the operation, and this unit should be earmarked for this operation and for nothing else. An assault bridge requires, roughly, one man per three feet for carrying, so that to deal with the amount actually carried in the Cavalry Division, some 70 men are required. When the covering party, assault parties and horseholders are taken out, very little would be left from two sabre squadrons.

ii. The difficulty of getting the assault bridge equipment up quickly.

It is carried in two light 6-wheelers and it must be kept as far up as possible, particularly in closed country. It is considered that it should be handed over to the unit chosen for the operation before the operation starts, instead of moving with the Field Squadron.

iii. The difficulty of getting up the pontoon equipment when required.

This is far more formidable than the previous difficulty, as the equipment is exceedingly bulky and Commanders are unwilling to have such unwieldy and very visible loads too far up in the column. The point needs very careful consideration, since it is obvious that no other vehicles can cross the river till the bridge vehicles have come up. (A photo showing the loaded vehicle of bridge equipment is given. Six such units are required for the Divisional Bridging equipment.)

It is impossible in a general article to deal exhaustively with all the various problems that arise, but the foregoing will serve as an introduction to the subject, and may perhaps arouse the attention of cavalry officers to the importance of the matter. Very considerable attention was paid to this matter in the Mechanized Force at Tidworth, and with the advent of Mechanized Regiments it becomes equally important for cavalry formations.

This year, experiments have been tried with lighter pontoons which may speed up the crossing of the light 6-wheelers. The lighter equipment will not carry armoured cars, and it will be for consideration whether the gain in speed will be sufficient to warrant the transport of the lighter equipment in addition to that required for armoured cars. It is undoubtedly essential that the Cavalry Division should have a bridging equipment which will carry all vehicles which form part of its establishment.

As a purely personal opinion, it is perhaps doubtful whether any very great increase in speed is essential. The assault bridge can be launched in a very few minutes, but no real test has been carried out to find how long it would take a squadron from the time of its arrival at the river to launch the assault bridge and to be formed up on the other side ready to move off. The disorganization resulting from swimming horses is considerable. Is this operation going to be so rapid that a delay of an hour for the building of the bridge to carry the machine-gun lorries is going to delay the advance to any appreciable extent ?

Machine-guns may be necessary to form the bridgehead, but they can be carried across and the bridgehead need not be so large that it affords absolute immunity for the building of the pontoon bridge.

2. *Hampering Hostile Mobility.*

i. Construction of obstacles, including the use of anti-tank mines.

It is an old axiom that obstacles are useless unless they are under fire, but it is one that is apt to be lost sight of. The expression "blocking a road" is one that is frequently heard on manœuvres, but as it can seldom be carried out in practice, the difficulties are perhaps not appreciated as fully as they might be, and the problem is worth a more detailed analysis.

Firstly, where should a road be blocked? It is obviously little use blocking it in the open. The enemy can go round the obstacle with very little delay. The block must be made at a defile through which the enemy *must* pass. This limits the choice very considerably, and in most cases reduces it to bridges. In a country which has many roads or, in very open country it is difficult to find a spot, apart from a bridge, the blocking of which would seriously hamper the movements of the enemy. In a mountainous country, conditions are different, but roads in such countries are actually defiles from one end to the other.

Secondly, how should it be blocked? We are limited to blocking those essential points which the enemy must pass. If they are blocked and left unguarded the enemy would certainly be delayed while he removed the block, but this delay would be slight. It is therefore necessary to defend the blocks. We therefore want a block which will force the enemy to emerge from his A.F.V. to remove the block. The defenders can then fire at them with some hope of success.

The problem, therefore, reduces itself to the blocking of these defiles which are actually defended. Of the elementary forms such as cutting down trees or blocking the road with wagons, little need be said. Cutting down trees is a fairly slow business, and the trees must be in the right place. It is not feasible to move a large tree once it is felled without cutting it up. A tree of three feet in diameter would take a couple of hours to fell. Explosives may do the work quicker, but it is difficult to ensure that the tree will fall where it is required. Finally, trees do not grow on bridges. These methods are therefore improvisations and must be treated on their merits.

What is needed is some certain form which will enable a bridge to be blocked and defended against A.F.V.s. If we consider a cavalry formation holding a river crossing pending the arrival of our main forces, the backbone of the defence will be the machine-guns holding the points of crossing. These are powerless against an A.F.V. and they must be provided with some weapon to stop this form of attack. An anti-tank gun is, of course, one solution, but this is a substitution rather than an accessory to the machine-gun. The anti-tank mine provides a quick solution provided it is available quickly and in sufficient quantities.

Anti-tank mines can be considered in two ways.

i. For minefields. This requires a very large amount of transport and mines and is outside our province at present.

ii. For road blocks. Mines have to be laid practically touching, and it requires one mine per foot of width of road. Twenty mines will block all ordinary roads, and if this number were available immediately for each section of machine-guns, the section could take on the defence of a bridge against all comers with some hope of success. If these mines were all carried in the Field Squadron, there would be little hope of getting them distributed in time. It is, therefore, considered essential that machine-gun lorries should carry 20 mines for each pair of machine-guns. Their weight would be about 200 pounds. A reserve would be carried in the Field Squadron, which could be used to assist any specially difficult points.

Their use involves no technical knowledge. The tops are screwed off and the mines placed in a row on the road. It is not even necessary to bury them, though it is preferable to do so. To ensure that they are effective against armoured cars, an angle iron picket is laid along the top.

Another point for consideration is the collection of the mines when the force moves on. It would be very difficult for the Field Squadron to distribute mines, but it would be impossible for that unit to collect them. The danger of leaving a well-hidden group of mines on some defile on our main line of advance is obvious, but the danger is real.

This suggestion rather removes the anti-tank mine from the sphere of R.E. co-operation. It overloads the regiment with another gadget, but in spite of these disadvantages it is considered that it is the only sound solution, and a recommendation to that effect was submitted last year.

ii. Demolitions.

Each Troop carries 1,120 pounds of guncotton. The amount carried in the rear echelons is still under consideration, but its supply will be on the same lines as S.A.A. This bald statement of fact is of little use to the cavalry officer, who wants to know how many bridges can be demolished, and how long it will take. This information is exceedingly difficult to give since bridges vary, but a rough generalization can be given which may be of some assistance; it must, however, be taken as a very rough guide only.

Bridges may be classified in many ways, but for the purposes of demolition they may conveniently be considered as follows:—

i. All forms of steel girder bridges.

These are the easiest and quickest to demolish, and it may be taken that a Field Troop can demolish any of them in a couple of hours, however big. They are not commonly used for road bridges in this country, though they are more common abroad. They are, of course, common on railways.

ii. Masonry and brick bridges.

These are the most common road bridges, and are more difficult to demolish. *Cavalry Training*, Vol. II, Sec. 82–6, lays down that demolitions which would interfere with the withdrawal will not be carried out till all vehicles have been withdrawn. This adds a further difficulty. The normal method of demolishing a bridge of this nature is to dig a trench down in the roadway as far as the arch and to lay the charge there. This will obviously interfere with the use of the bridge and cannot be permitted. It would be necessary, therefore, to drill holes from underneath into the arch. With our present equipment this is an exceedingly slow business, and would take many hours. The introduction of a pneumatic drill is under consideration and if authorized will cut the time down from hours to minutes.

It is difficult, therefore, to give a working estimate of time, but even if the trench across the road is allowed it may be taken that little can be done under four hours; one Field Troop could work on four medium-sized bridges at once, and it would carry sufficient explosive for about six bridges of this nature.

A further classification may be useful when considering demolitions.

i. Very low bridges. Such bridges exist over the Avon round Bulford. It is waste of time blowing up such bridges, as the *débris* of the bridges would make it quite possible for tanks and 6-wheelers to cross.

ii. Ordinary road bridges up to 30-foot span. These are exceedingly common, and this type of bridge is considered a medium bridge in the paragraph above giving the amount of work that a Field Troop can do.

iii. Modern bridges over new arterial roads. These are becoming larger and heavier, while the use of reinforced concrete introduces many new problems, which up to the present have not been fully investigated. From the point of view of the cavalry officer it is safe to say that he should not expect their demolition unless 24 hours are available for the work.

In considering demolitions generally, the one point which requires most thought is the question of the timing of the actual demolition. *Cavalry Training*, Vol. II, Sec. 76–3, is quite clear on the point, but the instructions are apt to be overlooked, and on manœuvres most certainly are. It is considered that in important circumstances—and most occasions are important—a paragraph should be inserted in orders naming the officer to whom responsibility is delegated.

3. *Miscellaneous.*

In rapidly moving warfare, little can be done in the way of shelters or washing arrangements. The Field Squadron carries an electric lighting set for the use of Divisional Headquarters; it can be started in a few minutes, but the fixing of the wiring and lights may take an hour or more, depending on the number of lights required.

Water supply is a more important consideration. At present each Field Troop carries one lift-and-force pump, while every unit carries sufficient troughs for its own use. This pump is insufficient and a power-driven pump is under consideration. If authorized, it will be sufficiently big to deal with the water supply of a Cavalry Brigade. Scattered units will have to look after themselves, but the provision of a suitable water point for a concentrated brigade will not present any difficulties provided the water is available, except, perhaps, in the collection of the troughs. This will have to be done under Brigade arrangements, but special attention will have to be paid to their re-distribution when the Brigade moves off.

Raids.

Cavalry Training, Vol. II, Sec. 9, deals with the use of Cavalry on raids, and it is curious to find that Engineers are not mentioned as "normally" forming part of the force. Raids are undertaken with the object of destroying men and material. The destruction of material is essentially an operation for Royal Engineers, and one that requires a considerable amount of organization and preparation. The guiding principle is that a special detachment of Royal Engineers should be earmarked for the purpose of the destruction, and should not be used for any other purpose. If, for example, a bridge has to be built over a river on the way, a separate detachment should be detailed for this purpose. If this is not done the work of destruction will be disorganized and will most certainly fail.

A timely demolition of a bridge in the withdrawal may give the raiding party an opportunity to get clear; this could be conveniently carried out by leaving a detachment to prepare the demolition during the progress of the raid.

Conclusion.

At the risk of being wearisome, emphasis is again laid on the fact that the advent of mechanization has increased the importance of R.E. work for the Cavalry Division. The whole tendency to-day is to increase our mobility and at the same time to attempt to decrease the mobility of the enemy. These were—intentionally—taken as the two main divisions of R.E. work. The matter is only now beginning to receive the serious attention it deserves, and the problem is far from being solved. It is necessary to ascertain what the problems really are and to experiment continually with existing equipment to find out its defects. Such experiments must be carried out under conditions as real as possible, *i.e.*, on manœuvres. Greater knowledge of each other's requirements and difficulties are required, in other words, closer co-operation.

MAP PROJECTIONS WITHOUT TEARS.

By CAPTAIN J. C. T. WILLIS, R.E.

THE subject of map projections is one which has caused a good deal of alarm in the minds of many R.E. officers, and it is hoped that this brief introduction, shorn of all formulæ, will assist in clearing away some of its terrors. It is admittedly a case of the blind attempting to lead the blind, but in the kingdom of the blind, the one-eyed is king.

A map projection is any systematic way of representing the meridians and parallels of the earth on a flat sheet of paper.

No map can be a perfect representation of the earth's surface, because a map is flat and the earth is round. That is to say that, although you can wrap paper round a cylinder or a cone, so that it is a perfect fit, you cannot wrap it round a sphere without creasing it. Similarly, you cannot stick a penny stamp on an orange.

A perfect representation of the earth's surface implies that :—

(*a*) All areas on the map would maintain their correct size relative to the corresponding areas on the earth.

(*b*) Shapes on the earth should be represented by exactly similar shapes on the map.

(*c*) Azimuths on the map should correspond exactly with azimuths on the earth.

(*d*) The shortest distance between two points on the sphere (a great circle) should be represented by a straight line on the map,

and, of course, if these four conditions were fulfilled, it follows that :—

(*e*) The scale of the map should be the same in all parts of it.

No one projection can produce all these desired results, so various classes of projections have been invented which aim at securing one or more of these requirements at the expense of the others ; or which strike a sort of golden mean between them all. The special purpose for which a map is required should therefore be considered and the most suitable projection chosen.

In selecting a projection a most important point to be considered is the ease with which it may be constructed, and the simplicity or otherwise of calculating distances, bearings, etc., upon it. No one, least of all the soldier, wishes to be involved needlessly in obscure mathematics.

Projections may be considered in the following groups.

(1) A projection which shows *areas* correctly and leaves other details to take care of themselves is known as an equal area projection and is obviously of more value to statisticians than to soldiers.

Note.—Mercator's projection (Fig. 1) is a good example of a projection which is *not* equal area: on this projection Greenland appears larger than South America and England is nearly half the size of India.

(2) A projection which shows the shapes correctly, over small areas, though the scale for different portions of the map will vary, is known as an *orthomorphic* or *conformal* projection. It will be seen that if the shapes are kept correct, bearings over relatively small distances will also be the same on the map and on the earth. It is for this reason that an orthomorphic is especially suitable for artillery purposes. In fact, it was the need for increased accuracy of artillery fire which made the soldier realize that all projections were not equally suitable for him, with the result that orthomorphic projections came into prominence during the late War, and remain the most suitable type of projection for all tactical purposes.

Since an orthomorphic projection shows shapes correctly, it follows that meridians and parallels, which intersect at right angles on the earth's surface, must also intersect at right angles on the map.

(3) A projection which maintains the correct direction of azimuth lines radiating from a central point is known as an azimuthal projection and will obviously be of value for wireless stations, radio direction finding, navigation, etc.

We will now consider a few of the more important projections, the reasons for their existence, and what errors we may expect to find in them.

1. The Simple Conic.

This projection is produced by considering a cone, with its axis on the polar axis, tangent to the earth at a given parallel (see Fig. 2). The features of the earth are developed along the radii of the earth outwards towards the cone, which is then opened out along one meridian to form a map. This projection will obviously give a true scale along the parallel at which it touches the earth. Elsewhere it is distorted, this distortion increasing with the distance from the tangent parallel.

The cone, instead of being tangent to the earth, can be made to cut the earth (see Fig. 3), in which case there is no distortion along the two parallels of contact, and at the north and south extremities of the projection less distortion is involved by this method than by the simple tangent cone. This projection in its simple form is little used.

A conical projection can be converted into either an equal area projection or an orthomorphic projection by a simple mathematical adjustment, as will briefly be shown.

In any conical projection the parallels (with the exception of the standard parallels) cannot be true to scale, they are either expanded or contracted. We can, therefore, by adjusting the spacing of the parallels along the central meridian, alter the properties of the projection.

If we *decrease* the distances apart of the parallels where their scale is exaggerated, and *increase* those distances where the scale is contracted, it follows that we shall obtain a projection in which areas are true to Nature, but shapes will be distorted; in fact, an equal area projection.

In the same way, to obtain an orthomorphic projection we must ensure that the scale along parallels and meridians is the same at each point. This means that where the scale of the parallel has been expanded, the distance apart of the parallels must also be increased, and conversely, where the scale of the parallels is contracted, the distance apart of those parallels must also be contracted. By this means *shapes* are kept correct and the projection becomes orthomorphic.

2. Lambert's Conical Orthomorphic.

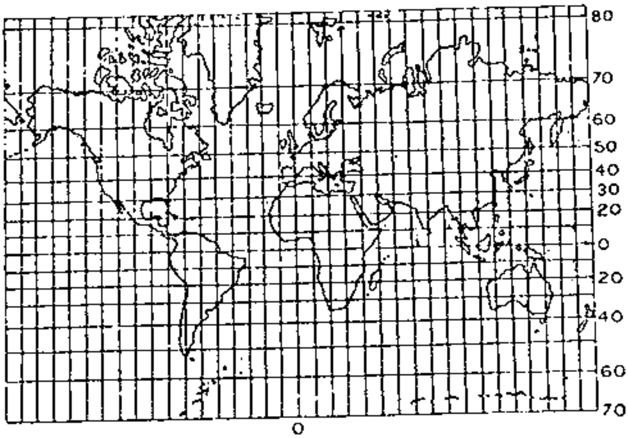
In this case a cone is assumed either to touch the earth at one parallel or to cut it at two parallels. The positions of the other parallels are found, not by developing them outwards along the radii of the earth, but by a mathematical computation which has the effect of spacing out the parallels along the meridians in such a way that the projection becomes conformal. As in all conical projections, the parallels are arcs of concentric circles and the meridians are straight lines which would meet at the centre of all these circles.

The parallels and meridians intersect at right angles. The two parallels where the cone cuts the sphere are called the two standard parallels. Along these parallels the scale is correct; elsewhere, the scale distortion increases with the distance from the nearer standard parallel. (See Fig. 4.)

This projection can be extended indefinitely in an east and west direction and, being orthomorphic, is very suitable for military purposes.

3. Cassini-Soldner or Rectangular Spheroidal Projection.

In this projection we must assume a central meridian, and some definite point on this meridian as origin. Further, we must assume great circles passing through each point in the field and intersecting the central meridian at right angles. The distance of any point from



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MERCATOR'S PROJECTION

Fig. 1.

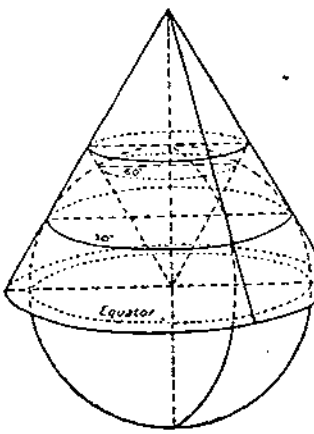


Fig. 2

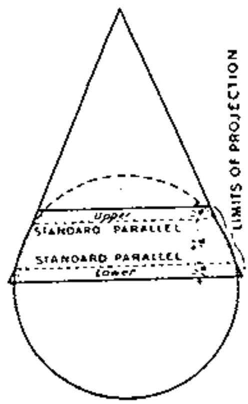


Fig. 3

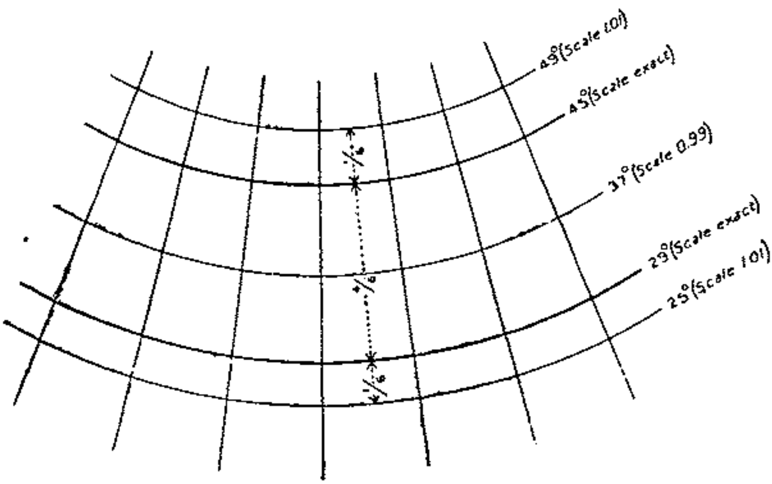


Fig. 4

the central meridian, measured along the great circle, is taken as the eastings of that point. While the distance (along the meridian) from the point of intersection of this great circle and the selected origin is taken as the northings of that point. (See Fig. 5.) The eastings and northings are then plotted as plane rectangular co-ordinates.

The defect of this projection is that eastings on the map are measured parallel with each other, whereas on the earth they converge as they depart from the central meridian. An inspection of Fig. 5 will make this clear.

Let us suppose that P_1 and Q_1 have the same northings $= x_1$: and P_2 and Q_2 have the same northings $= x_2$. And also that P_1 and P_2 have the same eastings $= y_1$; and Q_1 and Q_2 have the same eastings $= y_2$.

Now the difference between the northings of P_1 and P_2 is the same as the difference between the northings of Q_1 and Q_2. But clearly on the earth $Q_1 Q_2$ is shorter than $P_1 P_2$.

The Cassini projection makes $Q_1 Q_2$ equal to $P_1 P_2$ and also equal to $M_1 M_2$. This is obviously incorrect for all points which do not actually lie on the central meridian.

It is thus seen that the northings in this projection are exaggerated. The eastings, however, are but little affected. They are not absolutely correct, because on the map the lines $M_1 Q_1$ and $M_2 Q_2$ are straightened out and become parallel.

From this it will be clear that though distances in an east and west direction will remain nearly true to scale, distances in a north and south direction will be distorted. Thus the errors in Cassini are most marked in a north and south direction.

Cassini represents a sort of golden mean between equal area and orthomorphic projections and is widely employed. It is used by the Ordnance Survey for the 6-inch, 1-inch, ½-inch and ¼-inch maps of England. The scale error on this projection is 1/1000 at a distance of, 177 miles from the origin.

4. TRANSVERSE MERCATOR OR GAUSS-CONFORMAL.

It may be recalled that small circles parallel to the equator are known as *Parallels of Latitude*, and that small circles parallel to a given meridian are known as "*Sub-Meridians*."

In the ordinary Mercator projection, as used by the sailor, the projected distances between the parallels of latitude are increased as one goes further north or south of the equator, see Fig. 1: whereas on the earth the spacing of the parallels is, of course, exactly equal.

In the transverse Mercator, a central meridian is selected and the sub-meridians are spaced at distances which are successively greater as one goes farther east or west of this central meridian. One therefore speaks of the Gauss-Conformal as being a Mercator projection turned through 90°, hence it is called the transverse Mercator.

The distortion of northings in this projection will be exactly the same as in the Cassini projection, but in the transverse Mercator the eastings (which we have shown in Cassini to be nearly correct) are deliberately distorted to the same extent as the northings. This causes the spacing out of the sub-meridians already mentioned.

But since both eastings and northings have been enlarged (locally) in the same ratio, the projection becomes orthomorphic.

As in Cassini the scale error exists only in northings, while in transverse Mercator the same error has been introduced into the eastings as well as the northings, it follows that the error of *area* in the transverse Mercator is double that in Cassini. The orthomorphic quality in this projection has thus been obtained by a considerable sacrifice of equivalence of area.

This projection, thanks to its being orthomorphic, is of great value to soldiers and, since it is capable of being extended indefinitely in a north and south direction, has been used for maps of Egypt, the China Coast, etc.

5. The Polyconic Projection.

In this projection a series of cones is assumed, each having its apex on the earth's axis prolonged, and each tangent to parallels on the surface of the earth. (See Fig. 6.)

In America, where this projection is largely used, all parallels are thus made true to scale and are spaced at their true distances along the central meridian.

The other meridians are curves which cut the parallels at their true distances measured along each parallel.

The meridians and parallels do not, therefore, intersect at right angles, hence the projection cannot be orthomorphic.

An inspection of Fig. 7, which shows the various segments of the map "unrolled" will make it clear that the projection can be extended in a north and south direction, but that distortion increases with the departure from the central meridian.

This projection is much used in the U.S.A., and a modified form of it has been adopted for the international map of the world, scale 1/1,000,000.

A *Rectangular Polyconic* is formed by spacing the meridians at their correct spherical distances on *one* parallel only (possibly the equator), and making the meridians passing through this parallel cut all other parallels at right angles. The rectangular polyconic is largely used for making small scale maps, 1/2^M or 1/5^M, and is sometimes known as the "War Office" projection.

In constructing this projection it is usual to consider each map

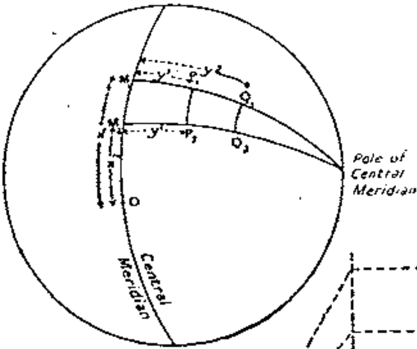


Fig 5

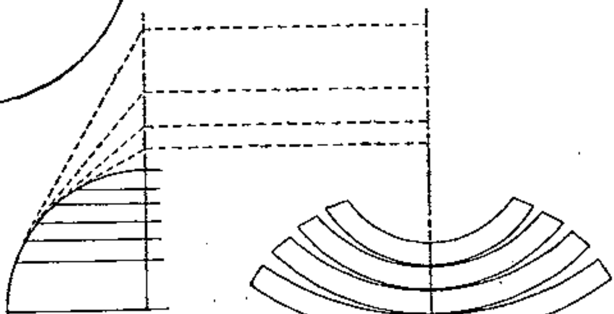


Fig 6

Fig. 7

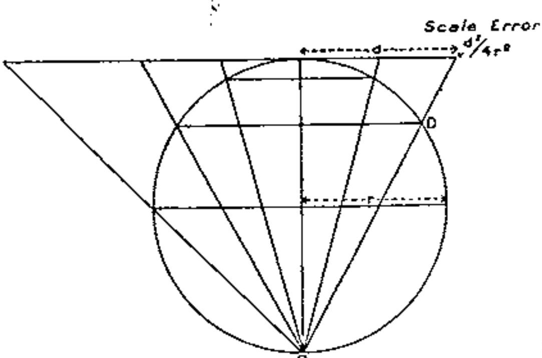


Fig 8. Stereographic Projection

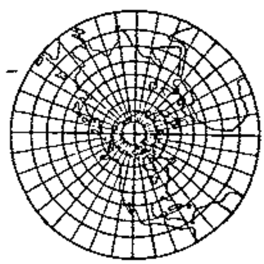


Fig 9. Stereographic projection

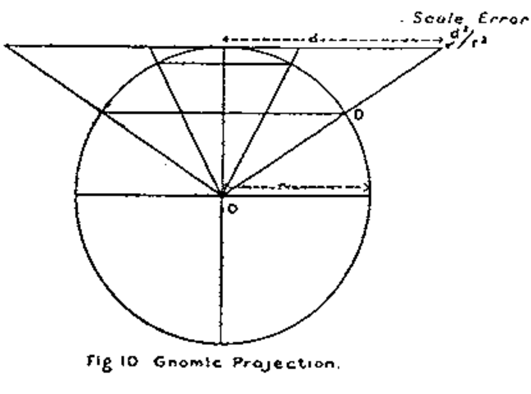


Fig 10 Gnomic Projection.

sheet separately, adopting a central meridian for each sheet and plotting the positions of intersection of parallels and meridians from it.

Sheets on this projection, so formed, cannot be joined accurately as the outer meridians of each sheet are curved inwards towards the central meridian, though in actual practice a few sheets can be made to fit by squeezing.

This projection is neither equal area nor orthomorphic, but represents a mean between the two. It is suitable for a zone running north and south but should not be extended in an east and west direction.

We have now considered in detail :—

1. An orthomorphic projection suitable for an east and west zone. (Lambert.)
2. An orthomorphic projection suitable for a north and south zone. (Transverse Mercator.)
3. A "golden mean" projection for small areas. (Cassini.)
4. The polyconic projection, and its cousin the rectangular polyconic.

Some other projections which may be encountered are :—

(*a*) *The Bonne*, an equal area projection much used by the French, but of little interest for military purposes. It is, however, used for 1-inch maps of Ireland and Scotland. It is a development from the simple conical projection.

(*b*) *The Stereographic* (see Fig. 8) in which the surface of the earth is projected on to a tangent plane from a point on the earth's surface immediately opposite the point of tangency. On this projection all circles, whether great circles or not, are shown as circles on the map (see Fig. 9). This is an orthomorphic projection and can be used for islands, or for the polar regions.

(*c*) *The Gnomonic Projection.* In this projection the surface of the earth is projected on to a tangent plane along radii drawn from the centre of the earth. (Fig. 10.) All great circles —that is the shortest distance between two points on the earth's surface, become straight lines on the map. It is thus of great value to sailors for "great circle" sailing. This projection is neither equal area nor orthomorphic. Its scale error is perhaps its chief defect, though the angular errors remote from the origin are also great.

(*d*) *Azimuthal Projections.* This is a group of projections which aims at maintaining correct azimuths radiating from some central point and would be used for radio direction finding and similar purposes. It will be seen that both the foregoing projections, stereoscopic and gnomonic, fall into this class.

An azimuthal projection would be constructed for use at a wireless station, in which the position of the station was taken as the centre of the projection, and from which all lines would radiate at their true azimuths on the earth's surface.

(e) *Mercator's Projection.* (Fig. 1.) This is an orthomorphic projection on to a cylinder in which the latitude scale is distorted to fall into line with the stretching in longitude which is caused by developing the surface of the earth on to a cylinder. (See remarks on transverse Mercator.) In this a loxodrome, or line of constant bearing, becomes a straight line on the map. This quality makes it invaluable for navigation purposes. Nearly all charts are drawn on this projection.

ERRORS IN PROJECTIONS.

(1) *Bearings.*

In most forms of projection the error of bearing round a point varies with the direction of the bearing from that point. In orthomorphic projections there is no error of bearing.

(2) *Scale.*

In the case of meridional projections like the transverse Mercator, the maximum scale error is $y^2/2r^2$ (approx.) where y is the distance from the central meridian and r is the radius of the earth.

In longitudinal projections, like Lambert's, the maximum scale error is $x^2/2r^2$ (approx.) where x is the distance from the central parallel. These figures may be taken to apply to all projections in ordinary use.

In azimuthal projections, the maximum scale error is ordinarily $d^2/4r^2$ where d is the radial distance from the point of tangency. But in the gnomonic projection the maximum scale error is four times this, *i.e.*, d^2/r^2.

These figures may be taken as giving, approximately, the errors in scale, due to the projection, likely to be encountered and, taken in conjunction with the permissible error of the map, will serve to indicate the limits to which the projection may safely be extended.

This scale error may, however, be halved by a simple adjustment which does not in any way affect the bearing.

Let us consider the case of a longitudinal projection with a central parallel, and let X be the scale error on the bounding parallel, north or south of this central parallel. Now it is possible to select two parallels, one on each side of the central parallel along which the scale error is the same, and, by introducing a reduction factor, make the scale correct upon them. These standard parallels will then be so spaced that the maximum error becomes X/2, negative at the central parallel and positive at the bounding parallels.

Exactly the same procedure can be adopted in the case of meridional projections. Here two standard sub-meridians are selected and the scale error on them is reduced to zero, giving a negative error on the central meridian and a positive error on the bounding sub-meridians, equal to half the amount that the error would have been, had the central meridian been made the standard.

This can be illustrated graphically by imagining that the cone or cylinder on which the projection is developed is made to cut the sphere along two standard parallels (or meridians) instead of being tangential to it. (Compare Figs. 1 and 2.)

This correction is applied to every linear quantity over the field of the map and is sometimes known as the scale factor. It is often incorporated in the tables from which the map is constructed, so that one need not worry further about it.

LIMITS OF PROJECTION.

For the purposes of surveyors, as distinct from mapmakers, the width or depth of a projection must be limited. A scale error of 1/2000 represents a directional error of about 1·5 minutes, which is approaching the limit of accuracy required for artillery purposes.

Accordingly, for a longitudinal projection based on a central parallel, the depth of the zone between the two bounding parallels ought not to exceed 250 miles, *i.e.*, 125 miles north or south of the central parallel.

Similarly, the width of a meridional belt also should not exceed 250 miles; in an azimuthal projection, the circumference which bounds the area around the point of tangency should not be more than 175 miles distant from this point.

If standard parallels and sub-meridians are introduced, the distance from the central parallel or meridian can be increased to 175 miles; in other words, the zone may be 350 miles deep or wide. In the same way that standard sub-meridians and parallels are introduced into other projections, a standard circle of zero scale error may be used in the stereographic projection and the distance from the centre at which this projection can safely be used may then be increased to 250 miles.

THE EFFECT OF THE ELLIPTICITY OF THE EARTH.

So far we have considered the earth to be a true sphere, but in reality it is an ellipsoid; that is to say that the radius of the curvature of the earth along a meridian and the radius of curvature at right angles to the meridian will vary with the change in latitude.

In general, projections which do not demand any great accuracy in use, such as the gnomonic, are still used in conjunction with a sphere, whereas surveyors who require all possible accuracy must consider projections as developed from an ellipsoid.

The difference in actual working between the sphere and the ellipsoid lies in the increased difficulty of computing distances and bearings on a shape which is not a true sphere.

Thoughtful mathematicians have recorded for us the formula by which these distances may be calculated, and, with a ready sympathy for our shortcomings, have drawn up tables for use with most of the common projections. These tables provide values, for given latitudes, of the various functions of the radius of the earth and the radius of curvature perpendicular to the meridian.

THE GRID ON A PROJECTION.

It is worth considering shortly the inter-relation of a grid with a projection.

A grid is a system of true squares on the surface of a map. The map is either built up on this grid, or the grid is superimposed on the map.

The objects of the grid are, briefly :—

(1) To enable map references to be given.
(2) To evaluate the effects of paper distortion.
(3) To provide a standard of reference for bearings, on parallel lines, independent of the convergence of the meridians.
(4) To enable distances and bearings between points to be computed easily and accurately in the field.

To fulfil these objects it will be clear that the grid must be built up of true squares on the map and that each square must be of a given and constant length of side.

The position of the grid is computed from the geographical values of the trigonometrical points and the points themselves are tied as regards their positions by the projection selected.

But it must be remembered that, since each grid square is of a given length of side, as soon as a grid appears upon a map a "fixed scale" element is introduced.

As long as the scale of the map remains constant within the limits of accuracy laid down, the map can be gridded with advantage. The addition of a grid at once shows up the scale error, and in any map where the scale error is appreciable the grid is valueless.

These few notes are only intended to be an introduction to projections as they affect the soldier. For fuller information reference must be made to some of the many books on the subject.

A SUBALTERN IN THE INDIAN MUTINY.

Containing some letters of Lieutenant Edward Talbot Thackeray, Bengal Engineers, afterwards Colonel Sir E. T. Thackeray, V.C., K.C.B., R.E. (1836–1927), *edited by* BREVET COLONEL C. B. THACKERAY, D.S.O. (*late Lieutenant-Colonel, R.A.*).*

I.—MEERUT.

HAVING passed into the Bengal Engineers through Addiscombe and Chatham, Edward Thackeray arrived at Calcutta in January, 1857, and was posted to the Bengal Sappers and Miners at Roorkee. Fellow passengers on the s.s. *Ripon* were Edward Jones, his greatest friend, first in his term at Addiscombe, and C. Innes, both of the Bengal Engineers, and both killed a few months later.

"At about 8 o'clock on the morning of May 13th, 1857," Thackeray relates, "two or three of the officers were standing outside their quarters looking at a pony which had been brought to the lines for sale, when Lieutenant Ward rode up and called out, 'Have you heard the news? We are to march to Meerut this afternoon.' Shortly afterwards, a parade of the whole Corps was ordered. Nine officers, 50 British non-commissioned officers, and 500 out of 700 native sappers were put under orders to march. By great exertions a sufficient number of boats was collected for the officers and men, and we marched down to the landing-stage and embarked at about 6 p.m. At this time none of us, with the exception of the Commandant, were aware of the state of affairs at Meerut. We thought that a local riot had occurred, and that we were ordered to Meerut for the purpose of helping to quell it, and we expected to be away for about a week. . . .

"On the morning of the second day, we saw a European driving along the left bank of the canal in a buggy. He was, I think, an overseer in the Irrigation Department. We hailed him to ask the state of things at Meerut, but he did not stop. He shouted, 'They're cottin' throrts in Meerut like mad, and burnin' 'ouses,' and drove

* These chapters are an abridgment of the first part of a future publication. Extracts from Sir E. Thackeray's *Two Indian Campaigns* (published in 1896 by the R.E. Institution), and other reminiscences, are distinguished by his initials, thus, [E.T.T.]. His elder and only brother, to whom several of the letters are addressed, was the Rev. F. St. J. Thackeray, Vicar of Mapledurham, and formerly a master at Eton. The brothers were the orphan sons of the Rev. F. Thackeray.—ED.

on in the direction of Roorkee. On the afternoon of the 14th, we disembarked from the boats, and marched to Meerut, which was about eight miles distant from the canal." [E.T.T.]

THE FIRST LETTER.

E.T.T. to his brother, F.St.J.T.

MEERUT LINES,
May 15*th*, 1857.

I write you a line to tell you I am safe and well, as I thought you may hear reports, and be alarmed about me. We marched in here this morning at 3 a.m. from Roorkee. We came 40 miles in boats and marched the rest. We slept about three to four hours the whole way. We started on the 13th.

My dear brother, I congratulate you extremely on your success in getting a fellowship. I got your letter the day we left Roorkee. I assure you I was so pleased to hear it, especially just starting on the march.

We knew nothing till we arrived here. . . . We were astounded by the dreadful news we got on arriving. We marched in between European regiments, the Carbineers (Queens) and 60th Rifles. The men were standing at their guns ready. On last Sunday evening, the 10th May, the native regiments, the 3rd Native Lt. Cavalry, the 20th N.I. and 11th N.I., when the Europeans were in Church, set fire to nearly every officer's bungalow in Meerut. The 20th N.I. murdered in cold blood four officers, the 3rd Lt. Cavalry two, and the 11th N.I. two or three. They murdered two officers' wives and children in the most horrible manner. A young officer of the 3rd was hacked to pieces. We got a *fakeer* in yesterday, who murdered one of the ladies, and hanged him in front of the men.

The regiments who got out of here marched straight to Delhi and murdered every European there except a few who escaped. One of our Artillery officers there blew up a thousand of the natives in the magazine, but was killed himself afterwards. We are waiting for more European regiments, and then, I believe, march straight on Delhi. All the officers (not on duty) here stay in one room all day. We are to be out on picket duty from 5 p.m. till 8 a.m. every night. We never stir without revolvers and swords. I hope, dear St. John, you will not be alarmed about me. I am very happy and put my trust in a good Providence. The sappers, I do not think, will ever mutiny.

Thank William Thackeray* for his most useful present to me of a revolver. I am very doubtful if this will reach you, as they are

* His cousin, William Makepeace Thackeray.

stopping the post. You have no idea how I long, and we all do, to be off to Delhi. It is with difficulty we can restrain the Europeans. We will hang the King of Delhi when we get there. My dear St. John, a mutiny is not a very pleasant thing, but I think in my next letter you shall have better news. The clergyman and his wife at Delhi were murdered in front of the King of Delhi's throne. I am afraid when we arrive they will bolt, but if they do give us a chance we will give it them. You must excuse this very short letter, but I must be off to the Sentries. . . . .

You heard that the reason of the Mutiny was the men having cartridges given them in which was bullock fat, which it is contrary to their religion to put in their mouths.

This does not state the case quite accurately. The suspected cartridges were not issued to the troops. The annexation of Oudh was, politically, the main cause of the Mutiny. The cartridge grievance was more in the nature of a pretext, engineered by the malcontents. But there were many contributory causes.

The immediate cause of the outbreak at Meerut was the public degradation at daybreak on the previous day, Saturday, 9th May, of eighty-five troopers of the 3rd Bengal Cavalry, who had been sentenced to imprisonment for six to ten years by a court martial composed entirely of Indian officers, for mutinously refusing to take the innocuous cartridges issued to them. . . .

On the following day, the Sunday evening service was the appointed hour for the troopers of the 3rd Cavalry to rise. Luckily, they did not know it had been changed, and the troops were not yet *in* church. Their first act was to set free their comrades in the gaol. The 11th and 20th Bengal Infantry rushed to their lines and armed themselves. Bungalows were already being fired in all directions, and their occupants butchered. The scum of the populace joined in the murder and riot. Colonel Finnis, commanding the 11th N.I., had galloped down to his lines, with some of his officers, and was urging his men to remain true to their salt, when he was shot by a soldier of the 20th. Other officers met the same fate. Nearly every stray man, woman and child was murdered, a few being saved by loyal Indian servants.

In the British lines, bugles had sounded and taken up the alarm. Horse, foot and artillery were speedily under arms. But confusion prevailed among those on whose promptness and decision all depended. It was nearly dark before the troops moved off together, the Carabineers (6th Dragoon Guards), 60th Rifles, Tombs's Troop of Bengal Horse Artillery, and Scott's Field Battery. The rebels—actually inferior in strength—had by then disappeared, none knew whither. It was decided to concentrate at the barracks, for the protection of the women and children, under the impression that the mutineers were still at large in the city, ready to attack. No steps were taken to follow, or even to keep touch with the rebels, who had fled to Delhi, thirty-six miles distant, where there was no British garrison. The atrocities of Meerut were there repeated. It was sixteen days before a column marched from Meerut. Although the wisdom of this course has been upheld by most of the highest authorities, among them Lord Roberts, the plain soldier cannot help thinking that a little less wisdom and a little more foolhardiness would better have upheld the honour of British arms.

SECOND LETTER.

E.T.T. to his brother, F.St.J.T.

MEERUT LINES.
May 18th, 1857.

The mail does not go till the 20th, and I still have time to give you a line. I hope anything you hear will not alarm you. I am sorry to tell you that the day after I wrote to you, the Sappers and Miners, natives, mutinied. They shot poor Captain Fraser, our Commanding Officer, and fled. The Adjutant* ran the gauntlet of the whole line. The Carabineers and Artillery pursued them and cut down fifty or sixty.

That day I was detailed on duty with ninety of them, destroying walls and bushes which could serve as a cover to an enemy. We were about a mile and a half from the lines. They worked very well and I was talking and laughing with them all day. About 3.30, someone told one of them that the Europeans were killing the Sappers in the Lines. They fled immediately, except about twenty who stayed with me. I had the Serjeant-Major and three other Europeans, non-commissioned officers with me. The natives all had their muskets, and sixty rounds of ammunition. The Serjeant-Major and I rushed after them and endeavoured by persuading and threats to make them fall in. It is a wonder they did not shoot us. At last we got about thirty together, and marched them towards the lines. Before we got there some of the others joined us, and I marched in fifty-four, thirty-six escaping, who were, I believe, afterwards killed. We met a troop of Carabineers. The officer told me the rest of the men had fled, shooting poor Fraser. Poor fellow, we buried him yesterday, and, please God, will soon avenge him. His wife escaped from the massacre at Delhi. The sappers I brought in were immediately disarmed. We have about 120 of them, and they work well. I will never trust natives again. It is a religious panic has seized the whole army.

* Lieutenant, afterwards General Sir F. R. Maunsell, K.C.B., Colonel Commandant R.E.

I am on picket nearly every night. We have fifty Europeans in the Sappers, which is a great thing. We are about 2,000 Europeans strong here. How we wish they would attack us. A native was shot by his own men protecting Fraser. I never knew what a wound a bullet could make before I saw him. His head was blown to pieces. Men are hung in camp every day. We are expecting Jones and Carnegie every hour. They were at Missourie and have to join alone. I trust we shall march on Delhi soon. You have no idea how sharp you get at answering the sentries. If you don't say "Friend" instantly, they fire.

I am very well, thank God, and all our officers. . . . We are all in very good spirits. . . . I don't think that there ever was a body of men who would fight better than our garrison. We have lots of Artillery. The Carabineers are splendid fellows. . . .

I hope you will be able to read this. . . . It is rather a sharp opening of a soldier's life. We are fortifying the place every day. I am afraid I shall lose all my books and saddles. I started from Roorkee prepared for a week's campaign.

The mutiny of the Sappers is thus described elsewhere by Sir E. Thackeray:

"Early on the morning of the 16th May, I received orders from Captain Fraser, the Commandant, to take a party, consisting of 3 British non-commissioned officers and 90 native sappers, to the Grand Trunk Road, leading from the northern part of the city to Delhi, for the purpose of dismantling some old walls which had been built near the sides of the road. It was anticipated that an attack might be made by the rebels from Delhi. . . . I never saw Fraser again alive. The sun beat down fiercely on our little party, and the hot wind felt like the air from a furnace as we passed the deserted and blackened remains of the bungalows, which the Sepoys had set on fire a few days before. As we passed through the streets of the bazaar, the natives peered over the walls at us, and I remarked to the serjeant on their furtive and scowling looks.

". . . A large portion of the walls had been demolished, when a little after 3 o'clock my attention became attracted by the sound of bugles in the direction of the cantonment. Almost at the same time, a native trooper of the 3rd Light Cavalry galloped down the road at the side of which the sappers were working. He was in uniform, fully-armed, with sword at his side and pistols in his holsters. His horse's mouth and flanks were lathered with foam, and he gesticulated and pointed in the direction of Delhi. I turned to look towards the men, and saw that many of them had laid down their pickaxes and shovels, and had run to the piles of muskets, from which they commenced taking their arms. Before any order could be given, they were running along the road, following the trooper in the direction of Delhi. I then ordered the bugler to sound the assembly, and by dint of threats and expostulation, and with the aid of the European serjeants, we succeeded in inducing 36 men to fall in. Looking towards the houses in the vicinity, I could now see large numbers of the Meerut *budmashes* (ruffians) collecting near the bazaar, and poking their heads over the walls, as if expecting to see what was coming next. I ordered the little detachment to march to the lines, and before proceeding far we were joined by 28 men, who had at the first bugle call been undecided, but finally made up their minds to rejoin their comrades who had remained staunch.

". . . I saw the body of the havildar who had tried to save the Commandant. He was lying on his face on the ground, the back part of his head having been blown away by a shot from behind. . . . The sight of the corpse of this faithful soldier, treacherously slain by a Sepoy while trying to save the life of his commanding officer, roused in the minds of all who saw it feelings of anger, and a desire for stern retribution against the mutineers. I now learnt that, while Captain Fraser was issuing orders for the removal of the ammunition to the magazine, he was shot from behind by one of the Sepoys, and the havildar was killed at the same time while trying to protect him. The Sepoys then fired at the Adjutant (Lieutenant Maunsell), who had a most narrow escape. After the murder of the Commandant and the havildar, the Sappers fled from the cantonment. They were pursued by the Carabineers, and a party, consisting of about 50 men, were overtaken among the sand hills. They took up a position under cover of the hillocks, and commenced firing at the Carabineers. They were, however, overpowered and killed.

"Lieutenant David Ward, of the Engineers, had on the morning of the same day also been sent out with a party of sappers by Captain Fraser, to execute some entrenching work on one side of the station. This party remained faithful, and Lieutenant Ward brought them back to the lines, where they were disarmed. On the following morning, some of these men expressed a wish to be allowed to go out to bury their comrades who had been killed by the Carabineers. Lieutenant Ward volunteered to accompany them, and went out with a party of Sappers to bury the men who had been killed on the previous day. This was a highly dangerous service, as it was thought at the time that the sight of their slain comrades might excite the passions of the men. Ward brought back his party to the lines after this hazardous duty." [E.T.T.]

It is a curious commentary on the attitude of those in command, that bodies of armed sepoys, known to be disaffected, should have been sent out under inexperienced young British officers, as though conditions were quite normal. In justice to the loyal few, Sir Henry Norman's official account of the Siege of Delhi, published in 1858, may here be quoted: "The remnant of the old corps of Sappers and Miners behaved with the most perfect fidelity, and on numerous occasions with exemplary gallantry, notwithstanding that the bulk of their comrades were opposed to them." They were the only trained sappers present at the Siege, and the value of their services to the army cannot be exaggerated. For this result, great credit is due to the two young officers, Thackeray and Ward, who brought their men back with them to the lines. At the end of the Siege, the sappers were the only Hindustanis from Lower India still serving with the army.

"We had now about 50 European non-commissioned officers, and about 150 native sappers. The latter did excellent work in fortifying the Dum-Dumma and other buildings in the station. . . . Two days after the Mutiny of the Sappers, I received orders to take a small detachment of the 3rd Light Cavalry to a village, distant about seven miles from Meerut, to collect some tools. The *sowars*, or troopers, were the remnant of the regiment who had mutinied on the 11th, and gone off to Delhi, after killing two of their officers.

"On the afternoon of the 27th May, to our great delight, the long-expected order was issued for a column, under the command of Brigadier Archdale Wilson, to march towards Delhi, to join the force which was moving down from Umballa, under the Commander-in-Chief, for the capture of the city of Delhi. . . ." [E.T.T.]

Third Letter.

E.T.T. to his brother, F.St.J.T.

Camp Ghazeeoodeennugger
(10 miles from Delhi).
June 1st, 1857.

I hope you won't be alarmed by the length of the name of the place where our Camp is pitched at present. I don't know whether you received two letters I wrote from Meerut, but since I wrote them I have really not had time to write a line. Events have happened so quickly and we have had so much to do. However, I will try to give you an account of it all as well as I can.

When I first arrived in India, the first sign of disaffection among the Sepoys took place at Barrackpore, close to Calcutta, the Sepoys refusing to use their cartridges on account of bullocks' fat being in them. You know it is contrary to their religion to touch either bullocks' or pigs' flesh, and about this they are very particular.

The cartridges were then changed, but ever since the troops were in a bad state. At last the 19th and 34th Regts. N.I. were disbanded and several of the Sepoys hung.

The next place where the troops became disaffected was Umballa and then Meerut. It was at Meerut, a day before the great outbreak, that 85 Sepoys were imprisoned with hard labour for 14 years, which is supposed to be the cause. (*See page* 453.) Many people think that the religion is only an excuse and that the King of Oudh and other Rajahs are at the bottom of it. However, I don't pretend to know the cause, but one thing is certain that there is, as some distinguished person says, 'a row in the house.' I am sorry to say that now about 20 regiments have mutinied. At Roorkee, we had no idea of anything, when, on May 13th, an order came for us to march to Meerut. I gave you an account of our march there and the mutiny of the Sappers, when they shot poor Fraser, our Commandant.

There is a place at Meerut called Sudder Bazaar, and when the regiments mutinied the people came out of this and murdered the English in the most horrible manner. Two English ladies, officers' wives, were cut to pieces and burned to death. Many children were murdered. I cannot tell you the details of some of the murders, they are too horrible. Four Sapper serjeants who were not attached to the regiment and were living in a bungalow, were brutally murdered with their wives. How I long to go in at them at Delhi. You will be surprised to hear I have seen a good deal of fighting and been under a very heavy fire already. However, of that presently. I tell you of those murders, because I know you would like a true account. When the regiments at Meerut mutinied (all Sepoys, of course), they marched to Delhi (why they were not cut up by the Carabineers, I don't know). At Delhi, there is an immense magazine and it has often been wondered why it was left entirely in charge of native troops, the 54th, 47th and 38th Regts. N.I. and some Artillery being the only force there.

When the mutineers arrived at Delhi the regiments there were on parade. The mutineers of the 3rd Light Cavalry rushed on to the parade of the 54th and pistolled the European officers in front of their men, who never attempted to protect them. This was the signal for a general massacre. The other regiments shot their European officers, and every European in Delhi, except about 40 who escaped, was murdered. The King of Delhi at the head of it all. Poor Mrs. Fraser was at Delhi, but escaped. Her child was murdered. A party of 12 gentlemen and several ladies escaped. They walked the whole way from Delhi to Meerut (40 miles). They were pelted with stones at many villages they passed through. They were robbed of everything they had, and were nearly naked. They lived on grain or anything they could get. Lieut. Salkeld, Engineers,* was of this party. He is now with our force.

. . . The Sappers mutinied about the 16th. About 100 of them stayed. We have 50 European N.C. officers, which is a great thing. Other regiments which mutinied had no Europeans except the officers. . . . (*Continued.*)

THE ACTION ON THE HINDUN. [E.T.T.].

"The column which marched out of Meerut under Brigadier Archdale Wilson, on the 27th May, consisted of two squadrons of the Carabineers, a wing of the 60th Rifles, Scott's Light Field Battery, Tombs' Troop of Horse Artillery, two 18-pounders, all manned by Europeans, with a small detachment of native sappers and some irregular horse. On the 30th May, the column arrived on the left bank of the River Hindun, near a place called Ghazee-oo-deen-nugger. I visited the place in 1868, eleven years after the battle. . . . The ditch round the village, which I recollect to have seen filled with dead mutineers, had been filled up and the walls levelled. . . .

"At the camp on the Hindun, 14 Engineer officers occupied one European private's tent, with a single thickness of canvas. . . . The heat was so intense that we wrapped wet towels round our heads, and lay down with our heads under the solitary table that we had brought as a mess table. About three o'clock in the afternoon a round shot was fired into the camp from the opposite side of the river. The shot killed a non-commissioned officer of the Carabineers. The bugles sounded, and the troops fell in, and at once marched towards the bridge that spanned the river. The shot fell thickly about as we advanced. The mutineers, flushed with success, had come out from Delhi to give battle to the Meerut Brigade before its junction with the Umballa force. . . . Under cover of the guns, the 60th Rifles advanced to close quarters with the enemy. The mutineers broke and fled under the galling fire poured in upon them, and numbers were bayoneted. They left five guns in our hands. Major Tombs, with the Horse Artillery and Carabineers, dashed across the Hindun to the right, and successfully turned the left flank of the enemy. Major Tombs' horse was shot under him during the action. A Sepoy of the 11th Regiment fired his musket into an ammunition wagon just as a party of the 60th, under Captain Andrewes, were gallantly seizing the guns. Captain Andrewes and several men of the 60th were killed by the explosion and others were carried away wounded.

"About noon on the following day, Whit Sunday, the bugles again sounded the alarm. The enemy had again come out from Delhi,

* Lieut. Philip Salkeld, V.C., who died on 11th October of wounds received at the blowing in of the Kashmir Gate. Lieut. Willoughby, who had blown up the magazine, was also of the party, but was murdered on the way.

and had taken up a position on the right bank of the Hindun, about a mile from our advanced posts on the bridge. . . . The fight was one almost entirely of artillery. When the enemy's fire slackened, a general advance was ordered, and the enemy retreated, carrying off their guns to Delhi. Our men were so exhausted by the heat, and by thirst, that they were unable to improve their victory." Seven hundred British soldiers had, however, signally defeated seven times their number.

THIRD LETTER (CONTINUED).

E.T.T. to his brother, F.St.J.T.

June 1st, 1857.

(*Page missing.*)

. . . . I cannot tell you our correct loss, but I do not think it was more than 30 killed and wounded. . . . .

Yesterday, Sunday, about 9 o'clock a.m., the force turned out again, but the enemy did not advance till about 12. When I say advance, I mean they came so near as to be carefully out of range. We were employed making a sand-bag battery to defend the ditch. After the Artillery and Rifles had advanced, half the Sappers were ordered to advance and support one of the guns. (I forgot to tell you that first a round shot came right into our battery. We saw it coming bobbing quickly along the road. We got out of the way as we could, but one of our serjeants was rather too late. It just grazed the calf of his leg, but has not wounded him severely, though it is much swollen. It was a wonderful escape.) I went with the half of the Sappers to the Fort, the other officers were McNeill and Carnegie and Geneste. We ran two miles in the heat of the day. The grape were tearing the trees all round us. Such a whistle they make, knocking up the dust all round us. We were a very small body to which I suppose we owe our escape. I thank God for his mercy in having spared us. We got up to the heights and drove the enemy back. We took no guns yesterday as they kept them in the rear. We spread out in skirmishing order and popped away at them. Our Quartermaster-Serjeant had a rifle. I saw him shoot one of them at about nine hundred yards. We could not get near enough for me to use my revolver.

Poor Lieut. Perkins, Artillery, a very fine fellow, was killed by a grape shot. Twelve of the Rifles were struck down by the sun, four of them died. The heat was fearful. When the water-carriers came up the rush was tremendous. I suffered very much from thirst. I always wear white clothes, and a hat made of pith, a sort of helmet, as a protection. I think it was owing to their small cloth caps the Rifles suffered so. I saw one man sun-struck, he was raving. Our loss was very small. I saw a good many of the enemy dead. Round shot had hit some of them and knocked them to pieces. We drove them back. I wish we could advance, as it is very harassing work out in the sun all day. I was out about 12 hours yesterday. Hurrah, the Gurkha Rifles have just marched into camp. They are a hill regiment and hate the Sepoys. They are 600 strong and splendid little fellows, very like Europeans. They marched 70 miles in two days. We probably shall be turned out again this afternoon. . . . I hope you will be able to read this, but as the penitent convict at Newgate says at the end of a long letter in verse (*vide Punch*):

> " I writes this from my little Cot,
> Best of times is bed."

The table in the tent being occupied by sleeping officers and the thermometer about 100 in the tent. However, I think the convict was better off than us, our little cots consisting of a rug and a pillow on the ground, and I don't think I ever slept so soundly in my life as I do at night here.

This is the first quiet morning I have had. I daresay I have written a great deal about what is not very much to what we shall have, but I thought you would like to hear all about it and being the first time I was under fire. Jones is here. I never was better in my life than I am now, and we are all very jolly and have great fun. We have hardly any knives or anything. Your present to me of a cup, knife, etc., is invaluable.

I am so glad you have a fellowship. . . . I must now conclude, for I am thoroughly tired. . . . .

P.S.—Am very lucky in getting into action so soon.

THE BATTLE OF BADLE-KA-SERAI (*Alipore*). [E.T.T.]

" We remained in our position on the Hindun from the 1st to the 5th June, and on the evening of the 5th, we commenced our march to join the force that was moving down from Umballa, under the Commander-in-Chief, General the Honourable G. Anson. . . .

" On the morning of the 7th, we joined forces with the Umballa column. The meeting with old friends caused much rejoicing, and all were eager for the attack on the enemy's position at Badle-ka-Serai, which it was known would be made on the following morning. . . . We now learnt that Major-General Sir Henry Barnard had succeeded to the command, on the death from cholera of the Commander-in-Chief, General Anson. On the 6th, the siege train of 28 pieces arrived. On the morning of the 8th, we marched out of Alipore at 3 a.m., to attack the enemy, who were strongly entrenched at Badle-ka-Serai, their forces consisting of cavalry and infantry and 30 guns."

FOURTH LETTER.

E.T.T. to his Aunt, Miss Henrietta Shakespear.

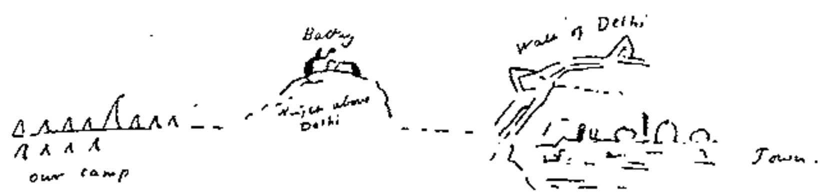
CAMP DELHI
(Heights above).
June 20th, '57.

. . . I am, thank God, quite well, and never was better, though we are out in the sun or at night 8 hours out of the 24. I received two very nice letters from you, here in camp. You can't think how glad I was to get them, because I am afraid the post is not very safe in these stirring times here. However, I hope we shall soon be in Delhi, and then I will write lots of letters.

We marched down the River Hindun and joined the Umballa force on the 7th of June (after two nights' hard marches), about eight miles from Delhi. The next morning we advanced on Delhi. The Umballa force consisted of H.M. 9th Lancers, H.M. 75th Regt., the 1st and 2nd Bengal Fusiliers (Europeans), and Artillery. The force which came from Meerut, as I told St. John, consisted of H.M. 6th Carabineers, H.M. 60th Rifles, Artillery and Sappers.

July 2nd. We have had so much to do in the last week, I have not had time to write till to-day. We are eight hours out of the twenty-four in the batteries, and we get so tired we can't write much.

I will go on from where I left off, the event of the 8th of June. We started about 3 o'clock in the morning, in order of battle. I was with a company of Sappers (you know they did not all go at the Mutiny—about 200 stayed); I in the 3rd column. After we had marched about two or three miles, the sound of heavy guns was heard in front, and we knew the 1st column was engaged. I never knew anything more exciting than getting closer and closer, and then the round shot and shell began to whistle past us, and tear up the ground all around. The Ghurka Regiment and 75th Queen's were with us. Men were carried past us in palanqueens—poor fellows, many dead and badly wounded. We passed one of our light batteries which had met the brunt of the enemy fire. One tumbril had blown up, and two or three Artillery men lying dreadfully scorched and dying in the road. I never saw such a ruin. Dead bullocks were lying all about. The enemy had taken up a splendid position and made a very strong battery about four miles from here. We drove them out of this. In fact they never waited to let us come up, but ran for it. We captured four heavy guns here. Many of the enemy got inside a strong-walled sort of village, which was barricaded, where they fired at our men. Our little party of Sappers came up and we burst open the doors and rushed in. We had orders to destroy all the villages on the way which had harboured the rebels. No quarter is given to them. I daresay you will think this cruel, but if you think of the horrible massacres of our women and children and of the mutinies where six or seven European officers were shot down in front of their native regiments, without a man trying to help them, you will see it could not be otherwise. After taking this position, our force rested about half an hour and then we again advanced. The enemy retired to the heights above Delhi, where we are now. They poured a very heavy fire on us as we



advanced, but they never waited to let us come close, but fled into Delhi, leaving altogether 20 guns in our possession. Col. Chester (Adjutant General) was killed, Capt. Russell, Lieut. Harrison, and about 50 men on our side, and about 150 wounded. The enemy lost great numbers. I saw many of them on the road. It was a glorious day, but I wish we had followed it up, as we have since remained here, and lost many men in skirmishes with the enemy. . . . (*Continued.*)

The battle of Badle-ka-Serai was one of the most decisive of th Mutiny, for it gave us the Ridge, from which we were able to prosecute the "siege" of Delhi. Of the enemy opposed to us, it was reckoned that 1,000 never returned to Delhi; 13 guns were captured.

"The troops were posted at intervals along the ridge which overlooks the city. We were all much exhausted after the action and the march under a hot sun. . . . The Camp was pitched in rear of the ridge, and a bungalow that had partially escaped the conflagration after the Delhi massacre was told off for the headquarters of the Engineers. We located our mess in the billiard-room." [E.T.T.]

(*To be continued.*)

ROORKEE PATTERN STEEL CRIBS.

By BT. LIEUT.-COLONEL G. LE Q. MARTEL, D.S.O., M.C., R.E.

VARIOUS types of trestle equipment have been tried at different times and used with varying success. For the lighter loads the normal type of trestle, with two legs and a transom adjustable for height, has proved satisfactory over a large number of years, but the design of a heavy trestle or trestle tower for the heavier loads produces many complications. The transom has in this case to be of considerable weight, and there is difficulty in distributing the heavy loads in each leg on to the ground. Moreover, a large and awkward trestle has to be erected, even if a low trestle about 4 ft. high is all that is required, and short trestles are very commonly needed. Again, if a high trestle, say 20 ft. in height, is required for a deep, dry gap in rugged mountainous country or for railway work, the normal trestle equipment is useless. The necessity for being able to adjust the height of the transom without disturbing the roadway, only arises in the case of tidal ramps and, as not one per cent. of the trestles erected in war are required for this purpose, the point is not one of importance. It is true that an adjustable transom enables the transom to be raised if the legs sink or settle unevenly, and with very light trestles this is a distinct advantage, but with the heavy modern loads, such as tanks or the heavy armoured cars, a trestle bridge resting on insecure foundations in this way would be quite unsafe and impracticable. In addition to the normal type of trestle equipment, tubular trestle work has been tried and used, but although this type of work is very suitable for scaffolding and many other purposes, it does not appear at its best for trestle work, and the tubes have to be cut to length or packing used to obtain the right height for the heavier loads. Another method of solving the problem of rapid trestle work is the existing steel cube, but this is heavy and slow for anything except the very heaviest loads.

As an alternative to the above some steel cribs have been constructed at Roorkee, as shown in Fig. 1 in the drawing. There are only two types of crib; they take the form of a skeleton steel box, 18 in. square, and are made in 3 ft. and 6 ft. lengths. The cribs can be joined together in any direction by using four $\frac{3}{8}$-in. bolts. Thus, piers or trestles can be built to any height by 18-in. stages. The strength of any crib is 12 tons in compression in any direction.

The drawing shows various types of trestle and pier, but these can be varied to an endless extent. Details of the cribs are as follows:—

	3-ft. crib.	*6-ft. crib.*
Weight	105 lb.	195 lb.
Safe thrust	12 tons	12 tons
Limiting shear stress against bending ...	$1\frac{1}{2}$ tons	$1\frac{1}{2}$ tons
Limiting bending moment in one box ...	180 inch tons	180 inch tons
Cost of material in India for one box ...	11 Rs.	20 Rs.

Note.—One 6-ft. box supported at the ends will carry a concentrated or distributed load of 3 tons against bending, the limit being failure by shear, but these cribs are not really intended to take bending moments.

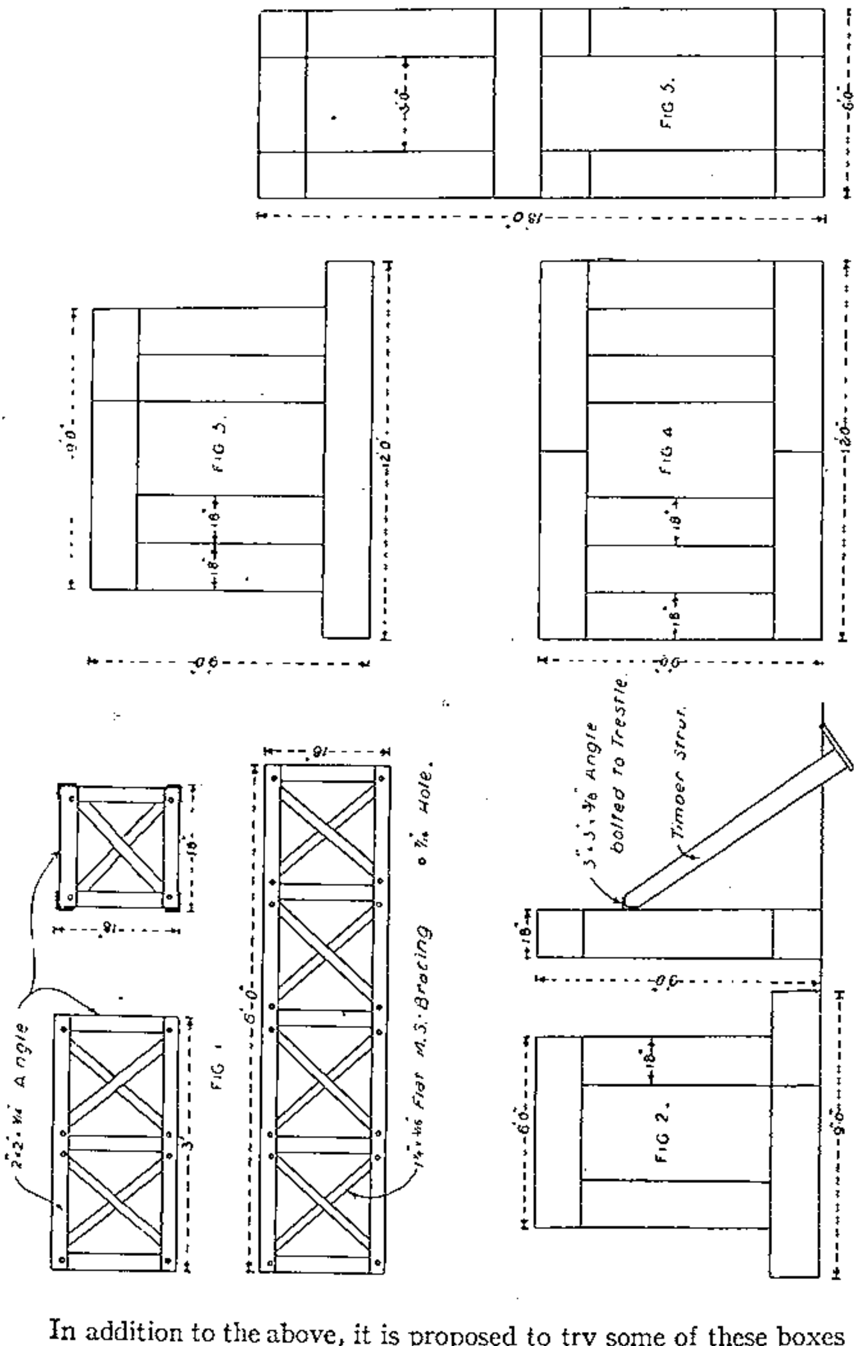
The sides of these cribs and the vertical members are all made from 2 in. x 2 in. x $\frac{3}{16}$ in. angle, and the diagonal bracing on the sides and ends is made from $1\frac{1}{4}$ in. x $\frac{3}{16}$ in. flat, mild steel.

Fig. 2 in the drawing shows a typical medium trestle built from these cribs. This was used in a test to support one end of a girder bridge across a 60-ft. span. The bridge itself weighed 14 tons and lorries weighing about 5 tons were passed over repeatedly; the trestle appeared to take the weight quite easily and was particularly free from any sign of vibration or sway under the load.

This medium trestle consists of four 6-ft. cribs and one 3-ft. crib, and short 4 in. x 2 in. channels are used to distribute the weight of a timber transom on to the trestle. The total weight of the trestle, including the timber transom and short channels, comes to 1,237 lb., which is just a little less than the medium trestle of the pontoon bridging equipment, and it is, of course, far more rigid than the trestle equipment would be when used at this height from the ground. This test was really on overload, as a heavy trestle would normally be used with such heavy girder work.

Figs. 3 and 4 show two typical types of heavy trestle, using four uprights instead of the two in the medium trestle. Any of these trestles can, of course, be varied in height by 18-in. stages quite easily. The heavy trestle should carry loads up to 20 or 30 tons for heights up to, say, 14 ft. For greater heights, it should prove better to use two trestles built together as a tower. Fig. 5 shows the side view of a typical tower of this type. The type shown is 18 ft. high and consists of two heavy trestles. These trestles are bound together at the top and the bottom by 3-ft. cribs, and in the centre they are bonded together by using 6-ft. cribs, which are placed under the uprights in the top half of the trestles.

In the tests that have so far been carried out, these cribs appear to make such a rigid trestle that no lateral bracing or struts appear to be necessary. Longitudinal bracing will, however, often be required, especially when trestles are used by themselves, and not built up into trestle towers. For this purpose it is proposed to bolt angles of 18 in. x 3 in. x 3 in. x $\frac{3}{8}$ in. mild steel on to the sides of the trestles and fit timber struts into these angles as shown in the side view in Fig. 2.



In addition to the above, it is proposed to try some of these boxes joined end to end as a long column for use as a derrick. For this purpose, special end pieces are needed which taper to a point, and it is proposed to use fish-plates in addition to the ordinary $\frac{3}{8}$-in. bolts for joining them together, so as to increase the strength of the column in resisting a bending moment. These fish-plates should not be used for trestle work, as they are unnecessary for this purpose.

The design of these cribs has been worked out in detail at Roorkee, and the necessary jigs made so that they can be manufactured without skilled labour and to ensure that they shall all be interchangeable. The trials that have been carried out up to date show that these cribs can be built up very rapidly and that they are very light and cheap; a small fixed spanner is provided for tightening the nuts. It is true that the present medium trestle equipment could be lightened if it was re-designed, but it would still be heavier for short trestles and incapable of use for trestle work over 14 ft. high. Moreover, this method of using crib work provides a groundsill with a good distribution of weight, which is a very weak point in the present trestle equipment for medium or heavy loads. It therefore looks as though it may become possible to use some form of steel crib work of this nature to fulfil all military requirements for medium and heavy piers, and if this proves to be the case we may then be able to revert to a really light and handy trestle as our trestle equipment for the lighter loads. These cribs are also very useful for the rapid erection of towers for water tanks, searchlights, etc.

The design will no doubt be improved on in detail; for instance, the flat bracing may be found to be liable to damage if the cribs are thrown about. Angles of $1\frac{1}{4}$ in. x $1\frac{1}{4}$ in. x $\frac{3}{16}$ in. might be used, in which case one diagonal might suffice as it could take compression, but the flat bracing has the advantage that it is easier to tighten the nuts up inside the cribs. They will stand a fair amount of rough handling and as the 6-ft. boxes weigh less than 200 lb. there is no excuse for unduly rough treatment. The cribs in their present form are cheap and we can afford to throw away damaged ones, and this may be better than trying to make them proof against all rough handling. It is possible also that welding may be found suitable as a means of construction and this would probably provide a stronger crib for the same weight.

There will, of course, be a temptation to complicate the idea and provide such things as swivelling attachments to enable the outside legs to be splayed. It is suggested, however, that we should not add too many complications and frills. In the present design, everything is extremely simple and easy and appears to work well, and although it may possibly be found advantageous to add a few more shapes and sizes of cribs, the temptation to complicate the scheme and lose the present simplicity should be guarded against.

BRIDGING ON THE NORTH-WEST FRONTIER OF INDIA.

By COLONEL C. H. HASWELL, C.I.E., *Deputy Chief Engineer and Secretary, Public Works Department, North-West Frontier Province.*

WITH the advent of mechanical transport and motor-cars, the question of road bridges on the roads of the North-West Frontier of India has become a matter of great importance. Prior to 1917 only one large bridge existed, the Connaught Bridge across the Swat River at Chakdarra, on the road to Chitral, constructed by Captain Biddulph, R.E., in 1902. This is a steel girder bridge consisting of five spans of 160 feet each. A few masonry bridges existed on the road between Kohat and Bannu, and on these bridges forty-foot brick arches were used.

There are a very large number of dry torrent beds traversed by the main arteries of communication, and in the days of tongas this did not affect traffic. All torrents are subject to heavy floods after rain, lasting from four to twenty-four hours, and if one arrived at a river in flood, it was a case of waiting till the flood had subsided sufficiently to allow the tonga to get across. After a flood, the bed of the nullah was cleared and smoothed, and left till the next flood washed it away.

Between 1907 and 1917, masonry causeways were constructed in many of these dry river beds, but a great deal of money has been wasted in maintenance and repairs, and for mechanical transport a causeway is never satisfactory in any river bed where the slope and velocity of water are great. It is a sad fact that not one single main road in the North-West Frontier Province can be guaranteed open for through traffic during or after rain. Great strides have been made in the last few years, but a great deal still remains to be done.

In 1916, the first of the new set of bridges was taken in hand, and it so happened that, at this time, the North-Western Railway were replacing their girder bridges with heavier types to cope with the increased load of locomotives and rolling-stock. A large number of old girders, quite suitable for road bridges but useless for railway work, were therefore available, and the first bridge across the Raisan River, on the road between Kohat and Parachinar, was constructed of pin Warren girders, picked off the scrap heaps of the North-Western Railway, which were erected at a cost of approximately Rs. 150 per ton.

The Military Engineer Services put in the foundations and piers, the Railway Bridge Engineer fabricated and erected the girders with his trained bridge gangs, and the flooring, consisting of either steel troughing or a reinforced concrete slab, was finished off by the Military Engineer Services.

Thus bridges could be constructed at a minimum cost.

All girder bridges are now provided by the Bridge Engineer of the North-Western Railway from old material, with a consequent great saving in capital cost.

The point that rules bridging is finance, and for years endeavours have been made to find a type of bridging which is cheap and yet satisfactory. The difficulty which engineers are up against in boulder torrents is the moving bed. In most rivers there is an underground flow, and, during floods, the top portion of the bed from a depth of four to fourteen feet, according to the volume of the flood, is in suspension and rolls. This brings very severe pressure against the piers, and unless they are founded well down into the solid bed and well below the limit of scour, they are apt to tip over, as has happened in many cases.

When constructing the piers for the bridge across the Kurram River at Thal, a great volume of water was met, and eight-inch centrifugal pumps were used to deal with it.

Owing to the water, the sides of the excavation needed shoring, and it was found possible to drive 80-lb. rails to a depth of thirty feet with an ordinary monkey.

The rails were braced, shoring timbers hooked on to the rails, and the amount of excavation reduced and simplified.

After a series of floods, the rail piles were found still standing intact and this led to the belief that piles were a possible solution for road bridges in the North-West Frontier Province.

In 1923, steel screw piles,* constructed by Messrs. Braithwaite & Co., came to the notice of military engineers, and these have been tried with great success in boulder beds. The screw is cast steel, three-and-a-half feet diameter, with a pitch of six inches. The shank is seven inches diameter forged steel. With the aid of a water jet, these screws can be put down to a depth of twenty-five feet, but if a boulder larger than six inches is met, which cannot be moved by the screw, the boulder has to be dug out.

The screws are taken down to bed level and a steel trestle to carry the roadway is bolted on. An elaborate and expensive electric capstan is required to drive the screw, and as the material of the bridge is all steel, the carriage item is expensive. This form of bridge costs approximately Rs. 450 per foot run for a twelve-foot width of roadway. In an endeavour to reduce costs, reinforced concrete pre-cast piles were tried, but these splintered before they had been driven six feet into a nullah bed.

In 1927, a pamphlet describing the vibro-concrete piling system came to notice, and as it seemed too easy, it took some time to get the idea accepted. Eventually, the Government of India agreed to the provision of one seventeen-inch piling plant and an experiment was tried on the Khiali nullah, one of the branches of the Swat River, on the road between Peshawar and Charsadda.

* See "Rapid Bridge Construction in South India," *R.E. Journal*, March, 1928.

This nullah was chosen for two reasons :—

(*a*) It was a hard boulder bed, and if piles could be driven into this sort of nullah bed, they could be put in anywhere.

(*b*) There is sufficient water during the cold weather to enable a boat bridge to be maintained. In the flood season, logs float down and cause severe damage to the boats, and the boat bridge is sometimes closed for days, for repairs.

A permanent bridge was decided on and has been constructed during 1928. The work has been under the supervision of Captain M. R. Jefferis, M.C., R.E., and it is due to his ingenuity and perseverance that it has been a very great success, and has, it is believed, solved the question of cheap bridging in the North-West Frontier Province. (*Photo* 1.)

The principle is a very simple one. A hollow steel tube, closed at the end with a removable shoe, is driven to the required depth by the latest form of pile-driving machinery. Being steel, the tube will go through anything except rock, as it will stand a twenty-ton blow.

When driven, the reinforcement cage is let down, and the tube filled with concrete. Withdrawing links are then fitted on to lugs on the tube and the action of the hammer reversed. The tube is then gradually withdrawn, being driven back a small amount at each blow. This shakes and, at the same time, rams the concrete into the space where the tube was. Thus a green concrete reinforced pile is formed without any chance of splintering or damage.

In some cases when driving in a boulder bed, the tube is apt to get off the straight. Any eccentricity is corrected by connecting the piles of one bent by a ground sill, moulded at bed level.

On this sill the concrete trestle is moulded, which carries the roadway of the bridge. (*Photo* 2.)

In river beds which can be dried by moving the water about, the system is ideal, but in water the present methods are not quite satisfactory. The difficulties will be overcome by driving a cast-iron pipe on the outside of the steel tube, down into the solid bed, and leaving the C.I. pipe permanently. The outside pipe will give greater strength to the pile at the point between the moving and the solid bed, and will also protect the surface of the concrete against erosion by water and gravel.

The following rough costs show the cheapness of this form of bridge against other types :—

	Per foot run approximately. Rs.
Masonry piers with steel girders	1,200
Steel screw piles with steel trestles and decking	450
Vibro-concrete pile piers with R.S.J.s and concrete decking	150

One great item of saving is in carriage of materials. In all river beds, sand and gravel suitable for good concrete can be obtained, and therefore only cement, the R.S.J.s for the road bearers, and the reinforcement have to be taken to site.

As most bridges which have to be constructed are miles away from any railway, this is a very important consideration.

It is now proved satisfactorily that the system is sound, and it is intended to gradually replace causeways, as they are washed away, with this form of bridging. The mechanical side of the plant was at first a difficulty, but the Pathan is adaptable, and Captain Jefferis has been able to train almost expert gangs from local material.

The following is a detailed report of the methods adopted by Captain Jefferis for the construction of the Khiali Bridge, with calculations and comparative costs :—

Nature of rivers—The Kabul and the Swat rivers enter the Peshawar plain through gorges in the hills. From these points they spread out, the former into four main branches, the latter into two. All these branches are of similar nature. Their average bed slopes vary from 1/600 to 1/1,200. The widths vary from 500 feet to 1,200 feet. In the main, the banks are from one to six feet above high flood level.

The bed consists of boulders in gravel with pockets of sand; the boulders are approximately ninety-eight per cent. six inches to twelve inches, with two per cent. larger boulders up to a maximum of two feet diameter. The lower portion of the banks is of a similar consistency, the upper portion being mainly silt and sand hardening into "pat."

The permanent or winter water only fills about half the nullah bed and then only in a series of shoals and pools. A maximum of five feet may be taken for the depth of water during the winter. Many fords across the river do not exceed eighteen inches in depth.

These conditions prevail from the beginning of October to the end of March, when the snow water begins to melt. For the remaining six months, the surface level of the water is four feet to five feet higher and the velocity of the river attains about ten m.p.h. After heavy rains in the hills a further rise of as much as five to six feet is sometimes experienced.

These rivers bring down deodar logs from Swat, Kohistan and Afghanistan during the flood season from May to September, and when the floods subside many logs are left high and dry all along the river banks. These logs come down on the first flood of the next season and do considerable damage to boat bridges, as they are not controlled. The biggest logs weigh about five tons and measure some four feet in diameter and twenty feet in length.

Stability of rivers.—The relative quantity of water passing down the various branches of the rivers varies from year to year, depending on the position of banks and shoals at the point where the branches separate. A branch in high flood carrying an unduly large proportion of water may overtop its banks in some places. This may lead to a new channel being cut out. This channel, however, is unlikely to be cut out deeper than the main stream in one flood, and it is considered very unlikely that in such a case the river could not be returned to its original bed by suitable training works.

Erosion of the banks is of seasonal occurrence. It has been found, however, that boulder stone bunds in wire crates can withstand the set of the river if properly maintained every year. A set of the river at any one point does not normally continue for more than three or four years at a time.

The principle on which the bridges have been sited has been to give the river adequate waterway and in no way to attempt to force it through an abnormally narrow channel. In fact, sites have been chosen greater than the minimum obtainable, in order to allow for the decrease in the waterway due to the pile bents.

Type of bridge.—The Michni Bridge, constructed in 1914, is situated where the main Kabul River enters the plain. It consists of 100-foot steel girder spans on masonry piers. The latter were sunk on a curb, pumps and grabs being used to excavate inside them.

The greatest difficulty was experienced in sinking these wells, due to the large boulders in the bed of the river, and it was not found possible to go more than twelve feet below mean nullah bed level or eight feet, say, below maximum nullah bed level. This leaves a very small margin for scour and is the cause of grave anxiety now, as one pier has settled slightly. Sheet piling, unless of exceptionally heavy section, could not penetrate the nullah bed.

It was therefore considered that some form of pile bridge would prove the most economical form of construction.

Vibro-concrete piling plant.—The only pile which could be sunk in a nullah bed of the nature existing would be a steel pile. As the cost of construction with permanent steel piles would be prohibitive, the vibro piling plant or some similar form of plant only remained.

The plant consists of a boiler, winch and 45-foot jib carrying the tube and hammer, the whole mounted on a base fitted with rollers. The winch is capable of a pull of three tons on each of two drums. It is also fitted with two external capstans. (*Photo* 3.)

The jib is constructed of timber, with steel leaders for the hammer and pile. It is also hinged at the bottom front edge, so that it can be assembled on the ground and hoisted later. The 2-ton hammer is of the ordinary single-acting, semi-automatic type except that it has a special automatic fitting for reversing the action of the hammer and withdrawing the pile.

The pile is a 16-inch drawn-steel tube $\frac{3}{4}$-inch thick, with a cast-iron head, which has a filling hole projecting to the front and a bulge at the bottom increasing the diameter to seventeen inches. A detachable cast-iron shoe is fitted loosely in the bottom and a cast-iron cap on the head carrying a wooden dolly. The links are carried by wire rope tackle, capable of fifteen-ton pull, and hook on to lugs on each side of the pile head, or the cap on the hammer. A wire rope from the second winch drum carries the concrete skip.

The method of driving is as follows :—The shoe is placed under the pile tube, the hammer lowered on to the tube and the links disengaged. The tube is then driven to the required depth.

The links are now fitted on to the cap and the cap and hammer lifted clear. The reinforcement cage carried on the skip rope is now lowered into the tube. While this is being done, the first batch of concrete is mixed and filled into the skip, which is then hoisted by the skip rope and the concrete shot into the filling hole. While a second skip is being filled, the hammer is lowered on to the tube head and the links fitted over the tube lugs.

A pull is now taken on the winch and the hammer started to work in withdrawing. The remaining three skip loads required for a twenty-foot pile are loaded into the tube in sufficient time to keep at least six feet of concrete in the tube.

The whole process, including a five-foot shift to one side, takes on an average three hours. A gang of twenty-five men can work the whole plant, including shifting, driving and mixing the concrete.

The plant can be rolled forward on its rollers by means of bars inserted into ratchet heads fixed in their ends. It can also slide sideways or be slewed round on its rollers by means of a wire rope, passing from the base of the machine out to a pulley hooked over the end of the roller and back to the capstan head on the winch.

The plant has also been fitted with road wheels. The weights of the various parts are as follows :—Base, 3½ tons ; winch, 2½ tons ; boiler, 3 tons ; jib, 3 tons ; tube, 2 tons ; hammer, 2 tons.

Mobility.—When the plant is fitted with its wheels, the jib, hammer, and tube are removed, dismantled, and carried separately.

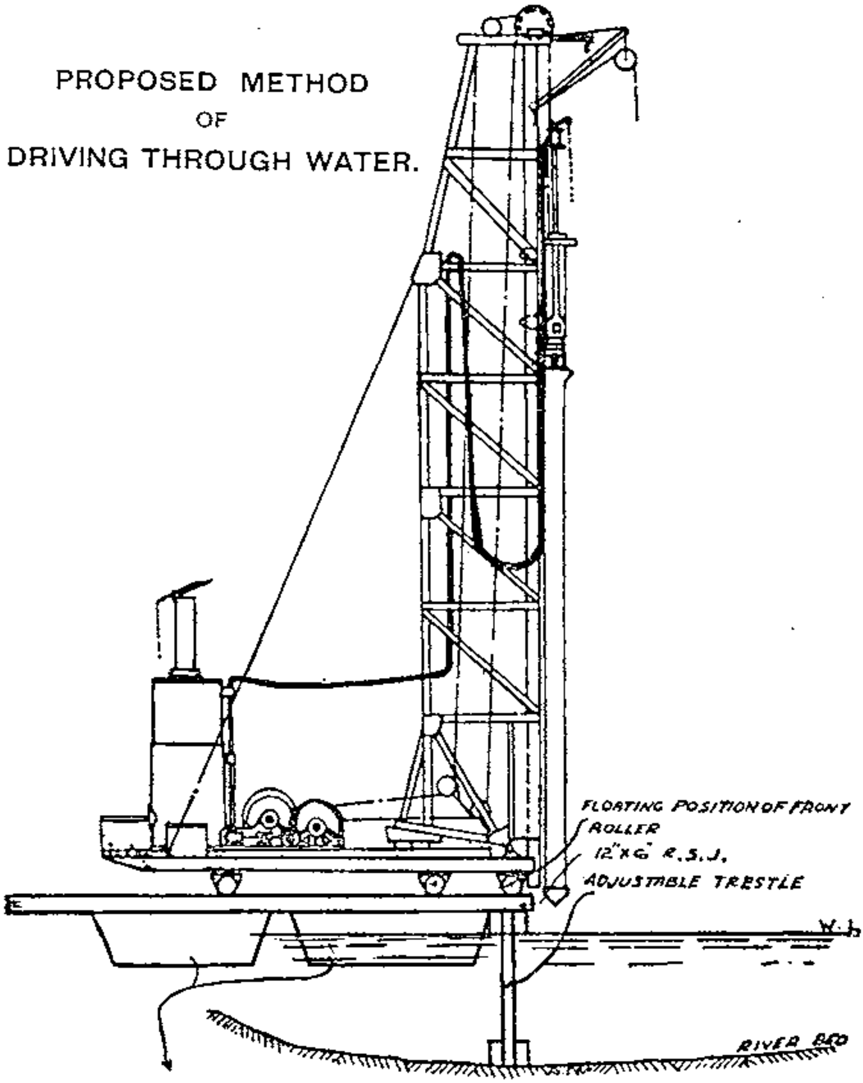
The plant can be towed by a steam roller or tractor along metalled roads at a speed of about one mile per hour where corners, gradients or overhanging trees do not impede its progress. For short moves where a steam-roller is not available, a pulley can be fixed to trees or a hold-fast ahead of the machine and a wire rope attached to the draw-bar and passed round the pulley back to the capstan head on the winch. On unmetalled roads the plant can only be towed by a steam-roller by laying sleepers under the wheels. The progress under these circumstances is rarely half-a-mile a day.

A better method for cross-country work is to use the steam-roller as a hold-fast and attach a pulley to it. The plant can then haul itself up to the roller by means of its winch, as indicated above.

Driving.—When driving in a dry nullah bed, where three piles and one guard pile are required per bent and thirty-feet spans are being constructed, a maximum of three piles a day can be driven. Including a forward shift of thirty feet, the average drops to about two piles a day. Allowing for breakdowns, an estimated figure of one-and-a-half piles a day may be taken. When driving through over 2 feet 6 inches of water, the plant must be floated on boats.

The method used for doing this, with the country boats available, was to fix two R.S.J's. 12″ × 6″ at 40 lb. across two boats leaving

PROPOSED METHOD OF DRIVING THROUGH WATER.



3 feet 6 inches between them. The plant without its rollers, with its jib erected, is then slid on to the boats sideways, so that the tube can be driven between them.

The difficulty about driving from boats is to get the pile straight. Lowering the pile on to the nullah bed alters the trim of the boats, and it is not possible to moor the boats sufficiently rigidly to stop the pile becoming out of plumb if an obstruction is met while driving.

To avoid this the following method will be tried:—Load the plant with its rollers crossways on two boats, without a space between the boats, by rolling it along them on two R.S.J's., which should project three feet beyond the boats. When the plant is floated to the site of driving, a trestle can be fixed under the projection of the R.S.J's. The plant can now be rolled forward, throwing part of its weight on the trestle. The pile can then be driven beyond it. The advantage of this method is that the boats are adequately moored.

When driving through water, great difficulty has been experienced in completing the portion of the pile between nullah bed level and water level. Up to three feet of still water, a ring of sandbags can be made, say, six feet in diameter, and an island formed by filling in with earth. Beyond this depth and in flowing water, some form of steel outer casing must be employed from a depth of three feet below nullah bed level to water level. (*Photo* 4.)

The difficulties of fixing this outer casing in position are as follows:

(*i*) It is not possible to drive a ring of any sort through a boulder nullah bed unless the hole it is to occupy is driven out by the pile shoe.

(*ii*) The casing must be completely watertight, or the flow of the water outside will withdraw the cement from inside.

(*iii*) A close-fitting casing round the pipe as required by (*i*) above can only be driven when the bulge on the lower end of the tube is removed, as it fouls the casing on withdrawing.

It is, therefore, possible to drive through water by making up a sleeve of ⅛-inch sheet iron, fitting the tube closely without a bulge. This sleeve is covered by the overlap of the pile shoe and is held in position by a clip above it bolting on to the tube. The clip can be removed after the sleeve has been carried down two or three feet and the tube driven on through it.

The disadvantages of this method are that—

(*i*) The reinforcement of the pile is only covered by a minimum thickness of ¾-inch of concrete: this might be overcome by threading washers on to the reinforcement bars.

(*ii*) The section of the pile is reduced from seventeen inches to sixteen inches diameter.

(*iii*) The hole is not smoothed out so well by the bulge and it is not considered that so good a pile would result.

Many other experiments were tried to overcome this difficulty, but without success.

Piles.—The vibro-concrete piles for these bridges were driven to a minimum depth of seventeen feet below maximum nullah bed level, and the legs had a maximum height above n.b.l. of sixteen feet.

The outer diameter of the vibro pile is seventeen inches, and the reinforcement used consisted of six ¾-inch longitudinal bars, with -inch hoops spaced at two-foot intervals. (*Photo* 5.)

The maximum axial load that can be carried by such a pile is forty-eight tons, allowing a maximum stress of 500 lb./in.^{2} in the concrete and calculating for concrete inside the reinforcement only.

Eccentric loading.—If the load of W tons falls one inch eccentrically on the pile a bending moment of W in. tons will be set up.

$$\frac{{}^{r}b\,I}{y} = W$$

where $I = \frac{d^4}{20}$. $Y = \frac{d_2}{2}$. ${}^{r}b$ = stress in concrete due to bending.

Assuming that the d, including the reinforcement may be taken as $16\frac{1}{2}$ inches and $d_2 = 14\frac{1}{2}$ inches.

$${}^{r}b = \frac{W \times \frac{14\frac{1}{2}}{2} \times 2240}{(16\frac{1}{2})^4/20} = 4{\cdot}5\ W \text{ lb./in.}^2 \text{ per inch of eccentricity.}$$

Stress in concrete due to direct load $= \frac{W}{48} \times 500 = 10{\cdot}4\ W$ lb./in.^{2}.

Temperature stresses in the legs.—Allowing for a change of temperature of $\pm 25°$ F. the movement in a forty-foot span will be

$$\pm {\cdot}0012 \times \frac{25}{180} \times 40 \times 12 \text{ in.} = {\cdot}08 \text{ inches.}$$

Deflection of leg $= d = \frac{Pl^3}{3EI}$. Bending moment $= Pl = \frac{{}^{r}dI}{Y}$.

Stress due to deflection. ${}^{r}d = \frac{PlY}{I} = \frac{3EId}{3}\frac{ly}{I} = \frac{3Edy}{2}$.

Where l = 15 feet.

$E = 2 \times 10^6$ lb./in.^{2}.

$d = {\cdot}08$ in.

$Y = \frac{14\frac{1}{2}\text{ in.}}{2}$.

$${}^{r}d = \frac{3 \times 2 \times 10^6 \times {\cdot}08 \times 7{\cdot}25}{15^2 \times 12^2} \text{ lb./in.}^2$$

$= 107$ lb./in.^{2}.

Safe load on leg.—Allowing a maximum stress of 500 lb./in.^{2} in the concrete, one inch eccentricity of loading and a temperature movement due to one span

$${}^{r}w + {}^{r}b + {}^{r}d = 500 \text{ lb./in.}^2$$

$$10{\cdot}4\ W + 4{\cdot}5\ W + 107 = 500 \text{ lb./in.}^2$$

$$W = \frac{393}{14{\cdot}9} \text{ tons.}$$

$$= 26 \text{ tons.}$$

${}^{r}w = 274$ lb./in.^{2}.
${}^{r}b = 119$ lb./in.^{2}.
${}^{r}d = 107$ lb./in.^{2}.
500 lb./in.^{2}.

The set on finishing driving was never more than ·2 inches. The makers of the plant give 150 tons as the failing load for this set. This gives a factor of safety of six.

On a forty-foot span, as was used at Khiali, the weight of the R.C.C. T beam decking was 1·8 tons per foot run, or 73 tons per span. The live load may be taken as thirty tons dead load per span, totalling 103 tons.

Four legs were therefore required—the load on each being twenty-six tons—and the maximum stress in the concrete—500 lb./in.².

Expansion joints.—As has been shown above, the maximum stress allowable in the concrete due to temperature movement is 107 lb./in.². This will give a horizontal pull in the transom of P lb. per leg where $r_d = \frac{Ply}{I}$.

$$P = \frac{107 \times 16\frac{1}{2}^4}{15 \times 20 \times 7{\cdot}25 \times 12} = 300 \text{ lb.}$$

$$r_d = 107,\quad l = 15' \times 12,\quad y = 7{\cdot}25,\quad I = \frac{16\frac{1}{4}^4}{20}$$

The allowable pull on the pile bent at transom level is therefore 1,200 lb. per bent.

It was originally intended to give a steel plate sliding joint on every other span. If the co-efficient of friction be taken to vary from ·25 to ·60 for an unrusted-up joint to a rusted-up joint, the difference in pull on the transom will be ·35 × 36 tons = 13 tons.

This is obviously out of keeping with the allowable pull on a transom and the idea was abandoned.

Rollers for similar reasons were also ruled out. The design finally adopted was to break the bridge completely after every sixth span.

The three centre legs were sixteen inches six-sided reinforced concrete columns with six ¾-inch bars carried through in continuation of the vibro concrete piles.

The two legs outside these were "point supported legs" (Fig. 1). The method used for these was to mould a ground transom on the heads of the vibro piles. The leg reinforcement was then all bent into the centre-line of the transom. Extra bars were added in order to provide enough iron for the whole of the weight to be carried in the reinforcement. A layer of bitumen was laid between the bottom end of the leg and the ground transom, to protect the reinforcement and to allow for the movement of the leg.

The two outside bents of the six spans, carrying a half span load only, were constructed of R.S.J's. 12″ × 5″ at 30 lb. with a 4″ × 3″ T bolted down the web: the main axes of the R.S.J's. were at right angles to the line of the bridge (Fig. 2).

The top end was rigidly moulded into the T beam and the bottom end moulded into a ground transom and also bolted to the similar R.S.J. at the end of the next six spans which shared the same pile bent with it. A set of three legs per bent was used.

Calculations for R.S.J. legs.—The maximum movement in three spans will be $\pm$ ·24 in. $= d = \frac{Pl^3}{3EI}$.

where l = length of R.S.J. leg acting as a cantilever—
= say seven feet for a nine-foot leg.

The stress due to the force P is given by—

$$Pl = r_d \, I/y$$

$$r_d = \frac{Ply}{I} = \frac{d. \quad 3EIy \quad ly}{l^3 \qquad I} = \frac{3Edy}{l^2}$$

Where
$$E = 30 \times 10^6$$
$$d = \cdot 24$$
$$y = 5/2$$
$$l = 7 \times 12$$
$$r_d = 7{,}500 \text{ lb./in.}^2 \qquad W = 73/6 + 30/3 \times 3/4 \text{ tons.}$$
$$r_w = W \times \frac{2240}{A} \left(l - \ddagger \, (l/r)^2\right) \quad A \left.\begin{matrix} = 8\cdot 3 \\ + 2\cdot 5 \end{matrix}\right\} \text{square inches.}$$
$$= 6{,}350 \text{ lb./in.}^2 \qquad \ddagger = \frac{1\cdot 95}{25{,}000}$$
$$r = 13{,}850 \text{ lb./in.}^2 \qquad l = 7 \times 12 \text{ in.}$$

Four R.S.J. legs are required. $\qquad r = 1$ in.

Eccentricity of loading of legs.—It has already been shown that the stress set up in the pile by one inch eccentricity of loading amounts to 119 lb./in.^{2} per inch of eccentricity.

When driving piles, the head of the steel tube is held in to the jib, but when a large boulder is struck, say, up to six feet below ground level, the point may move sideways through the ground a matter of six inches. This can be rectified by overshifting the plant beyond the vertical, driving on another five or six feet and then shifting the plant back again to the vertical during the course of driving. If the boulder is met below six feet, it will not be possible to correct the pile completely, but the movement will not be so great in this case.

When driving from boats moored by ropes, the movement was found to be much greater, and the correction much less successful. This would, however, be partly corrected by using a trestle as indicated previously. The result of this is that a maximum slope out of the vertical of three inches or a horizontal displacement out of line of three inches may have to be catered for in the worst case.

It is, therefore, considered advisable to mould a ground transom 18" × 22" over all bents the piles of which were more than one inch out of line, and for all bents where R.S.J. or "point-supported" legs were used. The legs were then built in a straight line along the ground transom, which had to be strong enough to take a twisting couple of, say, dW in. tons

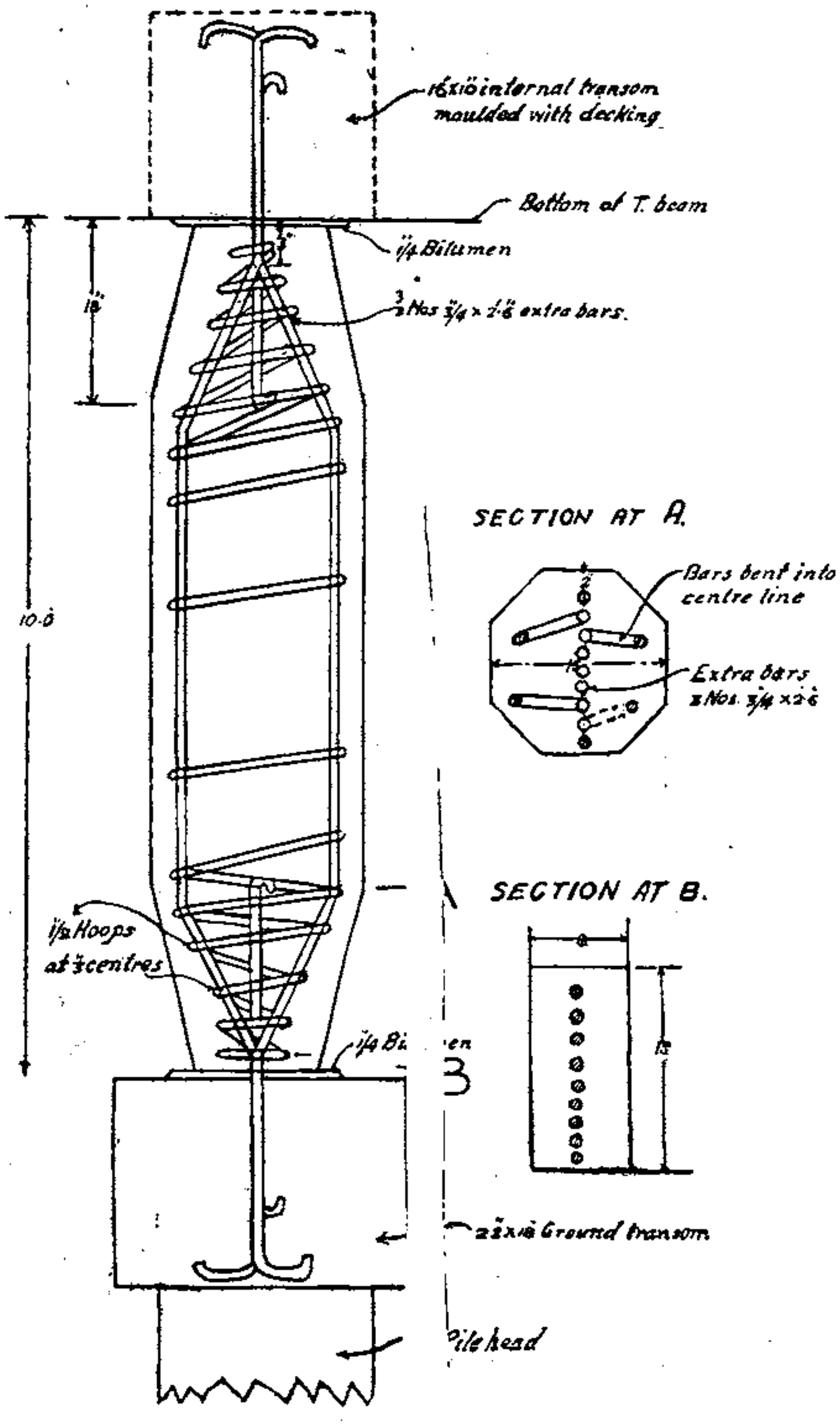
where d may be taken as two inches

$$\text{and } W = \frac{103}{4} \text{ tons} = 26 \text{ tons.}$$

$$\text{Couple} = 52 \text{ in. tons}$$

if the effective mean depth and width of the transom be taken as

POINT SUPPORTED LEG.



R.S.J LEGS FOR KHIALI BRIDGE
BENTS Nos 5 & 13

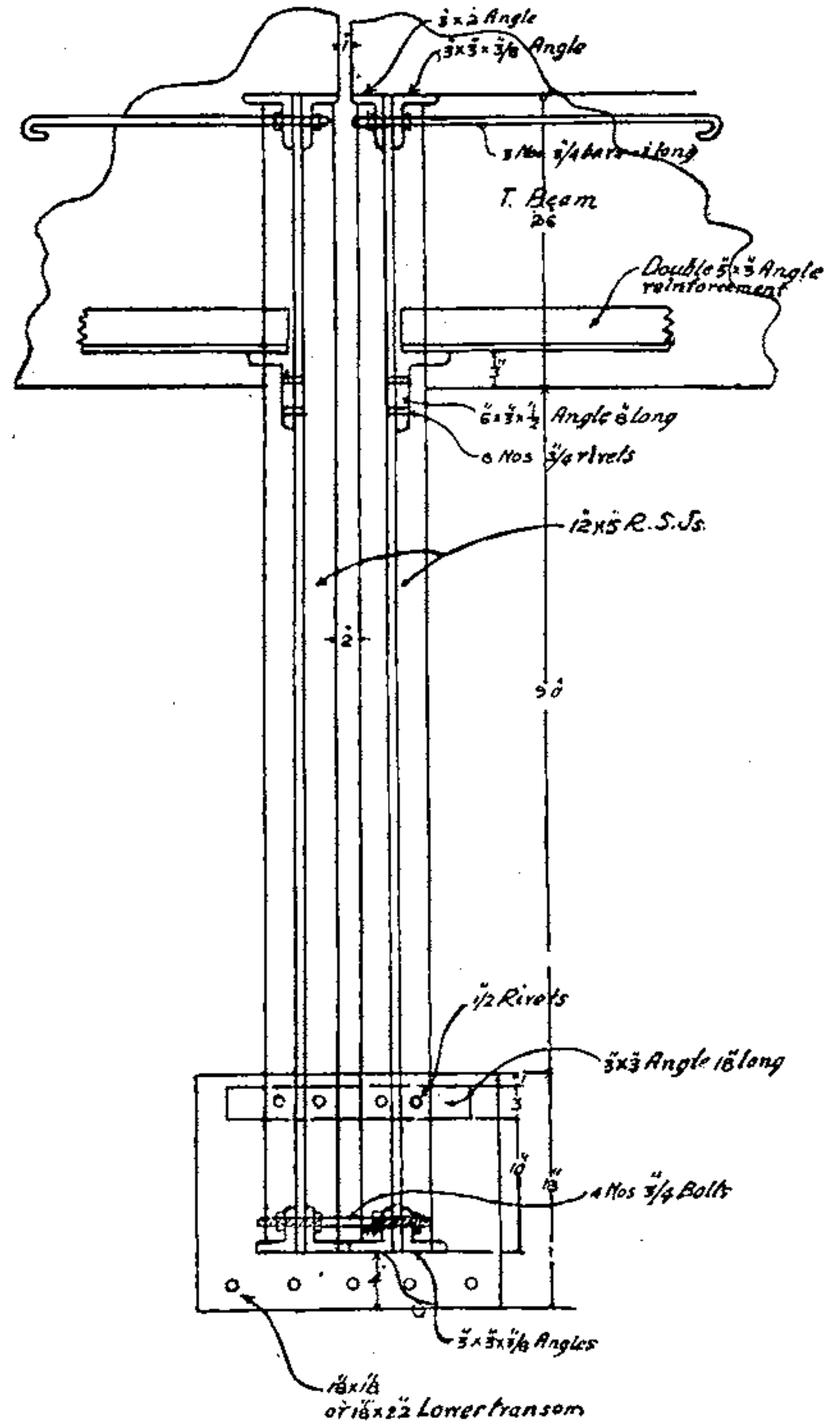
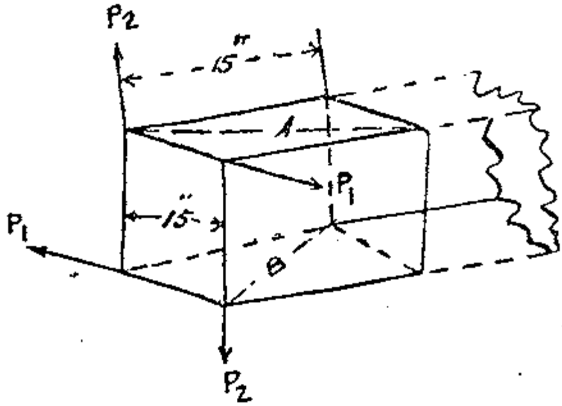


Fig. 2.

sixteen inches and a sixteen-inch length of the transom be considered. The faces A and B act as two girders in which the full lines are tension members and the dotted lines are compression members.



The latter can be taken by the concrete, the former must be taken by the reinforcement.

The couple acting on these two faces is P_1 P_1 which is equal to P_2 P_2.

$(P_1+P_2)b = 52$ in. tons.

$P_1 = P_2 = \frac{52}{30}$ tons $= 1{\cdot}7$ tons.

Section of steel required is $\frac{1{\cdot}7}{7{\cdot}5}$ square inches $= {\cdot}23$ square inches.

½-inch bar hoops at twelve-inch centres will do.

To give additional stiffness, however, ½-inch bars were used at four-inch centres, and four ¾-inch bars longitudinally in the ground transom. Where ground transoms were not used, ½-inch bar hoops at eight-inch centres with four ¾-inch bars were fixed in the upper transoms.

Cost of driving piles per bent—

	4 piles and 1 guard pile. Rs.	3 piles and 1 guard pile. Rs.
(1) (*i*) R. C. concrete work in vibro piles	370	278
(*ii*) R. C. concrete in legs ...	270	155
(*iii*) R. C. concrete in two transoms	223	223
(*iv*) Driving piles in dry nullah bed at 1½ piles per diem	167	133
(*v*) Piles shoes	130	104
(*vi*) Contingencies 10% ...	110	90
	1,207	983

Cost of driving piles per bent—	4 piles and 1 guard pile. Rs.	3 piles and 1 guard pile. Rs.
(2) Add for driving in water ...	167	133
(3) Add for sleeves where water exceeds three feet ...	150	120
(4) Add for twenty-one inches C.I. pipes nine feet long, with shoe	900	720
(5) Add for driving from boats ...	50	40
(6) Add for depreciation of piling plant calculated at a life of 1,000 piles	200	160

Cost of decking per foot run—

	40-foot span. Rs.	*30-foot span.* Rs.
(1) Slab only with hand rails ...	40	40
(2) T beams without main reinforcement	40	26
(3) Main reinforcement	15	11
(4) Contingencies, 10 per cent. ...	10	8
	105	85

Cost of bridging.—The cost of bridging per foot run for an eighteen-foot width roadway works out from the figures above as under :—

	40-foot spans. Rs.	*30-foot spans.* Rs.
(1) Bridging in a dry nullah bed without C.I. casings	140	123
(2) Bridging in the presence of water using ⅛-inch sleeve casings ...	150	133
(3) Bridging in the presence of water using C.I. casings	168	153

Note.—By using R.C.C. slabs on R.S.J.s on the thirty-foot spans the cost can be reduced by Rs. 5 per foot run.

The above quoted figures do not include the cost of abutments, approaches, training works, accommodation for labour, cost of bringing the plant to site of work, carriage of materials, etc.

On the Kabul and Swat rivers for each bridge these items may be taken as roughly Rs. 35,000. For a 700-foot bridge such as is being constructed at Khiali, this works out to Rs. 50 per foot run.

Economical span.—In calculating the most economical span for these bridges the waterway should be considered rather than the over-all span; this may be taken as four feet less the over-all measurement, allowing two feet for the guard pile and one foot for the swing of the water away from the bent on each side. The most economical span lies obviously in the neighbourhood of thirty feet.

Using R.S.J's. to carry the decking, the choice falls between three $20'' \times 6\frac{1}{2}''$ at 65 lb. and three $22'' \times 7''$ at 75 lb. The load to be carried is $18\ [190 - 4\ (x - 30)\ ]$ lb./feet run, (*M.E.S. Handbook*, page 50) the clear span is X feet.

The weight of the decking and girders is 2,400 lb. per foot run plus 3×65 for three $20'' \times 6\frac{1}{2}''$.

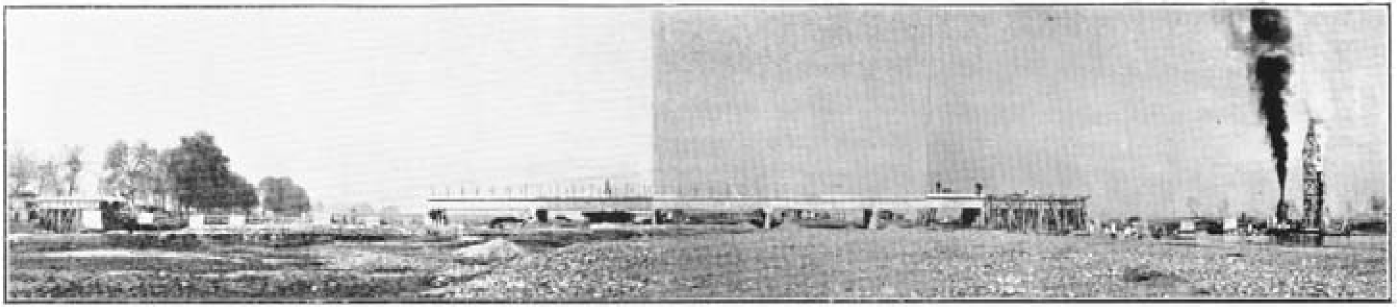


PHOTO 1.—Panorama, on 22. 12. 28, from downstream. Bay No. 1.—Centring in position. Nos. 2, 3, 4 and 5, piles driven. Nos. 6 to 11, decking complete, piles being driven on No. 15 bent. The boat bridge can be seen in the background.

Khiali Bridge

PHOTO 2.—End view of No. 6 bay, showing general arrangement of pi
and guard pile.

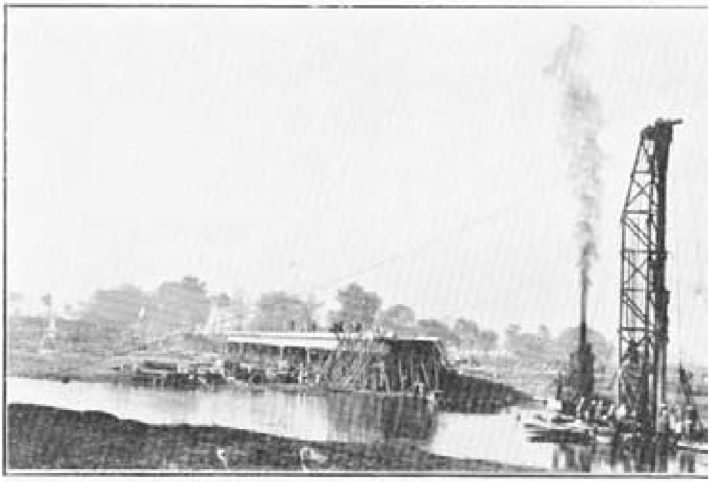


PHOTO 3.—General view from left bank, 22. 12. 28, showing shoring for c
of No. 11 bay.

General view from left bank.

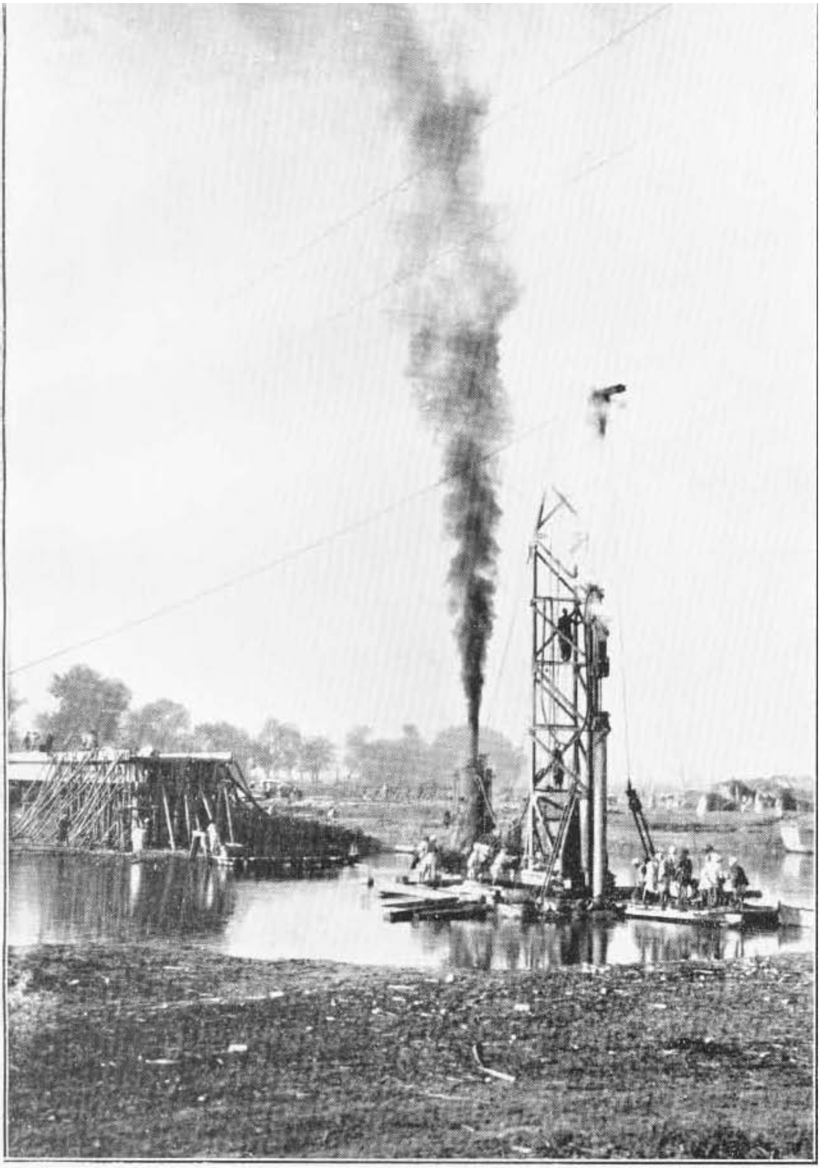


PHOTO 4.—Pile driver, working on bent No. 15, driving piles below the bund, through artificial island formed of boulders in trungas wall filled with earth inside. Depth of water, 4 feet.

Pile driver

PHOTO 5.—The right hand of photograph shows a ground transom being moulded on to the pile heads of bent No. 13. The pile heads, with reinforcement sticking out, can be seen in bent No. 14.

photograph

The total load is therefore (8,175 — 72x) lb./feet run. Maximum load per girder is (2,725 — 24x) lb./feet run.

$$\text{Maximum bending moment} = \frac{wl^2}{8} = \frac{(2{,}725-24x)X^2}{8}$$

$$\text{Moment of resistance of } 20'' \times 6\tfrac{1}{2}'' = \frac{16{,}000 \times 122\cdot6}{12}$$

$$(2{,}725 - 24x)x^2 = \frac{8 \times 16{,}000 \times 122\cdot6}{12} = 1{,}307{,}700$$

When $x = 20.$ L.H.S. $= 898{,}000$
$x = 25.$ L.H.S. $= 1{,}353{,}000$

$$\text{Maximum span} = 25 \text{ feet} + \frac{130 - 1{,}353}{1{,}308} \times 45$$

$$= 25 - \cdot5 \qquad = 24\cdot5 \text{ feet} - \frac{1{,}353 - 898}{}$$

Using three 22″ × 7″ girders at 75 lb.
load per girder 2,735 — $24x$ lb./feet run.

$$\text{Moment for resistance} = \frac{16{,}000 \times 152\cdot4}{12}$$

Maximum span = 28·0 feet.
Using 24″×7½″ at 90lb.
Load per girder = $2\cdot750 - 24x$

$$\text{M. of R.} = \frac{16{,}000 \times 203\cdot6}{12}$$

Maximum span = 33·4 feet.

The comparative costs work out as below—

Girder	22″×7″	24″×7½″	T. beam.
Weight	75 lb.	90 lb.	...
Clear span	28 feet	33·4 feet	28 feet
Over-all span	30 feet	35·4 feet	30 feet
Waterway	26 feet	31·4 feet	26 feet
Cost of decking per foot run of bridge	Rs. 49	Rs. 48	Rs. 44
Cost of bents with C.I. casings per foot run of bridge	Rs. 68	Rs. 56	Rs. 68
Cost of girders per foot run of bridge	Rs. 30	Rs. 36	T. beams Rs. 41
Total cost per foot run of bridge ...	Rs. 147	Rs. 140	Rs. 153
Total cost per foot run of waterway with C.I. casing driven in water	Rs. 171	Rs. 162	Rs. 178

As it is necessary to make use of the boat bridge decking for a period on top of the trestles, until funds are allotted for the concrete decking, bents must be constructed at thirty-foot centres and 22″ × 7″ girders used.

The load per bent with these R.S.J's. is 35 tons dead load *plus* 30 tons live load, including impact factor 65 tons, or 23 tons per pile.

SOME NOTES ON STEEL SLEEPERS.

By LIEUT. I. L. H. MACKILLOP, R.E.

STEEL sleepers have been extensively used by railways abroad for some considerable number of years past, but their adoption, in any quantity, by the home railways has been delayed until this year. The reason for this delay may be partly conservatism, and partly the difficulty of producing a satisfactory design, having regard to the high standard of permanent way practice in this country, but is chiefly due to the plentiful supply of cheap timber which has been available.

Although the railway companies have decided that a portion of the 1930 re-laying programme shall be carried out with steel sleepers, the design is still in the experimental stage, and no type has been laid down as a British standard.

There are, however, two outstanding types :—

Type I consists of a plain steel sleeper, with a cast-iron chair, cast on to the sleeper, being held on by four snugs. Fig. I shows this design ; it is known as the " Composite " steel sleeper, and it has been adopted by the G.W.R. and the L.N.E.R.

Type II consists of a steel sleeper and a steel chair, the latter being formed by stamping and bending up a portion of the top of the sleeper, and by inserting another piece of plate to form the rail seating. Fig. II shows this design ; it is known as the " Sandberg " steel sleeper and has been used in small quantities by the S.R. since 1921.

Comparing the two types, the second appears to have the disadvantage of weakness, owing to some of the metal in the sleeper being utilized to form the chair jaws ; moreover, this metal is taken from the place where most needed, *i.e.*, directly under the rails. An additional disadvantage is that the chair is composed of two pieces which tend to become loosened under traffic, whereas Type I, being all one piece, is not subject to this failing and overcomes the objection of " noisy running," which has been raised against steel sleepers.

With regard to cost, Type II compares favourably at 15s. 3d. per sleeper against 16s. 3d. for Type I ; if the comparison is made by weight, Type I shows an advantage of £7 per ton against £10 for Type II. This may not appear an advantage at first sight, since requirements for a length will be a certain number of sleepers and not a certain weight, but, as will be seen from the diagrams, Type I is a heavier sleeper, and the scrap value, being approximately proportional to the weight, is higher; it should also be noted that a heavier sleeper gives better running.

As has been already stated, the design is still experimental; the outstanding difficulty is how to pack the sleepers satisfactorily when they have been laid. In fact, there is some money to be made by anyone who can solve the problem. To those who are thinking that here is a chance to do this, a few remarks on what has already been done may be of use. There is no special difficulty in packing the sleepers when they are first laid, but when they have been down about a year the bed underneath tends to get consolidated, and it is then that the difficulty arises.

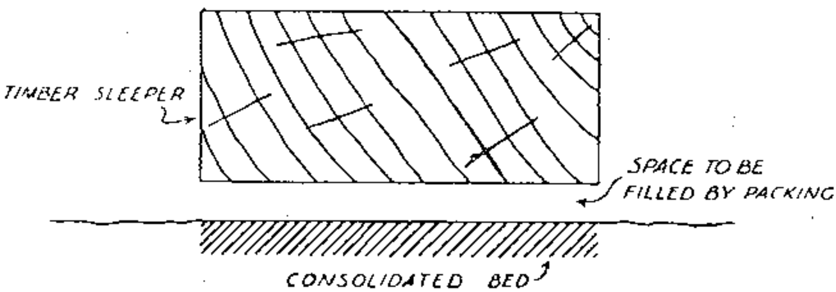


FIG III (a)

For example, let us suppose that, in order to remove a slack (*i.e.*, low place) in one of the rails, a lift of 1 in. is required. The track is lifted by jacks the required amount; ballast must then be placed between the top of the bed and the bottom of the sleeper.

The sketch (Fig. III (a)) shows clearly how this is easily done in the case of a timber sleeper, either by forcing in the ballast with a beater pick or by shovel packing.

The sketch (Fig. III (b)) shows the position with a steel sleeper. Shovel packing is practically impossible, and the use of beater picks is unsatisfactory, because, although ballast can be beaten in at the bottom, thus forcing the bed up against the underside of the sleeper, the bed will be disturbed and settlement will ensue. Moreover, this is not in accordance with the principle of placing the packing between the sleeper and the top of the consolidated bed.

A method is being tried in which four holes are cut in the top of the sleeper, one on either side of each chair; the packing (either sand or small chippings) being poured in through the holes. To enable this to be done satisfactorily the holes require to be 2½ in. to 3 in. in diameter, and close up to the chairs (*i.e.*, where the load will come). Holes of this size so situated, however, considerably weaken the sleeper and are undesirable; it has been found experimentally that holes up to 2 in. diameter do not seriously affect the strength of the sleeper, and the possibility of packing through a 2-in. hole is now being tried out.

Another suggestion has been to leave the ends of the sleepers open, and to pack through the ends. The turned-down ends of the sleeper, as designed at present, bite into the ballast and prevent side movement; if, therefore, the ends are not turned down, some other device must be provided to keep the track in line. With this in view, it has been suggested that two gussets, or stiffeners, should be welded into the underside of the sleeper, placed 12 in. to 15 in. inside the rail, one on either side of the centre line. These plates would be in a vertical plane and be parallel to the rails; they would thus bite into

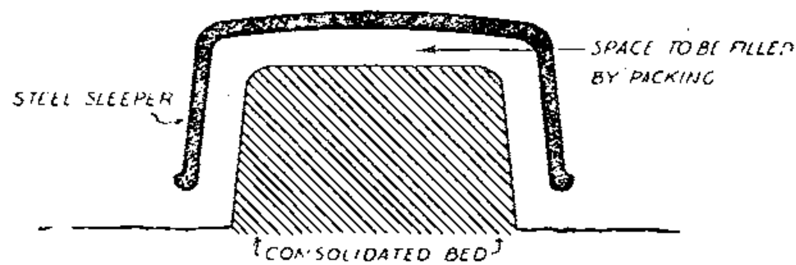


FIG III (b)

the ballast and prevent movement, and still leave the ends open for packing. The objection to this idea is that it involves an extra operation in manufacture and thus increases the cost of production; it is also stated that end packing would tend to cause the sleeper to sag at the centre.

Turning to the comparison of steel and timber, the following points are of interest :—

(1) *Cost.* For similar quality material, steel sleepers cost 1s. to 1s. 6d. more per sleeper.
(2) *Life.* The life of a steel sleeper is computed at 30 years, as against 20 to 25 for timber.

With regard to cost, the increase in scrap value of the steel sleeper more than discounts the increase in original cost. When considering the cost of maintenance, British engineers have, so far, worked on the assumption that both are equal; this remains to be proved.

With regard to life, some difficulty has been experienced with corrosion and consequent wasting of the metal, in ash or slag ballast, in marshy ground, or in localities in the neighbourhood of chemical and other works which contaminate the air with gases of a sulphur base. This shortens the life of the sleeper, but it can be overcome, to some extent, by the addition of ·25 per cent. of copper. The extra cost of this is about 7d. per sleeper.

There is one other consideration when making the comparison, and that is when the provision of insulation for electric traction or for track circuiting is required. These requirements present a problem, not by any means insoluble, but one the solution of which will undoubtedly involve an increase in cost.

While on the subject of track circuiting, it is interesting to note that the German railways, which use steel sleepers very extensively, have adopted a new idea and are developing the use of a silenium cell in this connection. The principle is similar to that now in use for timing high speeds. It utilizes the fact that when a ray of light, playing on a silenium cell, is interrupted, the interruption induces a small current in the cell. It is easy to see how this current may be relayed up to perform the same functions as the present track circuit currents; the ray of light, in this case, is interrupted by a train occupying the length of track in question.

Generally speaking, from the technical and commercial aspect, it may be said that there is little to choose between timber and steel, and there appears, therefore, small reason for the change.

While the technical aspect may be indifferent to the adoption of steel, the political and economical is strongly in favour. One of the reasons, in fact the chief reason, mentioned at the beginning of these notes for the tardiness of the British railways in using steel sleepers, was the plentiful and cheap supply of suitable timber. In the appendices to the summary of the proceedings of the Imperial Conference, held in 1926, reference, at some length, was made to the "world's timber position." It is significant that serious consideration of the use of steel sleepers commenced in the same year. A few short extracts from the reference will be of interest :—

> "(1) A review of the forestry situation throughout the world leads to the conclusion that available supplies of the principal timbers of commerce are rapidly approaching exhaustion. There is every likelihood that in less than 30 years a shortage of soft woods will be severely felt.
>
> "(2) Apart from wood used for fuel, 80% of the world's demand is for soft woods, *i.e.*, pine, spruce, larch and fir.
>
> "(3) In Europe, except Russia, the consumption of soft woods exceeds the growth by 3,000 million cubic feet annually.
>
> "(4) In Russia and Siberia vast areas of soft wood forest exist, but they are so remote from communication that *until the price of timber rises* they will not be an economic source of supply.
>
> "(5) It is estimated that in U.S.A. and Canada there is barely 25 years' supply at the present rate of consumption."

It is apparent, therefore, that the price of timber will gradually rise, and as it rises so will the case for steel sleepers improve.

The U.S.A. consume approximately half the world's timber, and as supplies naturally tend to go to the nearest consumer we obtain practically all our timber from Russia. To be dependent on outside sources for an essential raw material is undesirable, and the situation is not improved when the sources are narrowed to one only. The position is fully realized in this country and efforts are being made, in all directions, to find suitable substitutes for timber ; steel, being an entirely home product, is foremost among them.

One of the items in the programme outlined by the present Government in their campaign at the last election was the solution of the unemployment problem. Material assistance would result from the return to their pre-war status of our staple industries. The outlay by the home railways on permanent way material is in the neighbourhood of £7,000,000 annually, a considerable portion of which is expended on sleepers. The addition of this portion to the turnover of the steel trade would be an appreciable step in the right direction ; so much so, that the Government are pressing for the general use of steel sleepers. In fact, many conservative railwaymen, when asked for an opinion, say that it is the Government, and not the railways, who are responsible for the present movement in favour of the use of steel sleepers.

Suffice it to sum up that all concerned are agreed that a substitute for timber is desirable and that steel is suitable.

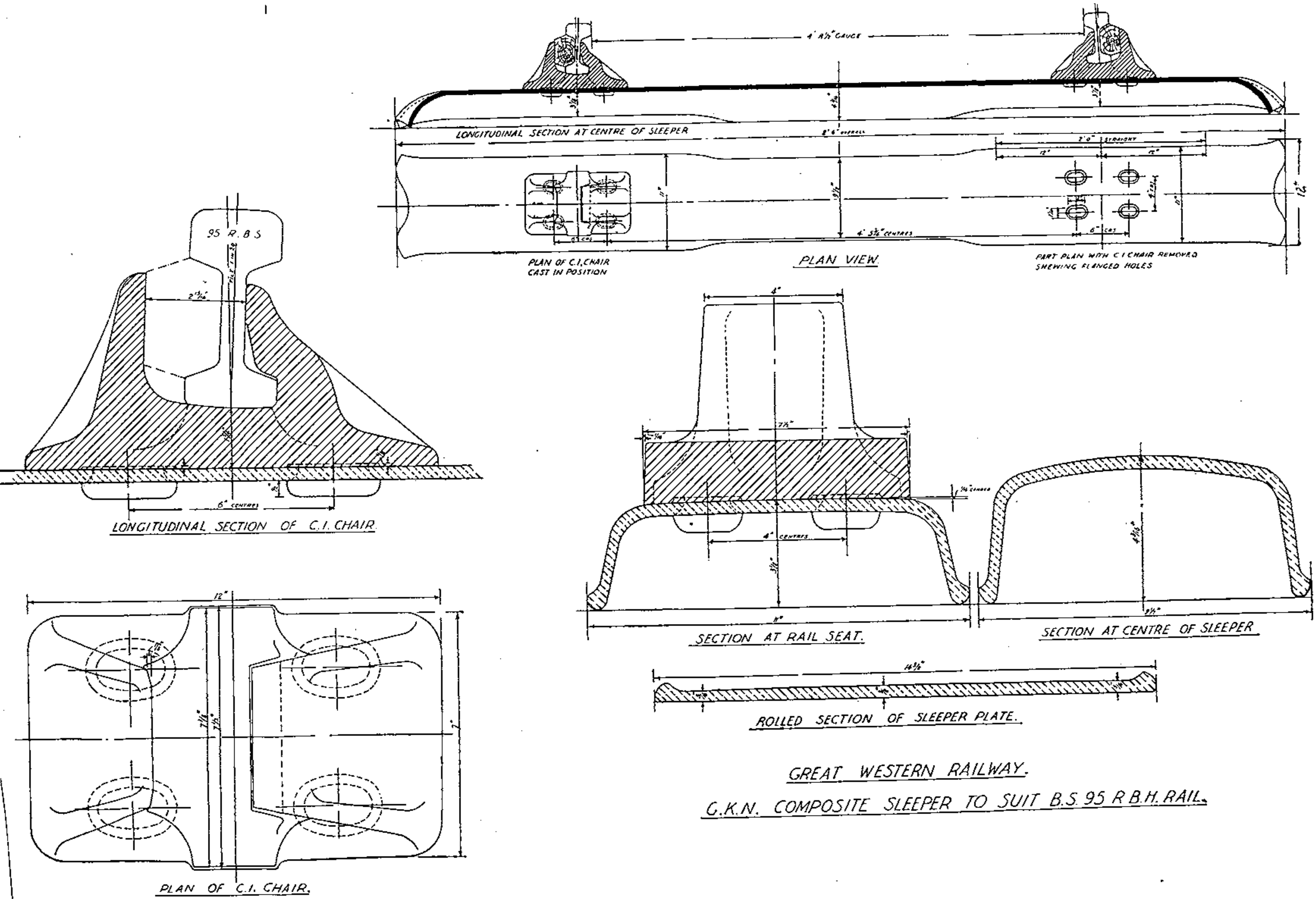
Many articles and papers have been recently written on this subject, and no apology is made that the majority of the facts and information in these notes have been extracted therefrom, but few, if any, have touched on the military aspect. Not being limited by the somewhat elastic space of "one short hour" some considerations, from this point of view, are added :—

(1) The suitability of steel sleepers for military railways.
(2) The sources of supply in event of war.

The 75-lb. B.S. flat bottom rail is the accepted type for military railways. Steel sleepers of both the Composite and Sandberg types to suit this rail are already in commercial production. While Type I appears to be more suitable for civil railways in this country, Type II (the Sandberg), having the advantage of lightness, will be favoured for military use. It is of the utmost importance to keep the weight of military permanent way down to a minimum, not only to facilitate handling in track laying, but also to enable store ships and construction trains to carry the maximum length of track. The Sandberg design, suitable for 75-lb. flat bottom rails, is shown in Fig. 4.

The weight of this sleeper, complete with four steel keys, at 136 lb., compares well with that of a timber sleeper, complete with

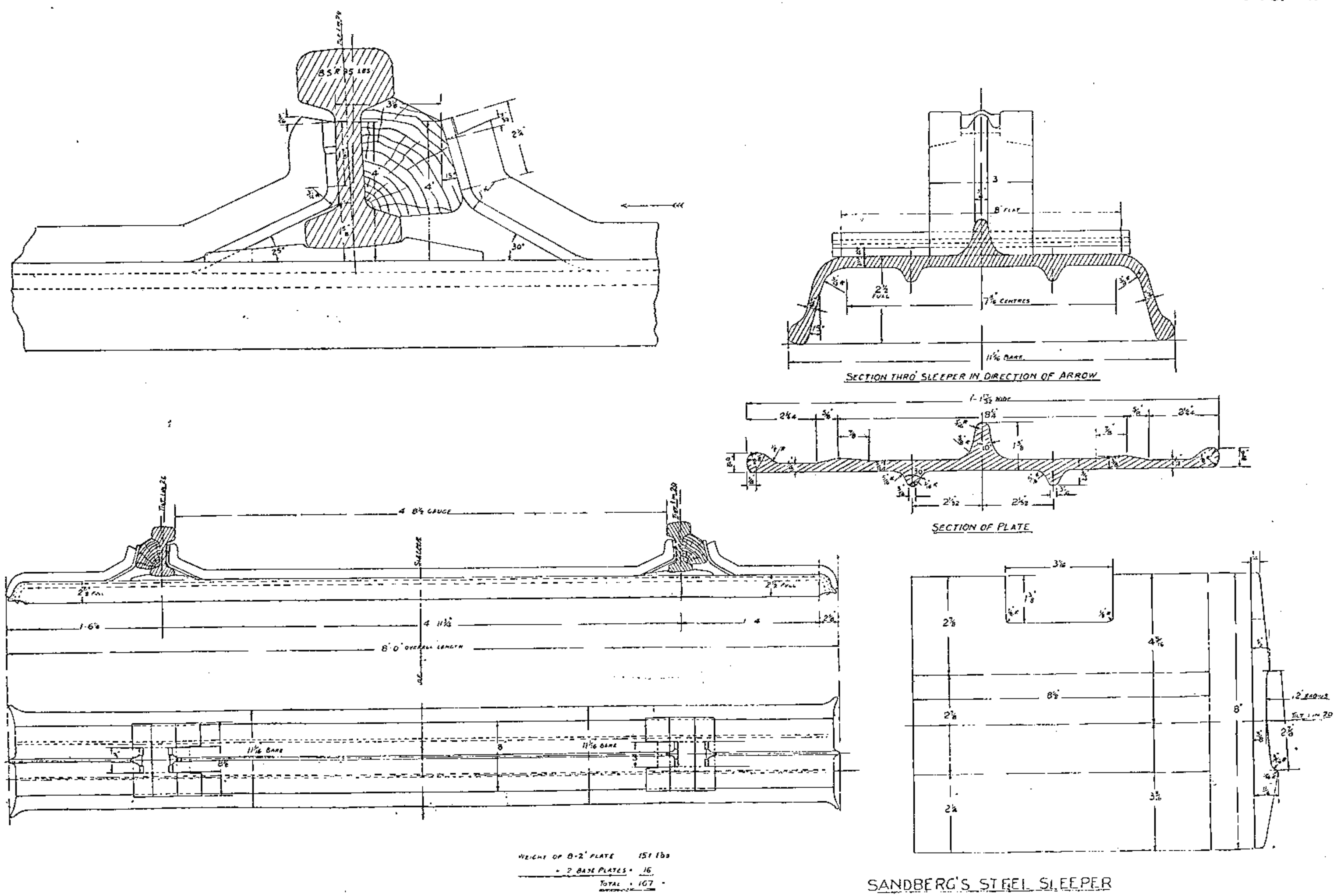
FIG I.



GREAT WESTERN RAILWAY.

G.K.N. COMPOSITE SLEEPER TO SUIT B.S 95 R B.H. RAIL.

FIG 11.



SANDBERG'S STEEL SLEEPER

two bearing plates and six spikes, at 134½ lb. uncreosoted, or 162½ lb. creosoted.

The use of taper steel keys should be noted; on military railways where sharp curves are frequent, it is normal practice slightly to widen the gauge in order to ease the passage of long wheel-base vehicles. This is very simply done by loosening one key and tightening the other, the gauge being variable within the limits of key taper. Further, in event of an adjustment of gauge being required for any reason a timber sleeper has to be re-spiked; constant re-spiking is undesirable as the re-driven spikes do not hold well on account of old spike holes. On the other hand, the gauge may be adjusted any number of times with no detriment to steel sleepers.

The design shown does not include the separate plate required in the case of bull-head rails, nor are the chair jaws so large, consequently the disadvantages of loose parts and weakness pointed out earlier in the notes do not apply for flat bottom rails.

A consideration of importance is that of "end on" plate-laying. Since there is no spiking to be done, it is estimated that a reduction of at least 50 per cent. can be made in the rear party.

The question of fittings (*i.e.*, switches, leads, crossings, etc.) with steel sleepers has not yet been solved by the civil railways; it is a difficult one; and it is aggravated in the case of military railways by the need for standardization of parts and the reduction of specials to a minimum. For the present, we must curtail our thoughts to the use of steel sleepers in plain line.

The question of the supply of steel sleepers in event of war presents little difficulty, and is perhaps the most compelling reason for their adoption for military use.

Steel sleepers are produced from start to finish in this country; by using them, therefore, we can release cargo space, previously used for bringing timber into the country, for other urgent commodities, and we are not dependent on an outside source of supply. As stated previously, designs suitable for military railways are now in commercial production, immediate supplies should, therefore, be available when required.

It has been shown that a timber shortage is imminent, and it may become essential to restrict the use of timber to necessities.

The writer ventures to express a hope that the authorities concerned will try and see their way to provide a small quantity of steel sleepers, to enable railway troops to become familiar with their use, and to settle upon the most suitable type.

SOME R.E. PROBLEMS IN AIR DEFENCE.

By CAPTAIN L. E. C. M. PEROWNE, R.E.

*"We can set our defence organization the exact problems it will have to solve in war . . . the handling of the searchlights and the system of control are the same in peace and war . . . and our peace manœuvres . . . will give us a very clear idea of how far we are progressing towards a solution."**

THE appearance of the new Manual, which is now in course of preparation, consolidating, as it were, the ground made up to the present day, will constitute a distinct milestone in the history of air defence. The object of this article is to review at this stage the extent to which our difficulties are already met; to define afresh the R.E. problems in air defence towards the solution of which we must continue research and to suggest a possible line of development for the future.

(A) "*. . . the handling of the searchlights . . .*"

(i) *General.*

The role of an R.E. unit in air defence is one of co-operation, either with fighting aeroplanes or with anti-aircraft artillery. The primary function of searchlights is the illumination of hostile aircraft. When clouds obscure the target, this function is held to have been discharged if three beams are accurately directed by sound, so that (if produced beyond the clouds) their intersection would indicate to defending aircraft the position of the enemy.

The Air Defence of Great Britain exercises may be taken as fairly conclusive tests as they reflect the work of both Regular and Territorial units. An official report on the 1927 Exercises states that many day raiders got through unattacked (in the aircraft fighting zone), but, "on the nights when exercises were carried out, no bomber which actually came over the lights was able to escape our fighters."†

The result of six weeks' continual nightly practice in 1928, culminating in A.D.G.B. manœuvres that year, bore out this assertion.

From the foregoing statement, backed by the experience acquired during five years of constant practice, it can be affirmed that, at the present stage of development, given trained men working together

* Major-General Ashmore, *Air Defence*, p. 145.
† These nights were admittedly easy for the defence.

for a season, no hostile aircraft should escape detection and illumination (as defined above) when passing over a lighted area* in any weather or at any height at which it might hope to make profitable bombing practice.

The weather, being beyond our control, requires but brief consideration. In general, it may be accepted that weather which is favourable for the attack is equally so for the defence and *vice versa*. On moonlight nights, when the ground lies clearly visible to the airman, silhouette spotting renders the task of locating him simple. When ground mist prevents those at the searchlights from seeing anything in the air, the land lies densely shrouded from the attacker's view. On such occasions it has been found good tactics not to expose the lights at all and so to leave the enemy in ignorance of his whereabouts.† When low clouds obscure the target from view from the ground, beams penetrate to a great height and can be seen by friendly pilots also above the clouds ; while by flying at a greater height than that of the attacker, the raider may be seen in silhouette against the clouds lit up generally by the beams from beneath, even if they are not being directed accurately at the enemy. At twenty miles, and even twice this distance under favourable conditions, defending pilots have been able to detect suspicious concentrations of beams indicating the presence of an enemy.

The competition between beam range and flying height provides the parallel to the eternal struggle in naval warfare between gun and armour. With a range under average weather conditions of five or six thousand yards along the beam, the M.C.D. equipment has within reach machines flying at heights up to twelve thousand feet. At the present stage of development it is questionable whether effective bombing on a large scale can be carried out at heights much above ten thousand feet, while experience in the War showed that, over sixteen thousand feet, the physical effects alone on the crews of the Zeppelins were so great as to reduce their striking power almost to vanishing point.‡

Research has, however, so far developed that, with the introduction of the H.C.D. lamp, machines travelling at the great heights of twenty thousand feet and above are brought within range of illumination from the ground. So that for the present, at any rate, the defence is in this respect well in advance of the attack. But in order to simplify spotting and to counteract the effects of the protective colouring of aircraft, as well as for gunnery purposes, as much light as possible, under all conditions, is required on the target, and

* The equipment referred to in the consideration of progress made up to the present time is the standard 90-cm. projector with M.C.D. lamp and long-arm control, used in conjunction with the Mk.IIIx sound-locator.

† As, for example, the *Silent Raid* on London, 19th October, 1917. Capt. J. Morris, *The German Air Raids on Great Britain*, p. 187.

‡ *Cf.* Major-General Ashmore, *Air Defence*, pp. 58 and 144.

this, therefore, demands continued research and experiment with lamps and reflectors directed towards both an increase of range and power of penetration.

The practice known as "jinking," or "beam-dodging," whereby a pilot endeavours to avoid detection or escape from the light by flying on an erratic course, is the most primitive form of tactics employed by raiding aircraft. No trained projector controller should allow himself to lose his target once he has picked it up, provided that the projector is well balanced and the raceway smooth-running.

A stationary or intermittently moving beam is remarkably easy to avoid, as anyone who has been over an illuminated area by night can tell, but by keeping the beam "live" when searching, it is possible to counteract the pilots' efforts to fly round it.

Although it is improbable that an enemy could spare the time for "jinking" when bent on a raid, and it is virtually an impossibility in the case of a formation attacking, it presents the controlling number of the searchlight detachment with almost his only problem and is mentioned here to call attention to the necessity for a "live" beam when searching, and for a well balanced and smooth-traversing projector.

(ii) *Spotters.*

The practice of raiders gaining height outside the lighted area and "gliding" over in almost complete silence, provides a very serious problem, and the detection of such machines, it must be admitted, is at present a matter more of good fortune than good management.

It is unlikely, however, that such tactics could be used effectively in a raid over such a large defended area as that of London; but in the field, where air defence will perforce be limited to small localities, it would seem to offer a very promising chance of evading the defence. Indeed, an R.A.F. report on some operations conducted in August, 1928, suggests that this method "is the only way to ensure that slow night bombers shall get through a defended zone undetected," and this opinion was amply born out by results.* Of eight machines which attempted the raid, only one was picked up before reaching the objective, a glide of some six or seven miles. The same report continued to state that all the machines had height enough to have glided out of the area again in silence, though this was not actually done. And this success was achieved over Regular troops, who had been in constant nightly practice with detachments composed of the same men, for several months!

There is no doubt that a great deal can be done by intelligent and experienced men acting as spotters. The occasional "back-fires" of the throttled-back engines, the accompanying exhaust flashes, and

* No. 7 (Bomber) Squadron, R.A.F., 29.8.28.

the wind humming in the rigging of the machine, may all be detected by an expert observer. On the occasion under review, officers, N.C.O.s and spotters were in several instances able to detect the hostile aeroplanes from these indications using good binoculars, but to remove the glasses from the eyes meant losing the target, and so no directions could be given to anyone else as to its position. Projector control from the spotter's glass is necessary.

In the past, it has been a regrettable error in many cases to regard the post of spotter as one of low importance. The tendency has been in these days of shifting personnel and reduced establishments* to build up a skeleton of so-called " key-men "—lorry drivers and lamp attendants—from the best available, then to select the listeners from the remaining trained soldiers, and finally to allot the balance of recruits and cooks' mates to detachments as spotters ! And all the time, were it only realized, the spotters are the most important members of the detachment. This is now very generally accepted in theory, but in practice the selection of the men for these duties is still very largely governed by other influences. A bad driver may wreck his machine, a poor lamp attendant let his arc out at a crucial moment during practice, and these are likely to have much more serious results in peace than failing to spot a silent target ; and the writer recalls vividly the case of an excellent spotter who was unfortunately a better batman !

Experience shows, however, that the degree of intelligence required for either of the technical operations referred to above is not nearly so high as that required by a man to become a good A.A. spotter ; and it is possible that a more suitable type may exist in civil life than can be found among any of the Corps trades of which the A.A. Company is composed.

The training of spotters is, unfortunately, difficult, experience being the chief attribute ; and it is all too generally accepted that actual practice by night is the only means of supplying this experience. It is true that, once a certain stage has been reached, by far the best training is for a number of lights in a training lay-out to be deprived of their sound-locators and to have blindfolded projector controllers. But a considerable amount of preliminary training can be undertaken by day, and indoors, once the objects to be aimed at are clearly understood. The preliminary instruction should be divided into two parts, the first of which should teach the man how to pick up his targets, and the second how to bring the beam on to them.

The men should first be taught the use of their glasses. It is generally assumed that any man understands the use of binoculars, but such is not the case. Men are not infrequently found using,

* The A.A. Searchlight Companies of the T.A. are reduced to a strength of sappers equal to only 75% of their war establishment.

quite contentedly, glasses in which one eye-piece is quite blurred and incapable of being focused, or which suffers from some other defect. It seems incredible, but it has been found necessary to devote a considerable time to instruction in this elementary knowledge, in order to ensure that the men do really use their glasses in focus. This can only be tested on print of some sort, the men being made to read newspaper headlines at thirty yards. With practice, men with good eyesight (and those without should be trained in some other duty) find it easy to read even smaller type. This practice carried out in a miniature range or barrack-room forms an excellent occupation for a rainy day, particularly if the competitive element be introduced, and accustoms the men to see detail through field-glasses.

The next stage is to train the man to appreciate quickly what he sees—a target may just be leaving the field of view as he comes up—and to this end groups of spotters should be taken out to a convenient view-point and, after inspecting for a limited time a conspicuous object such as a milestone, one of the men should be made to lower his glasses and describe in detail what he saw. At first it will be found that he has little to say, but after some practice and instruction as to what is required, he will be able to describe in the minutest detail pebbles, tufts of grass and other inconspicuous objects in the immediate surroundings of the milestone after a glance of only a few seconds' duration. This is very similar to the Boy Scouts' test of observation and, if carried out frequently, soon produces a very noticeable quickening of the brain, which is most essential to good A.A. spotters.

In addition to this, every man should be instructed in the use of his head as a sound-locator, in the principles of "silhouette" spotting, and in the methods of the so-called "Walking-stick School"; and made to practise them whenever an opportunity happens to present itself. The sight of a number of men at work suddenly pointing into the sky on the approach of an aeroplane is undoubtedly comic and the element of foolery is apt to creep in; but if the men can only be made to take this exercise seriously and to school themselves in it continually, it has been found that it becomes a habit with them to come up within a few degrees of the target each time.

The second part of the spotters' instruction is directed towards training his brain to take control of another's at a distance. The instructor moves a disc about on a wall. The spotter, standing some yards away, directs a blindfolded man to follow it with another disc. The speed of movement, slow at first, quicker and irregular at the finish, need not attempt to reproduce actual speeds of target or beam, for the object of the exercise is mind-training and practice in the use of the various tones of voice to ensure close control. But it is advisable to have the discs of proportions relative to the beam and target in order that the spotter may accustom himself to the degree of tolerance permissible.

"Spot-chasing," a familiar exercise on cloudy nights, can also be carried out indoors and can be used to provide valuable experience for spotters.

It is regrettable that, up to the present, practically no serious attention has been paid to these forms of training, and even the equipment available for the spotters has been sadly neglected. The recent provision of first-class binoculars has gone far towards improvement in this province, and being given a means of controlling the beam from the spotter's glass,* it is not unreasonable to suggest that efficient working may be achieved, against targets which are to be seen, by spotters alone, unaided by sound-locating apparatus. And this, indeed, may become a necessity if much progress is made in the silencing of aeroplane engines; or when local shelling or bombing renders the use of the sound-locator impossible. But picked men and serious attention to their training as spotters are necessary before such a result will be achieved.

(iii) *Sound-Locators.*

No reference has so far been made to a subterfuge to which raiding aircraft conventionally resort, namely, "sound-masking," of a high-flying formation by a low-flying noisy decoy. This is generally only effective against the lights immediately beneath the raiders, and the presence of more than one target is nearly always obvious to observers stationed to a flank, and trained N.C.O.s have little difficulty in deciding to leave the "decoy" to the attention of the nearest beam and search for the raiders higher up.

Interference with sound-locators caused by friendly "fighter" patrols appears to be an unavoidable nuisance when working with defending aircraft; but it need not present an insuperable difficulty to men who have been taught to recognize the noise of a single high-speed engine and to distinguish it from that of a multi-engined bombing machine, and who have been frequently exercised in this work *by day* when they can constantly check their own observations.

It may be assumed that in a fixed defence, such as that of London, the patrol lines will be within closely defined limits and a knowledge of these courses should be of great assistance to the listeners concerned in quickly identifying a friendly patrol. It is, however, a regrettable fact that, during an engagement, before the raider is illuminated, the attempts of the listeners accurately to locate their targets may be frustrated by interference from the approaching friendly "fighters."

Sound-locator instruction should be centralized as far as possible,

* Sights on top of the binoculars do not offer a satisfactory solution, owing to the need for a second person to transmit the observations of the spotter.

as much greater value can be derived by a class listening on, say, six instruments at one point, under the supervision of an officer and several specially trained N.C.O's. than in single detachments spread round the countryside.

The object of all sound-locator instruction should be to enable the man to visualize what he is hearing and to this end it should be in the form primarily of simple lectures on types of aircraft, their engines and the type of note produced ; and, secondly, of carefully arranged demonstrations by day recurring at frequent intervals.

The actual numbers selected as sound-locator crews should, in addition, be constantly exercised not only in straightforward location of single aircraft, but under conditions of interference such as are envisaged above. Co-operation with the R.A.F. in this class of work has always presented a difficulty, and very little has been attempted so far in the direction of really organized flying for sound-locator training. The more general procedure has been, for many reasons, confined either to listening to a machine detailed to fly for some other purpose on the rare occasions when it passes near enough, catching a few machines as they leave or return to an aerodrome, or on daily flights " over the area " when in camp.

These methods and those of elementary sound instruction do succeed in producing detachments capable of picking up reasonably accurately single machines at normal heights, but experience has proved that the detection of aircraft under interference from other machines is not difficult to men of quite average intelligence, if given opportunities for frequent practice under the same conditions when they can also *see* what they are listening to.

If, however, the question of interference can be dealt with, that of target speed is not so lightly to be dismissed. A recent edition of the *Morning Post** published a photograph of a new design of bombing machine ordered for the R.A.F., which is capable of a speed of 180 m.p.h. A target of this nature flying at ten thousand feet would not become audible to listeners posted on the outer line of lights, until it had proceeded three-quarters of a mile inside the normal sound range. A machine similar to the Schneider Cup winner of last year would first become audible to the same listeners when a mile and a half inside the area, and another thirty-two seconds would take him out of light range in the opposite direction ! This last case is probably looking rather far into the future, as such speeds cannot yet be applied effectively in the case of machines designed for long-range bombing, but it will be appreciated that quickness in locating by sound is the only counter to increase in target speed. With the comparatively slow-moving bombing machines which co-operate with searchlights on most occasions, no necessity arises for extraordinary speed in this work ; and the average good listener

* *Morning Post*, 17th February, 1930.

of to-day is satisfied to obtain a fix after some nine or ten brackets, lasting anything up to twenty seconds and more. Not only during that time is he unconsciously becoming fatigued, but he is simply wasting time, during which the target might be illuminated, or at any rate, during which the light might be exposed and searching actively for it. Listeners should be trained to make a fix in three brackets at most and exercised at it continually until a determination can be made regularly within the required degree of accuracy. The practice of languidly bracketing is most demoralizing.

Quite apart from the fact that the present sound-locator ring-sight is not graduated beyond 180 feet per second, it must be observed that any error in the determination of the "leading edge" is magnified more in the case of a high speed setting than in that of a low speed; and thus a high speed machine demands not only more rapid listening, but also more accurate determination of "leading edge." Few men to whom the duty is entrusted know more than eight positions, or ever use more than four! In the same way as described for the instruction of spotters and the actual listening numbers, these men must be taught and exercised, *when they can also see what they are contending with*, to fix the "leading edge" more accurately and to appreciate when the ring-sight speed setting obviously requires adjusting. An automatic means of determining "leading edge," when perfected, will be an immense advantage.

(iv) *Conclusions.*

From the foregoing considerations of what may to-day be regarded as the chief difficulties in the performance of the primary role of the R.E. in air defence, it will be appreciated that the somewhat sweeping assertion made at the outset is not without sound foundation. If results fail, on occasion, to bear this assertion out, it is because the training of spotters and listeners has not yet reached the standard required in order to obtain the most efficient results; and for this reason, the questions affecting the selection and training of these members of the searchlight detachment have been referred to at some length.

(B) " . . . *the system of control* . . . "

(i) *General.*

In the consideration of the secondary role of the R.E., a similar conclusion is reached. The part played by searchlight units in air defence control is the collection of intelligence, and the task is broadly defined in the *Manual of Air Defence*,* as follows :—

> " . . . to collect and pass on information as to the position, height, course and speed of hostile aircraft."

Before proceeding to review the present position in this province,

* *Manual of Anti-Aircraft Defence*, 1929, Vol. II, Section 2, para. 6.

it is necessary to have a more detailed interpretation of the actual requirements, and in order to obtain this, some consideration of the uses to which this information is put would appear to be desirable.

In defences where there is adequate depth, timely information as to the height and course of approaching hostile machines may be of assistance to the commander in ordering reinforcements into the air, or in concentrating his "fighters" across the line of attack. It further enables complete records to be kept which furnish useful information as to the courses habitually taken by the enemy, etc., which may be of value in forecasting the probable development of future raids. It also may be used to inform those responsible for the control of the civil population, street lighting, and so on, of the exact moments at which danger commences and ends, thus reducing to the shortest period possible the inconvenience caused both to industry and to the general public.

For all these purposes the accuracy of the information is not required to be of a very high degree; height to within one thousand feet, and position to within one thousand metres being all that is required. In fact, the operation maps in use at fighting area headquarters are not gridded below ten thousand metres!

In the field, however, where, at any rate in the early stages of operations, air defence will be confined to small localities, the depth of the defence is not likely to be sufficiently great to allow time for value to be derived from the information collected for any of the above-mentioned purposes except record.

But, when working in co-operation with artillery, another problem arises. The A.A. gunner requires to know accurately the height of his target and the height-finding instrument which he employs by day is not entirely satisfactory by night.* It thus becomes an additional object of the searchlight reporting system to obtain rapidly a verification of height to within fifty feet. So that, whereas the present searchlight equipment is such that no very marked difference need be drawn between fixed and mobile units in the general consideration of the main problem of detecting, locating and illuminating the target, the factors affecting the collection of intelligence differ very considerably in the two cases and it is necessary to treat each separately.

(ii) *Fixed Azimuth.*

In fixed defences, which can be prepared in time of peace and probably after the lapse of some time at a base of operations overseas, each searchlight can be connected to its section headquarters by telephone. With such a widely dispersed command as is furnished by a searchlight company in action, the provision of these com-

* The U.B.2 height-finder requires a very high scale of illumination to provide the necessary clean "cut" for an accurate observation, and work on anything in the nature of a "woolly" target is liable to considerable error.

munications for administrative purposes alone will be demanded at the earliest opportunity. Under these circumstances, a system known as fixed azimuth plotting can be used.

This depends for its action on the observation of angles of elevation of two projectors at the instant when the target crosses the "base line" joining their positions on the map. Six searchlights are usually connected to one section headquarters, where the necessary computations are made to determine the height and plan position of the target. When a target passes between two searchlights of different sections, the reports are passed direct to the company headquarters for collation.

In practice, conclusive checks of the results obtained are difficult, owing to the relative inaccuracy of the pilots' own determination of his position in most cases, but a recent detailed analysis of plotting, carried out on the fixed azimuth system in the Isle of Thanet by a T.A. unit of average efficiency in this branch of A.A. work, may be quoted as a fair example. In this case, the various conspicuous towns on the coast-line were made use of as points of entry and exit, and the courses reported by the pilot may, therefore, be accepted as reasonably accurate.

The analysis covers the work of only five nights, but the results do not vary to any extent from night to night. The time-lag remains fairly constant at two minutes; that is to say, the position of the target reached company headquarters two minutes late. Allowing for this, the average error in plan position was approximately two thousand metres; and heights were seldom within three thousand feet of those given by the pilot.

Changes of course inside a ten-thousand metre square were very generally followed correctly subject to a fairly constant error of course angle, fifteen to twenty degrees one way or the other.

Viewed, however, from the rather larger viewpoint of those who make use of the information supplied, these errors diminish into insignificance. The mean only of changes of course inside a ten-thousand metre square is of interest, and this becomes self-apparent as the plot proceeds from one kilometre square to another.

It is not entirely a question of training here, for there are many factors affecting, if not entirely removing, the chances of obtaining accurate results which are beyond the control of the troops. To begin with, the beam itself is dispersed 3 degrees, representing about 500 feet at a height of 10,000 feet, and there is no reason to expect the target to be held centrally in the beam while the readings are taken; in fact, the projector controller's instructions are to keep the target either in the "leading edge" of his beam, or where he can best see it. Then again, a slight eccentricity of the positive carbon, or even an irregular crater, neither of which can always be avoided, must produce a divergence of the beam from the true line of the projector; while the reflector cannot always be said to be mounted dead true and must produce a similar error. Quite apart from these potential sources of error, the pointers are nearly always several degrees wide, even where the degree marks themselves are not!

So that it may be admitted that, with the equipment at present available, the results actually achieved approximate very nearly to the limit of accuracy obtainable by the fixed azimuth method.

It is now very generally realized that every advantage is to be gained by the plotters, or at any rate, the officers in charge, sitting in the open where they can also see what is going on. Under such conditions it is possible to plot a very accurate course by eye alone, and, with but little experience to judge height to within one or two thousand feet. By this means, reports were received in London during the German air raids on Great Britain, within half a minute of the enemy crossing the coast;* and there can be no reason for neglecting to verify the information derived from the lights by the simple expedient of watching the operations in the sky. Yet this is very far from the general practice.

When the target is obscured by clouds, or by day, fixed azimuth plotting can be carried out by reading the required angles from sound-locators; and in spite of the little-exercised listeners, the results obtained at a trial of this method during the training referred to above, differ hardly at all in accuracy from those obtained by night.

(iii) *Visual.*

In field defences, where such an elaborate system of communications is not possible owing to the time necessary for construction, a different system, known alternatively as "Single Station," or "Visual," plotting, is employed.

In this method, the required information is obtained mechanically from observations in a small scale reproduction of the triangle enclosed by the line of sight from an observer to the target, the horizontal projection of that line, and the height of the plane of flight vertically above the observer. With the apparatus at present in use, this reproduction is made on a horizontal plane which is gridded, plotted and oriented to represent the searchlight lay-out and that portion of the topographical grid which covers it. The line of sight is reproduced by a sighting bar laid on the target, rotating about a point on the horizontal plane which represents the position of the observer on the ground. Each searchlight position on the gridded plane is provided with one or more lines radiating from it. The bearings of these lines are communicated to the searchlights concerned and marked on the bearing scales. When the beam, in following a target, reaches one of these bearings a signal is given, visible to the instrument position. This signal usually consists of a

* Major-General Ashmore, *Air Defence*, p. 93.

momentary dousing of the beam, and fixes the position of the target somewhere vertically above the given line. The intersection between this line and the vertical plane through the sighting bar, also on target, fixes the plan position of the aeroplane on the grid ; and the vertical height of the sighting bar above this point gives the height of the target to the same scale.

When, in 1928, a series of flights was made over a marked course, it was found that, with this system, plan positions were determined to within 1,000 metres and height readings to within 500 or 1,000 feet of those furnished by the pilot. The time-lag is also much less with this system than with the fixed azimuth method, as one complete link in the chain of communication is cut out, and the computation is automatic. On the average, plots were received in company headquarters within half a minute of the observation being made, though frequent delays occurred through the "jamming" of the communications with redundant information.

The degree of accuracy theoretically attainable by this system is still limited by the errors at the projector, for, although the angle of sight could be accurately determined by laying through a telescope with cross-hairs directly on to the target itself, the bearing on which the signal is made has still to be read at the projector. Any error in this will introduce an error into the right angle of the triangle of sight, and a simple calculation serves to show that, observing at a distance of 5,000 yards a target at 10,000 feet, the beam's width itself would account for an error in height of 300 feet. So that, although this method may be expected to yield considerably more accurate results than the fixed azimuth system, and has the additional advantages of saving personnel and equipment, and in reducing time-lag, it cannot be said, in its present form, to offer a possible solution to the gunner's problem of finding height by night.

(iv) *Conclusions.*

Viewing the situation generally, however, it may be stated that such degree of accuracy as is achieved under all conditions with the fixed azimuth system by unpractised troops, is sufficient for the purposes defined for fixed defences, and that the considerably greater accuracy required for co-operation with the R.A. is not to be obtained by these means. The time-lag alone remains an important factor, but this diminishes very considerably with practice, as can be seen from the results obtained by Regular troops when operating this system. On the rare occasions when an effective check has been made, the degree of accuracy was found to be not greater than that quoted above, though the time-lag was materially reduced.

The visual system, on the other hand, provides a means of obtaining heights accurately to within 500 feet, and the correspondingly more accurate determination of position ; but it may be asserted that this represents the limit of accuracy to be obtained by any system depending upon readings of beam angles taken at the projector.

Long-base height-finding with theodolites, though sometimes used by the R.A., is far from satisfactory, both on account of the difficulty experienced in obtaining simultaneous readings and the time taken in computing.

It is possible that a solution may be found in the automatic collation of courses plotted by two instruments of the visual type working on incorrectly assumed height, and some progress has been made in this method for use by day.

But, while awaiting the advent of some such system, we must admit ourselves unable to assist the gunner to the degree of accuracy required by him ; and, admitting the impracticability of achieving this accuracy by means of observations at searchlights, it is, perhaps, not unfair to cease to regard the problem as one for the R.E., and to assume that, when independent means for its solution are forthcoming, these should properly be the responsibility of the R.A. themselves.

Confining ourselves, therefore, for the present, to the purposes defined for fixed defences, it is difficult to see any real advantage in the retention of the former cumbersome system, even where telephonic communication does exist, and it is probable that the visual method will shortly displace it entirely.

To obtain the best results, it is necessary to direct every effort to the elimination of the time-lag, and, in addition, plotters and tellers should be trained not to accept any but very marked and sustained deviations in course reported from section headquarters. The majority of track records produced show an exceedingly tortuous track which was manifestly not pursued, and which would have become automatically straightened out in the course of reporting to sector headquarters.

It results, therefore, in a great saving of labour and reduces the "jamming" of telephone communications if plotters can be trained to anticipate this straightening out. In analysing some records of the type referred to, by removing unrealistic "kinks" and obviously impossible digressions of, perhaps, ten miles and back in one minute on a course at right angles to the main one, and by taking the mean course through the remaining plots, very close approximations to the courses shown by the pilot were arrived at. The plotters must, therefore, be educated to use considerable intelligence in sorting the information received and not, as is all too commonly found, merely act as a recording centre for the accuracies and inaccuracies alike of the several reporting stations.

This theory was well illustrated by the experiment conducted of employing the company serjeant-majors on plotting duties at company headquarters, when the considerably more accurate and reasonable tracks produced testified to the advantage of having plotters of superior intelligence who were not afraid to use their initiative.

It should always be impressed on the men employed on this work that the object of plotting stations is not to record the information submitted by the lights, but to provide the best available for the higher command.

(C) "... *progressing towards a solution* ..."

(i) *Economy of Force.*

From what has been said above, it will be seen that, technically, the defence, from the R.E. point of view, has at the present time means both of frustrating the enemy's object of reaching his goal undetected, and also of determining his height and course to within the required degree of accuracy.

But, although the present-day R.E. methods do provide these means, we must not regard them as anything but very primitive and inefficient. There never has been any difficulty in providing armour-plating to withstand the shell of the heaviest gun, but the problem before the naval architect has been to incorporate the heaviest armour possible in a battleship in relation to other factors in design, such as displacement and speed. In other words, his difficulty has been to armour his ship economically. Our searchlight methods of to-day provide a very uneconomical armouring.

To understand this more fully, it is necessary to glance at the organization by means of which these methods are applied.

A.A. searchlights are spaced roughly 3,000 to 3,500 yards apart, and a defence is built up of a series of equilateral triangles having sides of that length. At elevations below 30 degrees, it is found that searchlights illuminate the ground considerably by reflection and for this reason increase in power of the actual light is not likely to affect the spacing to any extent.

It may, therefore, be accepted as a basic fact, that one searchlight cannot effectively be used to cover more than three and a half square miles. That is, the area protected by a company of 24 lights may be taken as roughly 75 to 80 square miles.

Time is of paramount importance to the A.A. gunner and to the R.A.F. fighter, in order to reach the hostile machine with shell or m.g. fire before it reaches its goal. Depth, as in all defence, becomes then of chief importance in illuminated areas in anti-aircraft defences. It is now very generally accepted that the six-light or section lay-out round a small vulnerable point, such as a bridge, is ineffectual in that it does not provide an illuminated target at sufficient range for it to be effectively dealt with from the ground before reaching the objective. The diameter of such a defence may be taken as six miles. Allowing with the existing equipment and methods, at least 30 seconds for detection, a hostile machine flying at, say, 100 m.p.h., is in the centre of the defence and unloading his bombs within a minute of being located. Further, even if the defence be located some distance from the vulnerable point with the object of misleading the enemy, competent navigators claim to experience no difficulty, on the majority of nights, in locating their objective and thus avoiding the defence.

The minimum effective illumination may, therefore, be taken to consist of 24 lights. Now each light requires, at present, 10 highly trained N.C.O.s and men for its manipulation. This means that the defence from the air by night of a single point is not to be effected without the assistance of some 350 (including H.Q. and workshop personnel) highly skilled tradesmen.

The Anti-Aircraft Battalion, R.E., with its war establishment approaching 1,400 men, must be the largest unit in the expeditionary force, and yet it is only capable of *assisting* in the defence of four points, while the numbers required for the adequate protection of a large area like London are more readily imagined than enrolled.

It is true that for fixed defences at home, women can be employed for the majority of duties connected with plotting; and blind men were used in the Great War as listeners. Colonel Rawlinson tells us* with what joy they undertook this work which they could do better than any, and with what good results the experiment was attended. But there are difficulties in connection with the employment of such people, and for work in the field only able-bodied men can be used. As can be seen from what has been said earlier, the amount of training required by A.A. searchlight troops to operate the present system successfully is so great as to render any very rapid expansion impossible. So the chief problem seems to resolve itself into one of man-power. How can the number of skilled and highly trained men required be reduced to an economic level?

The target is at present located by listening with the sound-locator to the engine noises of the approaching aircraft. This occupies three men, who must not only have been fully trained and have good hearing, but who must have been in constant practice to achieve a successful result.

It is now an open question whether many experienced listeners on the sound-locator do not obtain their results by fixing the point of "maximum intensity," and not by the correct centring of the so-called "binaural effect," produced by phase difference of the sound waves interrupted by the trumpets of the sound-locator. If this be established, then many of the difficulties in the design of an

* Colonel Rawlinson, *The Defence of London*, pp. 112–114.

automatic locator disappear and the production of, at any rate, a one-man instrument does not seem to be beyond the bounds of possibility. Given such an instrument, two of the detachment may be dispensed with at once. Further, supply the detachments with automatic lamps and the duties of lamp attendant are so far reduced that they could be combined with those of the engine driver, if the light were placed close to the engine. Being given a form of distant control similar to that in use in coast defence, the long-arm and raceway disappear together with the projector controller, and the projector itself can then be mounted on the lorry, where the engine driver can also attend to the lamp.

The detachment of ten is now reduced to two N.C.O.s and four sappers, and this probably represents the limit of reduction due to labour-saving devices; but it should be quite possible to train the men to such a standard as would admit of running with a detachment of only three, composed as follows:—

1 N.C.O. i/c. spotter, drives by day.
1 sound-locator and spotter, can drive and work lamp.
1 mechanic (lamp and engine) trained as spotter.

These men would take four-hour reliefs in "sky watching" by night and the fatigue experienced as the result of a night's work would be no greater than with the full detachment, while on a night free from raids each man would obtain eight hours in bed.

(ii) *Protection.*

A subject of considerable controversy is that of the protection of A.A. searchlights against bomb splinters. Some consider that the risk of damage is slight and that the raiders will have more important objectives than individual searchlights for their missiles. But history relates occasions when deliberate attacks were made against the lights from the air,* and it is, therefore, probable that protection will be required at the earliest possible moment. With the equipment we have at present an elaborate earthwork is necessary, occupying the detachment of ten some three to four whole days to complete.† Experiments were commenced in 1928, with the object of designing an earthwork protection for the sound-locator and other members of the detachment. It was found that the listening post could be within 30 feet of the projector emplacement without being affected by arc noises. The effect of ground noises or the reflective effect so near the surface of the earth, was, unfortunately, not fully investigated before the experiments terminated. In the experimental

* *Work of the R.E. in the Great War*, Miscellaneous, p. 316.
† *Manual of Field Works, All Arms*, plate 78.

work the two emplacements were connected by a dog-leg C.T., at the bend of which a post was made for the L.G. and N.C.O. i/c.

This system appeared to provide adequate protection for the whole plant except the engine. In the case of fixed defences, it might reasonably be assumed that some form of stationary engine could be permanently installed in a bomb-proof shelter. But all that can be done for a lorry is to select a spot in a road cutting or quarry, suitable also from the sound-screening point of view, and build up breastworks round the engine and tank. The whole of this work, it was estimated, would occupy the detachment at least seven days under the most favourable conditions. So it would appear axiomatic that, with the existing equipment, it is not worth while starting to "dig in" in any position to be occupied less than a week.

Further experiment in this direction might well be undertaken with a view to deciding upon the most satisfactory dimensions and to producing a type plan for use in fixed defences.

With the detachment of three, much digging would be out of the question, so it will be necessary for the lorry to be armoured against splinters. The sound-locator will, of course, be removed some three hundred yards from the engine to avoid sound interference, and this might possibly be carried on a light trailer with splinter-proof sides, which would also act as a wind-screen to lessen the effect of wind blowing across the face of the trumpets.

(iii) *Mobility.*

The mobility of the plant for field use, at any rate, must be considerable. Cutting out the erection and dismantling times, by having the equipment permanently mounted on the vehicles, will greatly assist this and reduce fatigue in the detachment. On army manœuvres in 1925, searchlights were, on one occasion, dismantled and re-erected three times in 48 hours. This has always seemed one of the most irrational things about the R.E. anti-aircraft equipment. The gunner does not dismount the piece from its carriage and re-assemble it in the gun position !

The lorry must have the highest degree of cross-country performance attainable, combined with a reasonable road speed. In this respect, it should be similar to the R.A. anti-aircraft vehicles, with which it will have to work. The P.E. lorry, though admirable in many ways, possesses no cross-country performance whatever ; and the poor starting torque provided by the electric transmission renders it quite helpless in cases of ditching or bogging. For these reasons a geared vehicle seems desirable. The points calling for special consideration in design, such as the provision of a geared generator of sufficient output, extra cooling for stationary running, etc., are simple enough engineering problems and demand no further discussion.

The substitution of distant control multi-cable for the heavy main cable should result in a considerable saving, both of load and space, and with only three men and their kits to be carried instead of ten, one vehicle should provide ample accommodation without the overloading associated with the present system.

(iv) *Requirements.*

Assuming, then, the detachment of three, the following are required :—

(1) A high standard of training in spotting, which can be obtained on the lines suggested above.

(2) An automatic, or semi-automatic, sound-locator carried on a light armoured trailer.

(3) Distant control from this sound-locator and from the spotter's glass to the projector.

(4) A cross-country type of gear-driven lorry, with electric generator and armoured against bomb splinters ; carrying the projector, with automatic lamp, permanently mounted. Controls of both lamp and engine to be accessible to the same man.

(5) A one-man instrument for height-finding and track-plotting, submitting courses obtained by incorrect assumption of height on the visual system for automatic correction at company headquarters.

Such a system would reduce the numbers employed by one-third, and the searchlight company might then cease to be the mammoth it now is and revert to something less than one of Moses' original hundreds. This should not mean any reduction in peace strengths of A.A. troops, but a vast increase in the protection afforded by the same numbers. In this way, lighting for A.A. defences would be placed on a reasonably economical basis, and the efficient protection of a large area at short notice be no longer the impossibility it appears to-day.

(D) *Conclusion.*

"Where is the man who can fail to see that no city would be proof against surprise, when the ship could be steered over its squares at any time. . . . Iron weights could be hurled to wreck ships at sea, or they could be set on fire by fireballs or bombs ; nor ships alone but houses, fortresses and cities could be destroyed, *with the certainty that the airship could come to no harm* as the missiles could be hurled from a vast height."

Thus wrote Francesco Lana, a member of the Society of Jesus in Rome, when reviewing the possibilities of his aerial ship, designed as early as 1670.* It is curious that one whose thoughts were so far in advance of his day should not also have visualized the inevitable parallel development of the defence against air attack. The endeavour has been to show that, so far from the air raider being "certain to come to no harm," under the existing conditions, a successful solution has been found, at any rate, from the R.E. point of view, to the problems of air defence. But the training of searchlight troops is not up to the standard required to apply this solution with safety. It is certain that the present standard can be vastly improved if the possibilities of daylight training are properly appreciated, but the whole method is very uneconomical in man-power and therefore capable of only slow expansion. It is suggested that the real problem to-day is no longer how to detect and illuminate the target, or how to calculate its height and position, but how to do these things economically and with as complete elimination of the personal element as possible. The solution suggested is, it is admitted, Utopian, and is simply an effort to define the objects towards which research in this province should now be directed.

The technical problems connected with the required improvements are not beyond solution, and when solved will largely replace the human element in searchlight work; but *human observation remains that on which success ultimately depends*, and for this reason the greatest attention should be paid to the systematic instruction of *all* members of A.A. units R.E. in the work of spotting or sound-locating.

The work of the A.A. units is little known and still less understood by the Corps as a whole, and it is to be hoped that this article may have the additional effect of dispelling on the one hand, in those minds where it exists, the erroneous impression that air defence is a "black magic," and on the other, of convincing those who regard it as extremely simple, that here, too, the sapper is faced with problems which are not quite so easy as they look.

* Walter Raleigh, *The War in the Air*, p. 30. The italics are my own.

MECHANIZED CHESS.

By LIEUT. G. V. MICKLAM, R.E.

IT is a far cry from the age of plume, lance, and chain mail, to our age of gas, shell, and aircraft. Nevertheless the mediæval castle the priest and the knight, the courtier the king and the queen, have all breathed their spirit into the miniature battlefield of our ordinary chessboard. Most of us, attracted by the quaint carving of the pieces, by the eccentricity of their moves, and by the excited interest of the players, have at one time or another tried our hand at chess. Whether we have been successful or otherwise, we probably agree that it is a fascinating game—outwardly the slowest, but actually the swiftest, because it is as quick as thought.

As hinted above, the chequered board is in truth a battlefield, and each player the commander of a fighting force, struggling mightily to conquer his opponent's king, while loyally protecting his own to the last. Ethically, then, it is a noble game. In military education it is far more. Hence the old saw that "a good chess-player will make a good General."

Several writers have set out in full the similarities between the art of chess and the art of war. They point out that the immutable Principles of War are identical with the unchanging Principles of Chess. It might not be out of place, however, to bring our game up-to-date in terms of modern armaments and mechanization, and to see how our field of battle fits the sixty-four squares of to-day. Let us first assume the mantle of Alice, and consider our pieces through the military Looking-Glass.

King represents the nation, or the army headquarters, or the ultimate objective, as may be appropriate.

Queen. The air arm. Moves very rapidly, in any direction. Can do much damage by raids, but usually has to return home within a short period, unless well supported (as when ground troops capture an advanced aerodrome).

Castles. The reserve forces. Thrown skilfully into the fight at a late stage, they can entirely save a desperate situation, or improve a good one. A headquarters (king) can quickly interpose the reserves between itself and the enemy in case of temporary emergency ("castles").

Bishops correspond to the fastest vehicles of an armoured force, armoured cars in particular. They set off early in action, usually to a flank, and along a road. From the flank they are a constant threat to the enemy. The bishop is confined to diagonals in the same way as armoured cars are confined to roads. Moreover no bishop occupies the same sets of diagonals as his partner bishop; correspondingly no armoured car unit should muddle another by using the same sets of roads.

Knights. Other arms of the main body, including artillery in particular. They can attack from behind their own front line. They cannot by themselves checkmate an opponent, but require the support of other forces. The two knights, co-operating closely, can command a wide front within a certain radius.

Pawns. Infantry advanced guards and scouts, in one or two-man tanks. At the beginning of a campaign they move rapidly forward until they bump the enemy (pawn to two squares), whom they pin to a locality, thus securing room for their own main forces to manœuvre in the rear. They never retire, but stick to their posts to the last. Occasionally a small unit will break right through the enemy line, and become as valuable as even the air arm in demoralizing enemy communications ("queens").

THE CAMPAIGN OF 1936.

Whiteland, under Count Blanc, declared war on Blackland, under General Noir, on March 6th, and thus had the initiative.

The issue lay between contiguous civilized nations, and consequently each possessed accurate maps of the country of the other.

Whiteland.		*Blackland.*
P—K4	The advanced troops of each side were pushed forward by aerobus, until they met and held one another.	P—K4
Kt—KB3	Whiteland had worked out a sound mobilization scheme in peace time, and launched an attack quickly. First objective—to capture the enemy's advanced position.	P—KB3
	Blackland had just been in the throes of a general strike. Owing to a shortsighted financial policy which insisted that all power for W.D. purposes should be taken from the national grid in peace, all arsenals and aircraft establishments	

Whiteland. *Blackland.*

were a month behind their production programmes. Noir could only reply, therefore, by pushing forward a weak covering force, echeloned to a flank, to protect the forward troops.

Kt x P Blanc ordered General Knight, commanding the expeditionary force, to continue the planned offensive, regardless of the danger of being cut off.

As had frequently happened in military history, the effect of this premature action was nullified by a vigorous counter-attack by Blackland, and Knight's force, taken off its guard, was annihilated. P x Kt

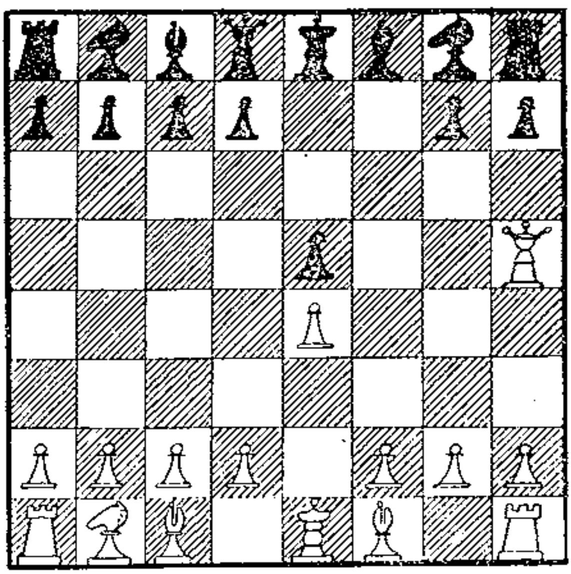


FIG. 1.—Position after fourth move of White.

Under cover of this action, however, Blanç had been able to make the final arrangements for a great air attack, for which everything was now ready (queen's diagonal left clear of obstruction).

Q—R5 (check). Accordingly, on March 12th, twenty-four squadrons of bombers and fighters of the latest type set out against enemy H.Q. This had been located by the incautious use of television on the part of Blackland. An intercepted picture of General Noir in his office showing certain Gothic windows had resulted in the identification of the actual buildings as being a priory ten miles behind the line.

Whiteland.		*Blackland.*
	A study of the War of 1914 had impressed Noir with the possibilities of such raids. He pressed a button on his desk, and in a few seconds an area of ten square miles around H.Q. was hidden under a pall of smoke. Under cover of this he and his staff made good their escape, and in half an hour had re-opened their offices two miles away.	K—K2
Q x P (check).	The air marshal, however, was not a man to waste time, and with the consent of Blanc he turned west and passed over the area of Blackland's advanced troops, who were weary after their counter-attack, and utterly wiped them out. A detached squadron, aided by a breeze which sprang up and dissipated the smoke, had meanwhile located the enemy's new H.Q., and the air force turned north. Noir's air defence force was not yet ready, and he had to move again at this threat.	K—B2
B—B4 (check).	It was useless, however, as although the attacking aircraft had dropped most of their bombs, they were able to direct a fleet of armoured cars, which had just set out from the base, and Noir found himself attacked on his right flank as well as menaced from above.	
B x P (check).	Fortunately Blackland's armies were by this time ready to move, and Noir received reinforcements, which he threw rapidly forward to oppose the attack in the centre. They were not in sufficient strength, and were overwhelmed. Their operations had, however, given confidence to Blackland, and opened up possible lines of attack for the main armies. It was a pity, therefore, that Noir was himself so near to the battle-front that he was rather apt to be influenced by local operations.	P—Q4 K—Kt3
P—KR4	Whiteland followed up their advantage as rapidly as possible, on the enemy's unprotected left flank, and Blackland could now see that they were in a hopeless position. A few hours later Noir surrendered, and Blanc dictated the terms of the armistice through phonovision apparatus.	*Resigns.*

It is, of course, open to question whether the next war would be one of such rapid decision. It seems, however, reasonable to assume that the air arm will be the first to launch a serious attack. Consequently, as far as our chess analogy is concerned, a rapid gambit has been taken as an

Whiteland. *Blackland.*

example of such strategy. On the other hand, it may be argued that the normal game between players of equal skill is a long drawn-out affair of deep thinking and extensive calculation of time and space.

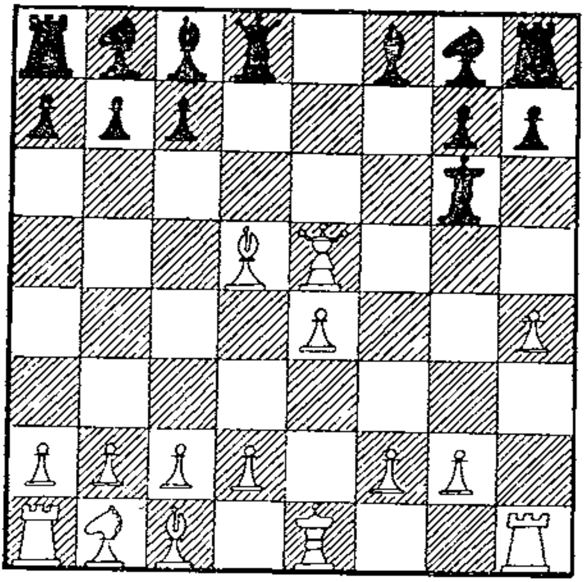


FIG. 2.—Position when Black resigns.

Perhaps, then, chess would point the moral that the next war will be one of still deeper thinking and more extensive calculation.

Take it how we will, our quaint little game reflects the spirit of strategy more truly than any other game, and as such deserves a greater popularity than it now enjoys.

MEMOIRS.

COLONEL H. W. SMITH-REWSE, C.B., C.V.O., D.L.

HENRY WHISTLER SMITH-REWSE, who died at his residence, St. Loo Mansions, Chelsea, on 24th February, 1930, was born at Glenrock, Sydney, N.S.W., on 8th November, 1850. His father was Thomas Whistler Smith, a well-known Member of the Legislative Council, son of Thomas Smith and Penelope Whistler ; his mother was Sarah Street, daughter of John Street, of Bathurst, N.S.W. Early in 1859, his father came home with his family to take up an important appointment in London, but died the same year. The widow and her family, after living for some years at Tonbridge and other places, settled down at Rochester, where she died in 1892. In 1889, in compliance with a deed by a relative, the name of Rewse was assumed by Royal Licence, in addition to and after that of Smith, from their ancestor, Sir Francis Rewse.

Henry was educated at Tonbridge School. His early love of cricket is recorded in a school report (year not inscribed) which said : "One half of the year he plays at cricket, the other half is occupied with recovery from the attack." Perhaps this was the reason for his transfer to Mr. Fleming, an Army Tutor of the same town. A year afterwards he passed into Woolwich, where he became an under-officer, and whence he passed eleventh of his batch into the Royal Engineers, gaining his commission on 15th December, 1871. His second Christian name was so appropriate to his cheerful disposition that it became a nickname, and he was generally known to his contemporaries as "Whistler."

After the usual Young Officers' Course at the S.M.E., he elected for service in India, and early in 1875 joined the Bengal Sappers and Miners at Roorkee, in time to take part in the Delhi Camp of Exercise of that year.

In 1876, he transferred to the Military Works Department. In 1878, when war with Afghanistan broke out, he accompanied the Khyber Column as Superintendent of Army Signalling, and was present at the capture of the fort at Ali Musjid. He remained with the Peshawar Force till September, 1879, when he returned to Rawalpindi. During the next phase of the campaign, Smith-Rewse again served as Superintendent of Army Signalling, first with the Khyber Force and then with the 2nd Divn., N. Afghanistan Force.

Colonel Henry Smith-Rewse CB CVO DL

For his services in this campaign he was mentioned in dispatches, received the medal with clasp, and was awarded a post-dated brevet, being gazetted Bt. Major on 29th December, 1883, after his promotion to captain in that month.

After further service in the M.W.D., he reverted to home service in 1882, and was posted to Chatham in charge of S.M.E. Workshops. In 1883, he was appointed Assistant Instructor in Field Works; but resigned in August, 1884, in the hope of having a greater chance of selection for active service in the Egyptian Campaign. His hopes were not fulfilled, and he remained on general duties at Chatham.

In 1885, however, his chance came; and he was appointed Brigade Major, R.E., of the Anglo-Indian Force, which the British Government had decided to assemble at Suakin after the fall of Khartoum in the previous month, with the purpose of defeating the Dervishes in the Eastern Sudan and protecting the construction of a railway to Berber. Smith-Rewse was present at the action at Hasheen, on 20th March, 1885, was mentioned in dispatches, and received the medal with clasp and the bronze star.

On return to England, in 1885, Smith-Rewse, after a course at the School of Musketry, Hythe, was appointed Instructor of Musketry at Chatham. In 1886, he became once more an Assistant Instructor in Field Works. In 1888, he was appointed Instructor in Tactics and Military Law, and held this appointment for the full five years. He was promoted substantive Major in 1890, and in 1893 proceeded to Gibraltar. In those days there was a great deal of engineer work in progress, mostly under the Military Works Loan; and there were two C.R.E.s as well as the C.E.

In October, 1897, he was brought home to the office of the Inspector General of Fortifications, and in the following month appointed Assistant I.G.F. in the Fortifications Branch, in which he remained until December, 1899, obtaining his promotion to Lieut.-Colonel, in April, 1898. These were halcyon days for the Engineer branch of the War Office and for officers employed on large works, as they were kept on them until completion, and under the Loan system there was no annual lapse of funds.

In December, 1899, he proceeded to Shorncliffe as C.R.E. of that Sub-District, and was there able to supervise some of the work of which estimates had been passed during his service at the War Office. Major J. Stewart, who was Reconstruction Officer during the whole period, writes: "The chief works comprised the reconstruction of the Camp, that is the replacement of the old wooden Crimea huts by permanent barracks, under the Loan. The most interesting work was the reconstruction of the Rifle Ranges at Hythe, which Smith-Rewse did extremely well. Many an evening, after office hours before dinner, he might be found on the corner of Sir John Moore's

Plain, with a mechanic and a contraption of wires and posts, designing the advancing and receding targets which became a feature of the Hythe Ranges."

In April, 1902, after four years as Lieut.-Colonel, Smith-Rewse was, under the rules then in force, appointed Brevet Colonel.

On 1st October, 1902, he was appointed Assistant Commandant, S.M.E. In October, 1898, the then Commandant, who had been promoted Major-General in the previous April, had been appointed also G.O.C., Thames District. He had continued to occupy the Commandant's House; and some of the barrack rooms at Brompton had been converted into offices for the District Staff. This dual command and the dual responsibility as to the S.M.E. had been much criticized and inevitably led to perplexities. In December, 1902, Major-General Sir Reginald Hart was appointed to the dual command. This resulted in a most happy combination, a memory of which will be treasured by all who served at Chatham at that period. In April, 1905, Sir Reginald succeeded in divesting himself of the command of the S.M.E.; and Smith-Rewse was appointed Commandant.

In June, 1905, in order to conform with the recently instituted system in the Infantry, the R.E. Records were transferred from London to Chatham, and a Colonel was appointed O.C., R.E. Depot, as well as O. i/c R.E. Records. This resulted in a very difficult situation—" two kings in Brentford." The offices of the S.M.E. were in barracks under the charge of the O.C. Depot; and the *personnel* of the S.M.E., both instructors and instructed (including recruits under test in S.M.E. shops), were under the O.C. Depot for discipline. This impossible system was discarded in February, 1907, and the command of the *personnel* of the S.M.E. and the two battalions reverted to the Commandant.

Smith-Rewse's command terminated on the 31st December, 1906. As there were no prospects of further promotion, he elected to retire, and his retirement was gazetted from the following day. During his tenure he and Mrs. Smith-Rewse had taken a lively personal interest in all ranks, and their departure was deeply regretted. An officer who was well acquainted with him at this period, writes: " Colonel Smith-Rewse was very popular with all ranks under him during his time as Commandant, S.M.E.; he was particularly keen on the Corps maintaining its reputation, especially in sports and games, and was ever ready with help to further this object. Furthermore, he had the great gift of possessing faith in those under him, and allowed them to 'run their own shows' without undue interference." Sir Reginald Hart, at a farewell dinner to himself on his departure on promotion in November, 1906, said: " During the four years that we have been associated together, and under rather trying circumstances, there has never been the slightest disagreement or unpleasantness. . . . Without his able assistance, encouragement, friendship and loyalty, I could never have carried out the duties of my two appointments. . . . During the two and a half years I was responsible as Commandant, he was more than my right-hand man; and so loyal to me that he never over-stepped the line or ignored my authority. . . . Were ever two men placed in a more delicate position? It would be very ungenerous of me if I did not publicly acknowledge the debt I am under to Colonel Smith Rewse."

From an early date he showed a flair for organizing "functions," in which he was assisted by his "presence," courtly manners, and *bonhomie*. One of his early contemporaries writes: "Given a free hand and the money, he was sure to produce something to be proud of." During his various tours of service at Chatham it fell to his lot to make the arrangements for many ceremonies in connection with the Corps. In 1888, Lord Wolseley unveiled various Corps memorials in Rochester Cathedral. In 1890, H.R.H. The Prince of Wales unveiled the Gordon Statue at Brompton Barracks. In 1902, Lord Kitchener visited Chatham and dined at the Mess. On 21st October, 1904, H.M. The King inspected the Corps at Chatham and lunched at the R.E. Mess; on this occasion, Smith-Rewse received the C.V.O. In May, 1905, H.R.H. The Duke of Connaught inspected the R.E. at Chatham and lunched at the Mess. On 26th July, 1905, H.M. The King again visited the Headquarters of the Corps to unveil the South African War Memorial Arch. On all these occasions he received the special thanks of those in authority for his arrangements.

During all his periods of service at Chatham, and especially during his tenure as Commandant, S.M.E., he did much to make the Headquarter Mess more comfortable and to maintain its standard and reputation. On his quitting the S.M.E. at the end of 1906, a high official of the Corps wrote: "Your work at the S.M.E. and your influence in moulding the young officers will be most beneficial to the Corps in times to come. You have the satisfaction of knowing that you have held perhaps the most important position in the Corps and have filled it worthily."

Though not a musician himself, Smith-Rewse was a great lover of music and always took the greatest interest in the Corps Band. It is believed that he was the moving spirit in procuring, through the influence of Lord Kitchener, the recognition by the War Office of the two airs known as "Wings" as our regimental march.

He was always keenly interested in amateur theatricals; and was an admirable stage manager, especially in connection with the R.E. Dramatic Society at Chatham, in 1885–1893.

At Gibraltar, as all good sappers should, he hunted with the Royal Calpe Hounds; and in 1897, his Barb pony, "Ruby," gained first prize in a large class at the Horse Show.

His early liking for cricket has been referred to in connection with his school days. At Woolwich, he played for the R.M.A. *v.* R.M.C., and distinguished himself as a bowler. At Chatham, for the Corps and the S.M.E., he played as opportunity offered up to 1891, and was a regular player at Gibraltar in 1894–7. In 1907, he was elected an agent (hon. member) of the I Zingari, as "a small return for your kindness to the I Z. when we have stopped at Chatham."

He was second to none in his love of the Corps and was always keen to do what he could for its advancement. "An Old Pal" writes: "He was always anxious to mitigate the aloofness that in our early days seemed to separate sappers from the rest of the army." This aloofness, it should be noted, was not the fault of the sappers, but due to the system, continued at least till after the South African War, which kept the sappers in peace work in a sort of water-tight compartment of their own. Smith-Rewse himself always cultivated friendships with officers in other branches of the army.

From early days he was eager to maintain a definite connection between the Corps at Chatham and the Cathedral at Rochester. There had been parade services in 1884 and 1888 for the dedication of Corps Memorials; such services took place again at later dates, but became discontinued. When he was Commandant, S.M.E., he re-started them; and in October, 1908, when Colonel J. A. Ferrier was Commandant, they were definitely recognized by the Dean and Chapter as the "R.E. Memorial Service," and since then have been held annually.

In February, 1908, Smith-Rewse was appointed the first Secretary of the Devon T.F. Association, under the Chairmanship of Earl Fortescue, H.M. Lieutenant of the County. This proved another happy partnership. Both were tremendously keen on their task; both were gifted with tact, and *persona grata* to all with whom they worked. His tenure of the Secretaryship continued through three phases: the constitution of the Territorial Force; its expansion during the Great War; and its re-organization after the Peace. The last, entailing much heart-burning, *e.g.*, in the conversion of yeomanry into artillery, necessitated the exercise of great tact and discretion.

In August, 1917, his name appeared in the *Gazette* in the "List of Mentions" for services rendered in connection with the War; in January, 1918, he was awarded the C.B. (Civil);* and in February, 1922, he was appointed Deputy-Lieutenant of the County.

In November, 1922, he vacated the Secretaryship, after nearly fifteen years in the post. His departure elicited many appreciative references in the papers and personal letters from leading residents in the County. His old chief, Earl Fortescue, after quoting figures

* He had been recommended for the C.B. in 1906 and 1907.

to show the mass of work that fell upon the shoulders of the Secretary of the Association in dealing with the expansion of the numbers of the Force during the War, the difficulties of providing buildings and equipping the men, the organization of the National Reserves, and the payment of Separation Allowances to wives and dependents, writes: "These figures will give some idea of the quantity and variety of work that passed through the Association's office, though no mention has been made of all applications for commissions, official and private, that came to the Secretary on their way to the Chairman, or of the interviews and odd jobs that fell to the lot of both; but through it all, though harassed by personal anxiety and bereavement, Smith-Rewse was always good-tempered, courteous and efficient. His Chairman, who was likewise Lord Lieutenant of the County, had the satisfaction of obtaining for him the honour of a C.B., a distinction given to very few other Territorial Association Secretaries, and of himself appointing him to be a Deputy-Lieutenant of the County he had served so well."

On leaving Exeter, Smith-Rewse settled down in London. He retained to the last his intense loyalty to the Corps, and was a regular attendant at Corps dinners, receptions, meetings and band concerts. He also maintained his love of cricket: an honorary member of the M.C.C., he was frequently at Lords, and the dullest of first-class matches did not fail to interest. Although, latterly, failing health made him inactive, he was particularly patient, never "groused," and retained his soldierly, upright figure to the last.

His end came quite suddenly from heart-failure, while talking to his wife and his former chief about their happy times in Devon. He was given a semi-military funeral, a gun-carriage being supplied by the R.H.A. The service was held at Christ Church, Chelsea, and the interment took place at Barnes Common.

In 1874, he married Florence Agnata Frances, youngest daughter of Major-General George William Powlett Bingham, C.B., D.L., who, together with one daughter, survives him. His eldest son, in the R.A., died of wounds near Ypres, in November, 1914. His youngest son, formerly in the R.E., who went to France with the Canadian Engineers, was killed in action at Festubert, in September, 1915, while serving as a lieutenant in the Winnipeg Rifles. His second son, a Resident Commissioner in the New Hebrides, met his death as the result of an accident, in February, 1927.

A.T.M.

COLONEL F. W. BENNET.

FERDINANDO WALLIS BENNET was born on December 13th, 1850, and died in his sleep on October 17th, 1929, after a long illness. He was the son of Richard Gully Bennet, of Tresillian House, Cornwall, and this estate, to which he succeeded on his brother's death, he passed on during his lifetime to his son, Capt. L. W. Bennet, late R.A. In 1896, Bennet married his cousin, Miss E. M. Palmer, daughter of Major-General H. S. Palmer, R.E. Both his two sons served in France, but his second son, Lieut. C. H. Bennet, R.A., died of influenza soon after the Armistice. His two daughters survive him; Mrs. Vivian, wife of Capt. G. P. Vivian, R.N., and Mrs. Ferguson, wife of Major Ferguson, O.B.E., Rajputana Rifles.

After being educated at King's College, Sherborne, Bennet entered the R.M.A., Woolwich, in July, 1868, and was gazetted to the R.E. in January, 1871, Lord Kitchener being of that batch. His meteoric career as a cricketer chronologically calls for notice first. No record exists of his having played at Woolwich, but after joining at Chatham his play rapidly improved until for one season, that of 1874, he was the best bat then in the Corps, if not the best bat ever produced by the Royal Engineers. In that year he made 889 runs for the R.E., with an average of 44·4 per innings, whilst also doing good service as a bowler and in the field. Amongst his biggest scores were 165 not out against the Civil Service, 133 against the R.A., and 127 against the R.M.A., figures which sounded more formidable in those days than at present. And this was when Renny-Tailyour, then known as the best bat in England against bowling not of the very first class, was at his prime. The game which stood out beyond all others in Bennet's memory was when he played under the captaincy of W. G. Grace for Kent and Gloucestershire against All England, making 47 runs. If my recollection is trustworthy, he was for a time at the wickets with Grace, scoring equally rapidly. It is also reported that Bennet was asked to play for England against Australia. After 1874, he seldom played again. He was also a fairly good golfer, playing on one occasion for the R.E. against the R.A.

After leaving the S.M.E. he served at Devonport, at Chatham again, and at Portsmouth, part of the time with a submarine mining company. From 1877 to 1880 he was employed with the telegraph units, part of the time in the south of England, where the Post Office had then handed over the construction and maintenance of their lines to the Royal Engineers.

At the Berlin Congress of 1878, Turkey had agreed to make certain reforms in Asia Minor and to permit the Powers to see by inspection on the spot that these promises were kept—which certainly they

Colonel Ferdinando Wallis Bennet

were not. Several military Vice-Consuls were, therefore, appointed for service in Asia Minor, having, however, no powers beyond giving advice and attempting to exercise a moral influence over the Turkish rulers. In 1881 and 1882, Bennet was employed on this service under Sir Charles Wilson, the Consul General, a chief whom he revered and whose esteem he won. His companions formed a distinguished group, including Lord Kitchener, Sir Herbert Chermside, and Colonel J. D. H. Stewart, 11th Hussars, the companion of Gordon, who was killed on the Nile in 1884. Bennet was given charge of the Adana district, and made many journeys of inspection, some of them with his chief. It was a dreary task, considering that in many parts the people were bordering on starvation and that little or nothing was being done to relieve their sufferings. He told his friends that the whole place was a seething mass of corruption and that all the officials were lining their pockets as quickly as they could. In most parts the inhabitants were quiet and orderly, being "content to live without hope and without education." In other districts anarchy prevailed and murder and robbery were of daily occurrence. Bennet felt that little good was being done, whilst others held that the work of the Vice-Consuls led to "some beneficial results of a more or less permanent character." Lord Dufferin wrote officially to declare that "a fuller and more exhaustive examination" had probably "never been executed in any part of the East," and directed Sir Charles Wilson to convey his warmest thanks to the Vice-Consuls for their zeal and energy.

It had been determined that for political reasons all the Consuls should be withdrawn in October, 1882; but before that date the outbreak of hostilities with Egypt had taken place, and all these officers were transferred at once to that country. Bennet much enjoyed the liberty of his life in Anatolia, but he must have been glad to quit these dismal scenes. His war service in Egypt on this occasion only lasted a few months, for he was back in England by the end of 1882 with the Egyptian medal and bronze star. He was attached to the Foreign Office for a short while in connection with his work in Asia Minor, and was then stationed at Aldershot for a year.

In 1884, he was again sent to Egypt for service on the Nile expedition, in connection with the Telegraph Department, for which he was mentioned in dispatches, received a brevet majority, and a clasp to his medal. He returned to England in 1885, and was employed until 1888 in the 2nd Division Telegraph Battalion at Falmouth and Edinburgh. From 1888 to 1891, he was second in command of the 1st Division Telegraph Battalion at Aldershot under Colonel "Dicky" Jelf, with G. M. Heath, Curtis, Hunter-Weston, Lyons and H. B. Williams as his subalterns. Then came three years' foreign service at Hong Kong, relieved by a trip with brother officers to Japan, U.S.A., Canada and Alaska, which he enjoyed thoroughly. His cousin, Miss Palmer, whom he subsequently married, was serving at Hong Kong at the same time as a nurse, her experiences there including a night on a plague ship with no other woman present and Chinamen dying every hour. On his return to England in 1894, Bennet was first employed at Aldershot, then as a Lieut.-Colonel at Exeter, and subsequently as C.R.E. at Belfast and Woolwich. He left England in 1899 to take part in the Boer War, where he served as A.A.G. on the L.-of-C. and later became Asst. Insp. Gen. of the L.-of-C. For these services he was mentioned in dispatches, made a brevet colonel, and received the Queen's Medal and two clasps. Those were anxious days for all who had the honour of their country at heart, and the earlier phases of the war were graphically described by Bennet as a "proper sickener." With regard to his services both in Egypt and at the Cape it may be said that those who are employed on lines of communication, who do their duty to the complete satisfaction of their seniors, and who are not constantly pulling the ropes in order to get moved forward—why, they are likely to stay where they are. This was essentially true of Bennet. They may, no doubt, console themselves with the thought that they are doing more towards bringing the war to a close than many who succeed in getting into the fighting line. To complete the record of Bennet's military service, it may here be noted that he was recalled in 1915–16 for duty during the Great War for nearly a year as C.R.E. at Plymouth; work which he found very trying, after fourteen years' absence from the Army.

Soon after his return to England from the Cape, that is, in September, 1901, he retired from the Army. He had had, he declared, a very good time in the Service, and had done his best; but he left with joy and gladness to settle down at Fairlea, his house at Northam, N. Devon, which became his centre of interest for the rest of his life, and from which subsequently it was very difficult to get him to stir. It was not far from his favourite Westward Ho! golf links, where he was for long a familiar figure, winning many medals, and, like a true sportsman, getting much pleasure out of the game whilst, with his declining years, his handicap rose slowly from 3 to 17, so, at all events, he asserted. He probably looked forward to spending the rest of his life in a leisurely way on the golf course, and in his garden pruning his apple trees which were a constant source of interest to him. But after his value came to be recognized in that locality he had little chance of being idle, and once at work again, he soon began to take a keen interest in local affairs, an interest which he maintained until his health broke down a couple of years before his death. At various times he served as chairman of the Bideford County Bench, as Vice-Chairman of the Northam Urban District Council, and Chairman of the district hospital, besides interesting himself in the local Horticultural Society and serving on the Board of Guardians.

He was especially active in safeguarding local public rights with regard to the removal of gravel from the famous pebble beach at Westward Ho! and thoroughly enjoyed his contests on this point with the Government Departments in London, which he regarded as being both obstructive and obstinate.

In spite of his excellent record of service, Bennet's friends all thought that his abilities warranted a more distinguished career in the Army than that which actually fell to his lot. Probably what told against him most was a certain want of ambition; for he admitted that he had not pushed himself sufficiently, accepting every position as it came, whilst striving to do his duty thoroughly therein. As we have seen, he was not one of those who regard every appointment, whether actually held or only coveted, merely as a rung in the ladder by which to mount to higher places. He had, moreover, a strong sense of humour and a keen eye for the weaknesses of his senior officers; both somewhat dangerous qualities. His dispatches to the Foreign Office seem to have caused amusement at times; as, for instance, when replying to enquiries concerning the administration of the law in Anatolia, he declared, so it was reported, that "there is no justice other than that which can be bought," whilst adding that he had put the dispatch aside for a fortnight in the hope of finding more to say, which he had been unable to do—thus probably giving information as concise and accurate as possible. He was somewhat unconventional in his ways, and cared little for society. For example, when staying in a country house when a dance was taking place for the entertainment of the cricket team of which he was a member, he was found tucked up in bed in perfect peace of mind.

Bennet's was, in fact, a well-marked personality, but one very difficult to sketch in words, though endearing him greatly to his friends and the young officers who served under him. And this must be my excuse for introducing one personal anecdote. He and I belonged to the same batch, and when saying good-bye before all were scattering at the end of our S.M.E. course, he spoke to me somewhat as follows: "Now don't let us have any silly nonsense about writing to each other; no one does keep it up; let us make a bargain never to put pen to paper to each other." On this we shook hands; but this was, in truth, the prelude to a correspondence which lasted with few breaks for over half a century—until he could write no more. Towards the end it was little more than an annual letter, which we both enjoyed, somewhat sadly it is true, as recalling many happy memories of the past. His marked individual characteristics, whilst they may occasionally have surprised those who did not know him well, yet served both to increase the keen feeling of affection which he aroused amongst his friends and to give rise to many pleasant and vivid memories in the minds of a wide circle of acquaintances.

L.D.

BRIGADIER-GENERAL GILBERT HARWOOD HARRISON, C.B., C.M.G.

GILBERT HARWOOD HARRISON was the elder surviving son of the late Sir Henry Harrison, Bengal Civil Service, and of his wife Fanny Matilda, daughter of Gilbert Abbot à Beckett, the well-known author of the comic histories of England and Rome. Born in June, 1866, he was educated at St. Augustine's College, Ramsgate, and at Beaumont College, Old Windsor, and at the age of 18 received his Commission in the Royal Engineers, having passed out of Woolwich fourth of his batch in December, 1884.

After the usual course at the S.M.E. he was chosen for a further special course of engineering at Armstrong's Works at Elswick, and on its completion was employed at the I.G.F.'s office until February, 1888, when he was appointed Assistant Inspector, Carriage Department, Ordnance Factories, at Woolwich Arsenal. He was at the time a young subaltern with barely three years' service, and the appointment was one that had hitherto been held by senior subalterns or captains only, but he fully justified his selection, and was very well reported upon on the termination of the appointment.

He was promoted Captain in May, 1893, and shortly afterwards was given command of the 2nd Company at Malta, subsequently moving on with it to Cairo on its transfer to Egypt in the following year.

At the end of 1895, Harrison was recalled to England to take up the appointment of Assistant Inspector of Iron Structures at the War Office, and he was serving there at the outbreak of the South African War, when he was sent to South Africa with the 10th (Railway) Company, in October, 1899. He was recalled at the end of the first phase of the war in January, 1901, and shortly afterwards was again ordered to Egypt in command of the 2nd Company.

For his services in South Africa he was mentioned in dispatches (L.G. 10.9.01) and was awarded the Queen's South African Medal with three clasps.

He was promoted Major in September, 1901, and in the following May was appointed Secretary to the R.E. Committee.

On the termination of this appointment in 1907, he proceeded to India on a tour of service, being posted to Allahabad on his arrival there. He was promoted Lieut.-Colonel in 1909, and was transferred to Fort William, Calcutta, as C.R.E. Presidency District. Whilst holding this appointment, he accompanied the G.O.C. on a special tour of inspection in Thibet, visiting all the posts there as far as Gyangtse.

On his return to England in 1912, Harrison was sent to Chatham

Brigadier-General Gilbert Harwood Harrison, C.B., C.M.G.

as C.R.E., and was subsequently appointed, in 1914, Chief Engineer, Thames and Medway Defences, on his promotion to Substantive Colonel.

At the outbreak of the Great War, he tried hard to get sent on active service, but it was not until June, 1915, that he could be spared from the important defence works which were being carried out under his supervision. He was then sent overseas, serving as A.D.W. under Major-General Sir Andrew Stuart. He was first quartered at Rouen, and remained there until 1916, when he was made Deputy Director of Works (L. of C. South). Five months later he was given the special appointment of Deputy Director of Works, Independent Air Force, and served in this capacity under Major-General (now Lord) Trenchard until his return to England in March, 1919.

For his services during the War he was mentioned in dispatches and was made a C.M.G. (L.G. 3.6.16). He also received the 1914–15 Star and the British General Service and Victory Medals.

On his return to England he was first of all appointed Deputy Chief Engineer, Eastern Command, and later on, Chief Engineer, with the temporary rank of Brigadier-General. He was holding this appointment when he retired in June, 1923, being granted the honorary rank of Brig.-General on retirement.

Harrison was made a C.B. in 1921, and in addition to the medals for South Africa and the Great War, he received the Coronation Medal of King Edward VII. for acting as one of the ushers in Westminster Abbey during the Coronation Ceremony, and also the Delhi Durbar Medal of King George V.

In 1888, he married Emily Rosina Quint, the adopted daughter of the late Sir Albert à Beckett, and is survived by her ; by a son who is a Captain in the Royal Tank Corps ; and by two daughters, the younger of whom is married to Capt. R. L. Thompson, R.E., whose father and grandfather are both well-known officers in the Corps.

Quiet and unassuming, Harrison was universally popular. Those who served under him soon realized his kindly nature and his great sense of fairness in his dealings with them, and they looked upon him more as a personal friend than as a commanding officer ; whilst those under whom he served fully appreciated his tact, sound commonsense and good judgment.

Shortly before his retirement, his C.-in-C. (the late Lord Horne) sent for him and told him how much he had wished to recommend him for further promotion, but that the precarious state of his health prevented him from doing so. For even at that time he knew that his days were numbered. Unfortunately, the continual strain and hard work of his four years in France had so seriously affected his heart that the doctors told him that, even with the greatest care, he could hope for only a very few more years of life. He refused, however, to be a burden to himself and to others by becoming a chronic invalid, and he gamely determined to " carry on " right up to the end. A sincere and ardent Catholic, he fully lived up to his high ideals. Nobody in trouble or want ever appealed to him without receiving ready assistance, not only by the easier method of alms-giving, but also by generous personal service. Many a man who was almost " down and out " has to thank him for permanent work, often obtained only with the greatest difficulty and after the expenditure of a lot of time and trouble on his part.

He was taken seriously ill on his arrival in the Riviera in November last year, but during the whole of his last illness he worried far more over the trouble and inconvenience he was causing to others, than over his own desperate condition.

He died of heart-failure at Bordighera on January 21st, and by his death the Corps loses one who not only tried to associate himself with it in every way, and who was truly proud of being a " Sapper," but also one who, both by the high standard of his work and by the fine example he gave in his private life, successfully upheld its highest traditions.

W.A.H.

COLONEL MALCOLM OF POLTALLOCH.

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PROBABLY the last surviving Sapper officer with both Crimean and Mutiny service was Colonel Edward Donald Malcolm, 16th Laird of Poltalloch, who died there on 20th March, 1930, in his 93rd year. Nearly 76 years have passed since he was commissioned to the Royal Engineers, and they were filled, right up to advanced old age, with public service of varied type. After retirement from the army, he took a keen interest in political work as an upholder of the policy of tariff reform ; he constantly visited his family estate in Jamaica ; and he was a Deputy-Lieutenant for the County of Argyll.

Born on November 13th, 1837, he was the third son of John Malcolm of Poltalloch by his wife, Isabella Harriett, daughter of the Hon. John Wingfield Stratford, of Addington Place, Kent. Their eldest son, John Wingfield, sat for many years in Parliament, and was created Lord Malcolm of Poltalloch in 1896. On his death in 1902 the peerage became extinct, and he was succeeded in the Poltalloch estate by his brother Edward, the second son, Leonard Neill, having been killed at Inkerman in 1854. Edward served in Turkey in 1855 to the end of the Crimean War, and was also in the Indian Mutiny. He was twice mentioned in dispatches and received the medal with clasp for the relief of Lucknow. Very soon after, he was campaigning in the China War. Here he was selected for a special service—that of obtaining good steam coal from Japan (then a jealously closed land) for the British Navy. The mission was successful, and Malcolm received the thanks of the Naval Commander-in-Chief, Sir James Hope. The next call was to Canada, where he built and completed a chain of three forts to strengthen the defences of Quebec on the south side of the St. Lawrence.

Malcolm returned home to become an Instructor at the School of Engineering, Chatham, where he specially studied the new subject of submarine mining defence. From Chatham he was appointed Inspector of Submarine Defences for the War Office. Here his organizing ability was shown, for the service was welded into a whole, able at a few hours' notice to defend all the important harbours of the country at a minimum of expense, since the work was done for the most part by volunteers on the spot.

On retiring from the army, after spending many years as C.R.E. in York, Edinburgh, and elsewhere, he was appointed one of the three Commissioners for re-arranging the boundaries of Scotland, under the Local Government Act of 1889. He was then appointed Engineer Adviser to the Secretary for Scotland for piers and harbours in the Western Highlands and Islands, and held the post from 1890 to 1893. From 1901 he was Honorary Commandant of the Clyde Submarine Mining Volunteers, R.E. He was made a C.B. in 1881, and after retirement from the army was awarded a distinguished service pension. He was a County Councillor for Argyllshire, and was an active magistrate. Like his father, he was both a good farmer and a good landlord, and had the typical interests of a Highland laird. He did much to maintain the breed and extend in many lands the reputation of the West Highland terrier, the oldest sporting dog known. His keenness as an angler was maintained to advanced age, and he was a lover of literature.

Colonel Malcolm married, on July 17th, 1867, Isabella Wyld, daughter of Mr. John Wyld Brown; she died in 1927. Their eldest son is Sir Ian Malcolm, formerly a prominent Unionist M.P., and now British Government Representative on the Suez Canal Board. The second son is Major-General Sir Neill Malcolm, President of the British North Borneo (Chartered) Company. There are three younger sons, all of whom held commissions in the army before and during the Great War, and two daughters, who both married officers of the army.

MAJOR W. C. HUSSEY, C.V.O.

WILLIAM CLIVE HUSSEY was born 2nd January, 1858, the second son of Mr. Edward Hussey, of Scotney Castle, Lamberhurst, Kent. He was sent to Mr. Lee's preparatory school at Brighton, and afterwards to Eton, where he was in the house of the celebrated Dr. Warre.

At Eton he was a "wet-bob," and he carried his love for rowing to Chatham and found there that his experience was of value to the S.M.E. oarsmen.

Being desirous of passing into the R.M.A., he left Eton in 1873 and attended the classes of Mr. Fowler, at Tunbridge Wells; he passed into "The Shop" in 1875.

At the R.M.A., he was high up in his term, and although he did not pass out head of his batch, he was promoted to be R.U.O. and was awarded the Sword of Honour.

Hussey received his first commission in the Royal Engineers 19th June, 1877.

On leaving Chatham, he was employed at Bermuda, where he acted as Adjutant, and also was A.D.C. to the Governor, General Gallwey. He came home from Bermuda in 1883.

In 1884, he was posted to "A" Troop (Pontoons) at Aldershot. When, in 1885, the Government of the day determined on the Bechuanaland Expedition, organized and commanded by Sir Charles Warren, then a Major in the Corps, Lieut. Hussey was selected for the post of Staff Officer to the C.R.E., Col. A. G. Durnford, and so had a share in operations which, though now almost forgotten, are memorable on three accounts, viz.: (1) Their objects, which were to relieve the Bechuanas from occupation of their lands by Boer squatters, to ascertain that the Transvaal State was respecting its then recently delimited western frontier, and to suppress the republics of Goshen and Stellaland, newly formed outside that line, were completely attained without the discharge of a single shot; (2) the way was opened for the extension of British rule to the Zambesi; (3) Imperial troops were, it is believed, for the first time clothed in brown corduroy, officers and men alike, to avoid the unnecessary casualties among the commissioned ranks experienced in former South African campaigns. The G.O.C. himself rode about with a carbine in a bucket and no sword.

The Imperial troops of the Expedition returned to Great Britain towards the close of 1886, and Hussey resumed duty at Aldershot, being transferred to the Telegraph Battalion at Clifton in 1888. He afterwards acted as A.D.C. to the I.G.F.

In July, 1897, Major Hussey was selected for the post of Assistant

Major William Clive Hussey CVO

Bailiff of the Royal Parks, under Col. Wheatley, thereby leaving the Corps and becoming an official of the Office of Works ; he succeeded that officer as Bailiff in March, 1902, and held that position till January, 1923, when he had to retire, under Civil Service regulations, on reaching the age of 65. Fond of country pursuits, he speedily mastered the principles of forestry and ornamental gardening, and was able to initiate and supervise much in the way of improvements during his term of office. In particular, he had to reconstruct many miles of road to meet the requirements of modern traffic. He set himself to appreciate the needs both of the country and of the general public in the use of the Royal Parks. The facilities provided for their use were gradually increased, notably in Greenwich Park, by throwing open areas previously enclosed and by the reservation of space for games where this could conveniently be done. As is well known, the floral display was greatly improved. The public functions which required special arrangements to be made by him were numerous, comprising the erection of stands for spectators and the provision of camps for the troops employed on such occasions. As examples may be cited the coronations of King Edward VII. and King George V. ; the funerals of Queen Victoria and King Edward. Such functions necessarily culminated in the Great War, when hospitals, training camps, aerodromes, stores and offices were erected in the Royal Parks. These last duties were carried out with a staff depleted to a nucleus, but it is recorded that, owing to Major Hussey's energy and good temper, no friction arose with the many authorities concerned.

When his time for retirement came, he had earned the good will of all with whom he was associated by his courtesy, cheerfulness and sympathy. A portion of a letter written by Sir Lionel Earle, Permanent Secretary to the Commissioners of Works, may be quoted :—

" I only came into personal contact with him when I was appointed in 1912, but I can testify, from my close association with him during those years up to the period of his retirement, to his untiring activities and efforts to do everything he could to improve the conditions of the Parks for Londoners.

" He was popular with his colleagues, and I think we all missed him when his date for retirement came."

His work was recognized by the award of the C.V.O. in 1923.

Besides his official duties, Hussey served on the Westminster City Council for a few years, and was on the Committee of St. George's Hospital. He was for many years a Churchwarden of St. Mark's, North Audley Street.

Major Hussey was a keen amateur artist, and devoted much of his leave and leisure to landscape painting in water-colours. He excelled in architectural subjects, and particularly in pencil drawings, for which his clean and accurate technique was admirably suited. He exhibited frequently at the Royal Amateur Art Society's exhibition, an organization of which he was treasurer for a good many years. On the Selection Committee of the Society his sound critical faculty was of great value. He was a competent horseman and a good shot, and enjoyed games and sport when his leisure permitted them. His tact, his cheery manner and his friendly companionship will always be remembered by those who knew him best.

He married in 1898, Mary Anne, daughter of the Honourable and Very Rev. George Herbert, Dean of Hereford, and is survived by his widow, a son and a daughter.

He died on 20th June, 1929, and was buried at Lamberhurst.

R.W.A.

SIR VINCENT CAILLARD.

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SIR VINCENT CAILLARD died in Paris, on March 18th, 1930, at the age of 73. He went there for an operation, which was successfully performed, but later contracted pneumonia.

Vincent Henry Pensalver Caillard was the son of his Honour the late Camille Felix Desiré Caillard, County Court Judge, and was born on October 23rd, 1856. On his mother's side he was related to Lord Beaconsfield. He went to Eton in 1869 and was in Mr. Warre Cornish's house. He left in 1872 and passed into Woolwich, where he was Pollock gold medallist, and joined the Royal Engineers in 1875. In April, 1879, he was appointed assistant to the British Commission for the delimitation of the Montenegrin frontier, and in the following October for the Arab Tabia Bridge Commission. He rejoined the Montenegrin Commission in March, 1880. In July of that year he was sent on special political duty to Epirus to report to the Berlin Congress, and in September he was attached on special service to Admiral Sir Beauchamp Seymour during the naval demonstration at Dulcigno. In February, 1882, Caillard was on service for the Intelligence Department, and in August he was attached to the headquarter staff during the Egyptian campaign, for which he received the medal and bronze star and the Medjidieh and Osmanieh Orders. [He retired from the Corps on 26th December, 1883.]

In 1883, he was appointed President of the Ottoman Public Debt Council, and Financial Representative of England, Holland, and Belgium in Constantinople. He resigned in May, 1898, in order to join the Board of Vickers, Limited, and received high Turkish decorations. He had been knighted in 1896. For 27 years Sir Vincent rendered valuable service as a Director of Vickers, for which post he was specially fitted by his diplomatic and financial experience. There was no part of that huge concern in which his influence was not felt. He was appointed financial director in 1906, and to his responsibilities in that capacity was added a large share in the control of the Company's foreign operations. Early in 1914, he negotiated for Vickers and Armstrongs the reconstruction of the Turkish fleet and all the Turkish dockyards and arsenals. Work had begun on this contract when the War broke out. It was chiefly due to his initiative and organizing ability that the Company was able to make during the War an enormous contribution to the national output of munitions and other material. He resigned his Directorship in September, 1927.

When Mr. Joseph Chamberlain started his campaign for tariff reform, Sir Vincent Caillard was one of his most energetic supporters, and he served as Chairman and later as President of the Tariff Commission. He wrote much on the subject, and contested Central Bradford in 1906. He also took a leading part in the Federation of British Industries, and was its third president in 1919. In addition to his work with Vickers, he was a Director of the Southern Railway, the Metropolitan Carriage, Wagon, and Finance Company, and other important concerns.

Sir Vincent Caillard had much musical taste, and composed various songs, including a setting to Blake's "Songs of Innocence." His first wife, a sister of the late Sir John Hanham, of Wimborne, was the energetic Commandant of the Red Cross hospital, which she and her husband established at Wingfield House, their home near Trowbridge. She died in 1926, and Sir Vincent married, secondly, Mrs. Zoe Oakley Maund, daughter of Mr. R. E. Dudgeon and widow of Mr. John Oakley Maund. He leaves a son and a daughter by his first marriage.

LIEUT.-COLONEL PETER NORMAN NISSEN, D.S.O.

EARLY in 1916, the problem of providing accommodation in forward areas for the troops in France was becoming very serious. Conditions had changed. The zone subject to shell-fire had widened: many villages had been destroyed and could no longer be relied upon for billeting. Simultaneously, the Expeditionary Force had grown from one to three Armies; a fourth was being formed. The projected advance on the Somme would inevitably entail the concentration of great numbers of troops in devastated areas. It was therefore obvious that large quantities of hutting and accessories would be needed in the following autumn and winter months.

At this juncture, news reached the E.-in-C.'s office that a temporary R.E. officer in a Field Company at Ypres had evolved a novel and promising design for a semi-circular hut made principally of corrugated iron. This officer proved to be Nissen, and by a happy coincidence he was appointed in March, 1916, to the command of the 29th Advanced Park Company allocated to G.H.Q. Troops, and then engaged on works in connection with the move of Headquarters from St. Omer to Montreuil. These works were carried out with remarkable efficiency and rapidity under the C.R.E. G.H.Q. troops, and in the course of their execution Captain Nissen came closely into touch with the E.-in-C.'s Staff.

An experimental hut was erected, the details of which naturally needed considerable modification in order to provide for standardization, portability and interchangeability of component parts before the design could be finally approved for manufacture. But Nissen's original ideas were confirmed, and the success of the final design was mainly due to his ingenuity, energy and intimate knowledge of workshop practice. Originally intended to provide weatherproof sleeping accommodation and shelter for men in forward areas, Nissen huts were utilized and adapted for every conceivable purpose. Eventually more than 100,000 of them were manufactured at a cost of probably not less than £6,000,000, and were supplied to British Armies on every front and to the American Forces. They may still be seen standing in many parts of France and in this country.

Nissen and part of his Company for some months were engaged on experimental work connected with accommodation for troops and accessories. The "Nissen" Hospital hut and steel tent; the Canadian-pattern stove, the "Universal" shelter for horses and stores, drying rooms, incinerators, hot-water apparatus for baths, and many other articles required for forward areas were evolved by them, and became well known to all who served in France.

Subsequently Nissen served as C.R.E., G.H.Q. Troops, and in 1918 he became C.R.E., Independent Force, R.A.F., at Nancy.

Nissen came of a Norwegian Canadian family, and was trained as a mining engineer. Before the War he made his name as the inventor of the Nissen mining stamps. In the face of much discouragement and opposition he had succeeded by enterprise and persistence in getting them widely adopted in the gold fields of South Africa.

No man was better qualified by experience and technical ability for the special work entrusted to him. He had genius for design and adaptation combined with a fertile imagination. His personal skill with tools was remarkable, and enabled him to gauge accurately the capacity of machinery and labour. It may be mentioned that in 1921 he designed and executed the War Memorial of the Institution of Mining and Metallurgy, of which he had long been a prominent member. Before the War, a statuette of his was exhibited at the Royal Academy.

Cheery and humorous, he was a most attractive personality. He brought into all his enterprises the enthusiasm and optimism of a boy, undeterred by occasional failures, of which in later life he had his share. His premature death in April last at the age of 59 was deplored by a very large circle of friends, amongst them many R.E. officers. His association with the Corps in the Great War was most happy, and contributed a notable share to the solution of many problems related to the well-being and efficiency of the Armies in France. His name, identified with the well-known hut, will be remembered when those of many men more conspicuous in the Service have been forgotten.

NOTE.—The "Nissen" hut, which was the descendant and enriched relation of the "Elephant" and other similar steel shelters adopted for trench warfare, was designed to give sleeping accommodation for 16 men with a floor area of 20 ft. x 16 ft. The roof consisted of curved corrugated iron sheeting, 8 ft. radius on curved steel ribs, lined with matchboarding or a thinner gauge of corrugated iron. Windows and doors were provided at the ends, which, like the floor, were of wood panels.

The total weight was under three tons, so as to allow of transport of a complete hut in a lorry. Each component part could be readily man-handled, and the whole assembled by unskilled labour. In a competition a party of 1 N.C.O. and 8 men of a Field Company, 51st Division, completed a hut from stacked materials in 1 hour 50 minutes.

W.A.L.

CORRECTION TO MEMOIR OF MAJOR-GENERAL SIR S. ROBERT RICE, K.C.M.G., C.B.

THE description of the inception of the Rice blockhouse given on page 348 *R.E. Journal*, June, 1930, is not intended to suggest that blockhouses were not of general use for defensive purposes in South Africa prior to the attacks on the railways by the Boers. Blockhouses had, in fact, been incorporated in the defences of Komati Poort as early as August, 1900, by order of the E.-in-C. (Maj.-Gen. Sir Elliott Wood, K.C.B.), who persistently urged the importance of this form of field defence against an enemy who had no artillery, basing his claims on his war experience at Suakin in 1884–5. These early blockhouses had sandbag walls three feet thick with steel loop-hole plates, of the Suakin type, which were erected in a day. It appears, however, that it was the design of the masonry blockhouse which suggested to Rice's imagination the possibility of an alternative design of almost universal application, constructed of material which was simple to handle and put together, easy to transport, and readily obtainable.

BOOKS.

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

A HISTORY OF THE BRITISH ARMY.

By the HON. SIR JOHN FORTESCUE, K.C.V.O., LL.D., D.LITT.

(Vol. XIII, with a separate volume of Maps and Plans. Price 40s. net. The set of 13 volumes with Maps and Plans, £16 16s. net.)

The thirteenth and last volume of this monumental work covers the period 1852–1870, and completes the story of the Old Army. The author leaves it to some other hand to write the history of the New Army which grew up after the Cardwell reforms had abolished purchase for officers and instituted short service for soldiers.

It is not often that in a military history we can gain useful light on the political questions of the present day. That the heads of the Army have often been at loggerheads with the politicians is unfortunately a fact, and the author has to refer to it time and again throughout his work. But in this volume we find a whole chapter dealing with a question which is in the forefront of British politics to-day. The author has done useful service in placing it on record. Many of us would wonder what connection there can possibly be between the policy of Free Trade and the Army! A perusal of the opening chapter will show that the adoption of the policy of free exchange in 1846 affected the army in several ways.

It is necessary to recall the fact that as a result of the famine in Ireland in 1845, Sir Robert Peel was induced in the following year to repeal the Corn Laws. "The effect," writes Sir John Fortescue, "on "British agriculture was gradual, but in the end—after the disastrous "season of 1879—crushing. Cobden and his supporters always repudi- "ated the possibility of any such result, but farsighted men predicted "it to be inevitable, and they were right. No doubt the leaders of the "movement acted from the purest motives. They were indeed jealous "of the country gentlemen who had so long ruled England, and they "pined to overthrow them in the name of liberty; but it would be "unjust to trace their action consciously to this source. Among their "followers, however, there was a vast body of self-seeking men, par- "ticularly in the industrial north of England, who desired cheap food, "in order that they might obtain cheap labour and make large profits, "and these formed the majority which imposed Free Trade on the "nation.

"The military significance of Free Trade was threefold:—

"First, it relieved the Army from the duties of the preventive service "which had absorbed a great part of its energies at home since 1662. "This was beneficial to the Army, though little was said about it.

"Second, there was the military danger of leaving the country unable "to feed itself without importing corn. Of this no account was taken. "The logical outcome of the policy should have been an increase of the "Navy in order to secure transport from overseas. The fleet had as "a matter of fact in the generation after Waterloo been allowed to sink "to dangerous weakness, and the peril was greater inasmuch as the "advent of the railways had destroyed the coasting trade, and thus "diminished the supply of seamen.

"Third, and this, although of the greatest military importance, was "also ignored by the greedy rank and file who followed Cobden and "Bright in 1846—the depopulation of the rural districts and the attrac- "tion of the peasantry into the towns, with its corollaries of physical "deterioration in the men bred in the towns and the steady fall in the "supply of country-bred recruits.

"Little heed was paid by the Free Traders to the warnings of sensible "men, for their leaders had prophesied that the whole world would "presently follow England's example, and the result would be universal "free exchange and universal peace! From a sentimental point of "view, the policy of free exchange in 1846 may seem to deserve commend- "ation as a generous act of voluntary disarmament, though assuredly "it was not adopted without the hope of solid gain. The Free Traders "were not only absurdly sanguine; they were not only sublimely "ignorant of history and of human nature; but they had utterly mis- "conceived the nature of war. They imagined it to be a matter of red- "coats and guns and bayonets, whereas the root lies in the competitive "instinct of every human heart and human brain.

"In 1850 Cobden, having failed to get the Army reduced, seized the "opportunity to press for a decrease in the number of officers, nominally "on the score of expense. But it was pointed out that the pay of a "lieutenant-colonel after deducting income tax and interest on the "purchase price of his commission amounted to only £107 per annum!"

It is only fair to record that it was Cobden who initiated the principle that the grant of self-government to a colony should carry with it an obligation to defray its own military and naval expenditure. The proposal was premature, especially on the naval side, but it was reasonable and long afterwards was gradually adopted. And it was the party to which Cobden belonged that first initiated examinations for promotion in the junior ranks of officers in 1850. It was they, however, who strenuously resisted Lord Derby's Militia Bill in 1852—fortunately without success; and it is their successors who have practically abolished cadet corps in the present year of grace.

So much for politics.

Sir John Fortescue gives us a useful sketch of the war with Russia in the Crimea, and does not spare the authorities which launched the British Army into a European war quite unprepared. This is followed by a general account of the Persian War and the Mutiny in India, in which there is much to digest in view of the unsettled state of India at the present time.

Short accounts follow of the campaign in China in 1859, the Umbeyla Campaign on the frontier in 1863, the Abyssinian Campaign in 1867, and the wars in New Zealand from 1861 to 1868.

In summing up, Sir John Fortescue shows how the British Army was on active service practically continuously from 1852 to 1868 in some part or other of the globe, and he traces the ups and downs of the Army throughout that period. As each crisis occurred the Army establishments were hastily increased, only to be reduced as hurriedly when affairs assumed a more peaceful appearance.

The Army was always short of the required numbers: it was underpaid and overworked. Such a state of affairs could not last for ever, and in 1867, a Conservative Government which came into power for a short time found itself faced with the problem of placing the army on a proper footing which would enable it to deal with emergencies as they arose without dislocating the whole of the machinery. A Royal Commission was appointed and made the following recommendations:

1. Enlistments should be for general service and not for particular regiments. This was accepted.
2. Military training schools for boys should be established akin to the training ships of the Navy. This was rejected on the score of expense—but has been adopted in the present century.
3. "Localization," meaning what is now the territorial system. This has been gradually adopted.

4, 5, 6. Recruits should receive a greater reward on enlistment: the soldier should get a free supply of necessaries: the ration of meat should be increased. The first of these was accepted, and in lieu of the two last the soldier's pay was increased by two pence per diem. It was then one shilling for wages plus one penny for beer money. Not a great increase, but an important concession.

7. Soldiers should receive an additional twopence a day upon re-engaging for a second term of service. One penny only was conceded.
8. The first period of service should be raised from ten to twelve years. This was accepted.

All attempts to solve the question of an army reserve failed for the time being, and it remained for a Liberal Government—with Cardwell as its War Minister—to solve the problem, together with the abolition of purchase, in 1870–71.

The disgraceful condition of the barracks at home and abroad had already received some attention, and the troopship service had been improved.

In his penultimate chapter, Sir John Fortescue has a good deal to say about the Commissariat and Transport services. He has recently written the first volume of the History of the Royal Army Service Corps, which is shortly to be published by the officers of that Corps, and his researches on their behalf have enabled him to include a résumé of his conclusions as to the organization and development of the Corps in his History of the Army. It is to be regretted that he has not found it possible to do the same for the R.E., R.A., and other branches, for this History of the Army is to a great extent a history only of the British Infantry.

In his final chapter, the author touches on some of the later developments in the administration of the Army subsequent to 1870, and tells us how the Expeditionary Force Canteen was developed out of the Canteen and Mess Co-operative Society in 1894.

The volume is an extremely interesting one to all old soldiers, and will serve as a guide to the younger, chiefly as to " what not to do " when they rise to high rank. To some politicians it will be hard reading.

The maps and plans are excellent and sufficiently illustrate the campaigns and engagements which are described.

H.B.-W.

HISTORICAL ILLUSTRATIONS TO FIELD SERVICE REGULATIONS, OPERATIONS, 1929.

By MAJOR H. G. EADY, M.C., R.E., *p.s.c.*

(Sefton Praed. 10s. 6d.)

Major Eady has published a new edition of his book, which has already been reviewed in these columns. This edition has a Foreword by Field-Marshal Sir George F. Milne, which in itself is an ample review of the book. He says: " I should have liked to have had this book by me " when I first started on my profession; as an introduction to the " study of *Field Service Regulations* and Military History it could hardly " be bettered. . . . The book should be useful to those who are studying " for examination or the Staff College provided that it is used as an " *apéritif* to further study rather than as a meal in itself."

The new edition, which has had to be much re-arranged and largely re-written on account of the publication of the new *Field Service Regulations*, includes a great deal of new matter; especially illustrations from the Great War. The latter, as the author points out, has been possible owing to the increase in authoritative works on the subject. The new material is admirably incorporated, and adds greatly to the value of the work. The addition of an index of campaigns is an improvement and should prove of value to students of special campaigns. The cross referencing is excellent. Criticism of such a book can merely be in the matters of detail. It is not clear why illustrations of the old principle of " maintenance of the object " have been omitted. In *Field Service Regulations*, it is true, this no longer appears as one of the principles of war, but it remains in that book, promoted as it were to an essential set down before all the seven principles.

The purist on staff duties will lament the use of the " unauthorized " abbreviation A.G. for advanced guard.

The Table of Contents has one mistake as to the page of the Foreword, and the headings in Chapter VI need re-arrangement on the lines of *Field Service Regulations* to avoid protective bodies such as flank guards, outposts, etc., coming under the heading " Advanced Guards."

Not only as an *apéritif* to the junior officer, but as a reference book or even a "pick-me-up" for the more mature student of war, the book can be confidently recommended to every soldier, and should find a place not only on his bookshelf but close to hand on his study table.

R.P.P.-W.

THE ASSYRIANS AND THEIR NEIGHBOURS.

By REV. W. A. WIGRAM.

(G. Ball & Sons. 15s.)

In *The Assyrians and Their Neighbours*, Mr. Wigram has written a book of interest, not only to those few who may have visited or served in Iraq, but to all who are students of, or like to keep in touch with, middle Eastern affairs. In the first few chapters of the book the author has given a brief historical introduction to his subject, and, as can only be expected in an attempt of this nature, the reader will find various statements which are perhaps insufficiently endorsed by historical evidence.

It must, however, be conceded that Mr. Wigram has succeeded in giving a picture admirably suited to his purpose as a background for the recent history of the Assyrians.

It is perhaps more with the very slender evidence in favour of the descent of the present so-called Assyrians from the historical nation of that name that the reviewer is tempted to quarrel.

The present Assyrian is a typical hillman, small, sturdy, with aquiline features; and in fact the reverse of Semitic in type. It seems far more probable that they are the descendants of a hill tribe conquered, no doubt, by the Assyrian and possibly transplanted to the plains round Mosul (ancient Nineveh), in accordance with that nation's well-known policy of transference of populations. On the downfall of the Assyrian Empire, such tribes would migrate to the hills once more. Such an event would not be in contradiction of the legends still extant amongst them and would perhaps be more in accordance with their physical characteristics and appearance.

There is little doubt that there is a difficult time in front of this small remnant of a nation and its record in the past few years is such as to call for our sympathy and best wishes for its future as part of the Kingdom of Iraq.

G.B.O.T.

A PRACTICAL NOTE ON TUNNELLING IN SHALE AND LIME-STONE.

By R. O. C. THOMSON, M.C., A.M.I.C.E., Executive Engineer, North Western Railway.

(Railway Board of India Technical Paper No. 274.)

This is a brief pamphlet on tunnelling, with reference primarily to Indian conditions. It justifies its title in being essentially a practical note, and gives many useful hints for carrying out this type of work, from fixing the centre line of a tunnel through the various stages of driving the heading, enlarging and completing the lining.

The details of timbering for the successive stages are clearly explained in the notes, together with the diagrams, which are good. The reproductions of the photographs are unfortunately mostly very poor and of little use.

The writer only briefly discusses the relative merits of top and bottom headings. In his notes and diagrams a bottom heading is usually indicated, and he would appear to prefer this method, though, as he points out, it is a question on which engineers hold different opinions. Indeed, the circumstances of each individual case must largely influence the decision as to whether top or bottom heading is to be adopted, and no one method can be conclusively preferred for all cases.

The problem of disposal of the tunnel spoil is one such factor of which no mention is made in these notes. In this connection, the writer's note in Chapter IV on opening up the tunnel face might with advantage have been elaborated. The desirability of completing the portal in good time "to hold up the face of the hill" should be noted; and if this is done, there should be no need to delay the completion of the approach cutting.

The importance of packing well between the lining and the limits of the excavation is duly stressed, and various warnings given against causes of accidents, showing the necessity for vigilant supervision.

This pamphlet should be of great assistance to any officer called upon to carry out or supervise tunnelling work.

J.R.R.

AMERICAN CIVIL ENGINEERS HANDBOOK.

By Merriman.

(Published by Chapman & Hall, Ltd., London. Price 40s.)

The average textbook on any engineering subject usually clothes its meat in a good deal of chat, which so far as the engineer is concerned is considered to be superfluous to his needs.

The engineer is generally a busy man and has not the time or inclination to delve into textbooks to search for what he requires. He wants to be able to put his finger on formulæ or other data at once, without first having to read all about how the said formulæ or data were evolved.

The textbook is excellent for a student, but the trained man who has practical problems to solve requires a pocketbook which contains bare facts and figures which are complete and can be found easily. The pocketbook under review is of this nature and deals with the data required by a civil engineer.

The information given is abundant and should meet all the needs of the profession for which it is intended. The articles are somewhat voluminous and could be condensed to a greater extent and still contain the same amount of information as clearly expressed.

The work is divided into twenty-two sections, the first five being given up to an explanation of the elements of the sciences used by the civil engineer in his practice and also include useful mathematical tables, such as Logs., Natural and Logarithmic Trigonometrical Functions, Areas, etc.

The sixth section deals with Survey and Map Making and the seventh with Materials and Strength of Materials.

The remaining fifteen give précis of the method usually adopted to solve various problems to be met by the civil engineer, such as the design and construction of foundations, steel and concrete structures—in fact, cover the whole range of subjects dealt with by that branch of the profession.

The contents of the volume are well displayed in a general table at the beginning of the book.

Each section also has its own more detailed Table of Contents and there is also a good alphabetical Index at the end of the book.

The book is bound in brown leather, lettered in gold and would make quite a pleasing addition to any civil engineer's office bookshelf.

From the Sapper's point of view, it is thought that a pocketbook containing all branches of engineering, such as Kempe's *Engineering Year Book*, which is only slightly larger in size, would be more useful.

B.C.T.F.

INTERMEDIATE MECHANICS—DYNAMICS.

By D. HUMPHREY, B.A., B.SC.

(Longman's Modern Mathematical Series, 10s. 6d.)

In his Preface Mr. Humphrey states that his object is to provide the long-felt want of a textbook embodying Calculus methods to fill the gap between the elementary book and the advanced treatise.

His book is designed for Higher Certificate and University Scholarship aspirants, and one's main impression on looking through it is that there is a vast gulf fixed between the requirements of those students who are reading for mathematical scholarships, and of those whose future is to be engineers.

The book contains much essential bookwork, and many excellent worked out examples, all of which is given in clear, and eminently readable form.

The main criticism from an engineer's point of view is that the conception of Moments of Inertia is not dealt with until the last chapter but one, with the result that the linear and rotational applications of Newton's Second Law of Motion are once again completely divorced; that many students find difficulty over rotational motion is due to this almost invariable practice, and one cannot help feeling that advanced students should not be encouraged to look upon the two forms of motion as being in any way different one from the other.

Then again, in Chapter I one cannot agree with the statement that the equations connecting "velocity," "space," "time" and "*constant* acceleration" are "of fundamental importance, and must be remembered." Constant acceleration is rare in engineering practice, and the parrot-like repetition of these formulæ that one finds even with the better students is a dangerous and quite unnecessary snare.

The use of these formulæ throughout the book has doubtless saved Mr. Humphrey and his compositor a good deal of work, but it is equally certain that his excellent book has not gained in value by it.

In conclusion, one can say that the book contains a great deal of good stuff for students reading either for the Cambridge Mechanical Sciences Tripos Qualifying examination, or even for the Tripos itself, and that the author, if he has not provided the textbook engineering students are looking for, has at least gone some way towards bridging the gap that unfortunately exists.

R.S.R.K.

(*a*) THE THEORY OF ELECTRICAL ARTIFICIAL LINES AND FILTERS.

By A. C. Bartlett.

(Published by Messrs. Chapman & Hall. 13s. 6d.)

(*b*) TRANSMISSION NETWORKS AND WAVE FILTERS.

By T. E. Shea.

(Published by Messrs. Chapman & Hall. 32s.)

In these days of long distance telephone messages from one end of the world to the other, the electrical network over which the telephone current passes is exceedingly complicated, and each portion of it is a cause of leakage and impedance in varying amounts, both of which cause distortion of the current wave form and consequently of the voice. It is, therefore, of the greatest importance to be able to calculate the current and voltage at one end of a network when a certain voltage is impressed on the other, and, luckily, exceedingly neat mathematical methods are available for doing this.

All networks may be considered as made up of a combination of simple sections, and artificial model lines may be constructed to check calculated results.

It will be seen that the subject is mainly of interest to communication engineers. Mr. Bartlett's book is an extremely clear introduction to the subject and should be invaluable to students, while Mr. Shea is a recognized authority. K.H.T.

SEWAGE AND SEWAGE DISPOSAL.

By A. J. Martin.

(Macdonald & Evans. Price 2s. 6d.)

This publication is a reprint of two lectures delivered at the Institution of Mechanical Engineers, under the auspices of the Chadwick Trust.

The author, in his Preface, writes as follows: "While my lectures "do not pretend to deal with all the technicalities of Sewage Disposal, I "have endeavoured to set forth its underlying principles in a clear and "interesting manner. I have also given a résumé of the changing ideals "which have inspired the treatment of sewage in the past and a survey "of the great advances which have been made in recent years."

We should like to congratulate Mr. Martin upon the success of this endeavour.

The book is eminently readable and conveys a singularly well-balanced idea of the value of the various processes which have been in vogue during the last hundred years.

To attempt to condense such a vast subject into two short lectures is a noteworthy feat and it would be surprising if there was nothing at which the carping could cavil. The chemists have already done so, but Mr. Martin's self-vindication has been both courteous and complete. There are, however, still a few points to which attention might be drawn, *e.g.*, it is interesting to compare the statement that "Disposal "by dilution is the most effective, the least offensive and the most "satisfactory way of purifying sewage," with the criticisms of the method in the following pages.

Again, the question of sludge disposal, the bugbear of most managers, is accorded a bare ten per cent. of the total book. This might surely have been advantageously elaborated, particularly with regard to digestion. It is noticed in this connection that Mr. Martin (p. 58) states that tanks should be large enough to hold three to four months' sludge. This would appear to be a dangerous generalization, which takes no account of either the *Ph* value of the sludge or the actual practice in the most modern German works.

The existence of an optimum temperature for sludge digestion is completely ignored.

In conclusion, the temptation to quote the following cannot be resisted: "One enthusiastic inventor, gifted with more imagination "than the rest, seriously proposed to supply the United Kingdom with "alcohol made from the London Sewage. . . . London is to be con- "gratulated that none of these proposals have been carried into effect."

The congratulation might reasonably be extended to the whole of the United Kingdom! A.D.C.

COMMERCIAL A.C. MEASUREMENTS.

By G. W. STUBBINGS.

(Chapman & Hall. 320 pp. Price 15s.)

The main feature of this book is the clear manner in which the author deals with the somewhat abstruse subject of the measurement of power and energy in unbalanced 3-phase A.C. circuits.

In the first chapter the elementary principles of A.C. circuits are explained. The author uses "p" for angular velocity instead of "w" and the term "average" is used sometimes, but not always to denote the "mean" value of an A.C. quantity. On p. 29, flux is confused with current. Apart from these minor criticisms, the subject matter is clearly expressed.

Chapter II is devoted to 3-phase circuits. It is thought that the explanations would be clearer if the two voltages in a 4-wire 3-phase circuit were referred to simply as "line" (*not* "phase-to-phase") and "phase" voltages.

Unbalanced 3-phase systems are dealt with by the method of positive and negative sequence components, and although this treatment is somewhat difficult to follow, it is well worth studying if a proper understanding of the 3-phase circuit is desired.

There is a slip in the numerical example on pp. 62 to 64.

$$\frac{\sqrt{3}}{5} = \cdot 346, \ \phi_0 = 19°6' \text{ and } \cos \phi_0 = \cdot 945 \text{ (not } \cdot 916\text{, as shown).}$$

This tends to upset the comparison on p. 64.

In Fig. 37, B_1 is the vector I_b advanced by 60°, and B^2 is the same vector retarded by 60°. Also, the phase of the positive sequence component lags behind the vector O V_c.

Chapter III deals with the measurement of current and voltage and all modern developments are given, including two coil induction ammeters and voltmeters and the thermal and copper-oxide rectifier types.

The improved performance of moving iron instruments due to the use of "Mumetal" is clearly explained.

Both the polar and co-ordinate types of A.C. potentiometer are described.

Chapter IV deals particularly with power measurement, Chapter V with instrument transformers and Chapter VI with the measurement of energy. It would appear that on p. 149, line 24, "one-tenth" should read "one-hundredth."

Chapters VII, VIII and IX are devoted to miscellaneous instruments, including power factor meters, frequency meters and phase sequence indicators and to instruments for measuring "reactive power" and kilo-volt-amperes.

The importance of correct connections when installing 3-phase instruments is very rightly emphasized throughout.

The book concludes with a chapter on test room equipment and some notes on the trigonometry of A.C. theory are given in an appendix.

A few misprints occur besides those specifically mentioned above, but they should be obvious to the reader.

The subject matter is thoroughly up-to-date and the references at the end of each chapter will be found of great interest to students intending to pursue the subject further.

All E. and M. officers will find the book useful, particularly on their special course.

W.M.

SURVEY OF INDIA.

GEODETIC REPORT, VOL. III.

From 1st October, 1926, to 30th September, 1927.

(Published by order of Brigadier R. H. THOMAS, D.S.O., Surveyor-General of India.)

Perhaps the most generally interesting event reported for the year under review was the determination of the longitude, by wireless time signals, of Dehra Dun observatory as part of the International Longitude Project. This project was referred to in the report of the previous year, when some accounts of the preliminary preparations were given.

The objects of this world project were: to determine the precise longitude of some 50 observatories, scattered over the earth's surface, all working in co-operation; to acquire a knowledge of the rate of propagation of wireless signals and of the regularity of the earth's rotation. The latter is being investigated by M. Bigourdan, Director of the Bureau International de l'Heure, from the results obtained at certain selected observatories. We look forward with interest to the conclusions he may arrive at. Less intensive observations are being continued at some of the observatories, including Dehra Dun, in an endeavour to discover possible long period or secular changes of longitude. Secular variations of longitude combined with those of latitude should be of great scientific interest.

For the purpose of this project, special wireless signals were emitted from four stations, namely, Bordeaux, Annapolis, Honolulu and Saigon, during the months of October and November, 1926, when all the co-operating observatories attempted to take observations for time and to receive all possible wireless signals during the period.

It is interesting to note that the new value of the longitude of Dehra, obtained by wireless, is 5 hours 12 minutes 11·794 seconds, while the old value, derived from the Indo-European telegraphic arc, in 1894–96, by Burrard and Lenox-Conyngham, was 5 hours 12 minutes 11·770 seconds; at the same time, it should be mentioned that the value of one of the component arcs Greenwich–Potsdam, as determined in 1903, would apparently increase the old value of the Indian longitude by 0·098 seconds. We may, however, look forward to a promised volume, in which the whole matter will be fully discussed.

A Prismatic Astrolabe, geodetic model, together with two transit instruments, were used for the determination of local time.

Anyone interested in the project should consult this report, where the whole operation is given in much detail.

In answer to an enquiry by Professor Wegener, the astronomical latitudes of Indian Stations at which observations had been made at long intervals were scrutinized to see if there was any evidence of earth movement. The result is that there is no evidence of continental drift, " nor, on the other hand, is there any disproof of the existence of a " drift of the order of 50 feet in a century."

The prismatic astrolabe has been used side by side with the transit instruments for determining local time for longitude purposes and it seems to have done its work well. As an instrument for determining latitude, it is not certain whether it will prove sufficiently precise for such exacting work as the determination of the variation of latitude, but for field purposes it should be very suitable.

A personal equation apparatus was devised for use with the prismatic astrolabe. The ideal apparatus is one in which the real star is reproduced as nearly as possible in the artificial one, so much so that the observer should not be conscious of the difference between them. That the observer should also look through the eye-piece of his own instrument and not make use of a separate instrument, as is generally the case in such apparatus. He should also use the same tappet he employs when actually observing. If possible, matters should be arranged so that he can sandwich-in observations for personal equation between his star observations. Most of these ideals seem to have been realized in the device, which is described in full detail. The true coincidence of the star images is recorded on a chronograph, which also records the coincidence as judged by the observer. The instrument is erected in the observatory in such a position that the astrolabe when set for observing can be turned on to the artificial star at will. But for the details of this ingenious apparatus we must refer those interested to the actual report, where full description and drawings are given.

Dr. Hunter has a short notice in which he further considers the most probable height of Mount Everest. The latest conclusion is that 29,050 feet is a fair value for the height, and that we must use geoidal heights and not spheroidal. The present time-honoured height of 29,002 feet is measured above Everest's spheroid placed so as to be tangent to the geoid in the plains south of Nepal. Owing, however, to the doubt which must always surround trigonometrical heights when the reciprocal angle cannot be observed, we understand any departure from the original value for record on maps, etc., is not contemplated. Nevertheless, the investigation of this question is of great interest.

Another point of interest to surveyors who have to work in forest-covered areas is the portable observing tower and lattice mast, designed by Dr. Hunter. The former is 60 feet and the latter 100 feet high. The tower weighs less than a ton and takes eight hours to erect. A "Storm-King" pressure-fed petrol lamp of about 500 c.p. was hoisted to the top of the mast and could be seen at a distance of 20 miles. They were used for the geodetic triangulation of the Burma Coast series.

Space does not admit of a reference to all the subjects dealt with in this report, but we may say it will repay a close study by those engaged in the class of work with which it deals. It is to be regretted that other survey departments of the Empire do not issue reports up to the high standard of the Survey of India.

H.L.C.

SURVEYING: AS PRACTISED BY CIVIL ENGINEERS AND SURVEYORS.

Including the Setting-Out of Works for Construction and Surveys Abroad, with Examples taken from Actual Practice. Intended as a Handbook for Field and Office Use, also as a Textbook for Students.

By John Whitelaw, Jun.

Eighth edition, thoroughly revised and enlarged by Colonel Sir Gordon Risley Hearn, c.i.e., d.s.o.

(London. Crosby Lockwood & Son. 1929. 16s. net.)

This is a standard work which had already gone through seven editions before the present revision. It contains all the usual problems in surveying which are likely to be met with by the civil engineer in the course of his work, and should, in this respect, prove most useful. There is also a full description of the various instruments and their adjustments. Since the book is already somewhat bulky, we think that the description of certain obsolete methods might well be omitted in future editions. For instance, no one would now use Lunar Distance, Lunar Occultations, Moon Culminating Stars or Eclipses of Jupiter's satellites for finding longitude, since the wireless method became available. The former methods have only an historic interest and might well give place to a description of the latest wireless practice, which, so far as we can find, is only incidentally mentioned on page 377 as a possible method; but is not again referred to.

Then, no mention is made of that comparatively new instrument, the prismatic astrolabe, now so largely used for finding latitude and local time for longitude combined with wireless time signals. This is a serious omission which should be attended to in future.

Again, it is hardly necessary in a book of this kind to include a description, with somewhat full drawings, of the Colby bar base-measuring apparatus, which has long since been displaced by more modern ways of measuring bases, though of considerable historic interest as showing how our grandfathers did their work. The same applies to the space devoted to the old theodolites used for the original geodetic triangulations, which are now only museum specimens.

Nor do we think the editor has done justice to aerial surveying. No mention, as far as we can find, is made of the methods developed so ably by Captain Hotine, R.E., and the Air Survey Committee, which have gone a long way since Jones and Griffiths wrote. The use of air survey for the purpose of examining alternative routes for railways to assist in the final selection of the alignment which has to be surveyed on the ground is not mentioned. For rapidity and cheapness in certain classes of unmapped country this has advantages over the older methods.

While we have pointed out where we consider this book might be improved, we do not wish to imply that it does not contain a great deal of excellent and useful matter. Everything connected with railway survey has been gone into in great detail.

The following headings of chapters indicate the scope of the work: Surveying Chain Only; Surveying with the Aid of Angular Instruments; Levelling; Adjustment of Instruments; Railway (including Road) Surveys and Setting-Out; Tacheometry or Stadia Surveying; Tunnel Alignment and Setting-Out; Surveys for Water Works; Hydrographical or Marine Surveying; Astronomical Observation Used in Surveying; Explanation of Astronomical Terms; Surveys Abroad in Jungle, Dense Forest and Unmapped Open Country; Trigonometrical Surveys. The index is only fairly comprehensive. H.L.C.

BELL'S POCKET GUIDES, ENGLISH COUNTIES, KENT.

By S. E. Winbolt.

(With Illustrations from Photographs by Winifred Ward. Price 6s. net.)

This is the fourth volume issued in this new series of *County Guides.* The get-up is very attractive, the information is accurate, and the illustrations are delightful. The only drawback is that the book must be selective within the limits of size set, and those who require a complete gazetteer of the county must look elsewhere.

P.H.K.

MAGAZINES.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1930. TOME I.—NOS. 4 TO 6 INCLUSIVE.)

Les opérations de l'Armée belge, 1914–1918.—*Combats de Hautem-Sainte-Marguerite et de Grimde.* The first three chapters, dealing with the field operations of the Belgian Army in August, 1914, appear successively in the numbers of the *Bulletin* under notice. The position of affairs in the early days of August, 1914, is reviewed; the main body of the Belgian Army had taken up a position on the Gette on August 7th, and had there awaited developments. The 3rd Division, having fallen back from Liege on the seizure of the fortress by the enemy, arrived on this river line on the 8th. The Belgian Cavalry Division, which had moved on the 9th *idem* to a position covering the left flank of the Belgian forces, had on the 12th, with the support of the 4th Mixed Brigade, repulsed the attempts of the German cavalry to cross the river at Haelen. The positions occupied by various formations of the Belgian Army on the evening of the 17th; a Belgian appreciation of the situation based on the information then available; the actual positions occupied by the German First Army at dawn on the 18th, and the intentions of the German High Command, are dealt with in introductory paragraphs.

Chapter I contains a detailed description of the situation of the Belgian 1st Division at dawn on the 18th; the Order of Battle of the Division, and the positions occupied by its brigades during the night of August 17th/18th are also set out in No. 4, which is furnished with sketch maps.

Chapter II contains a record of the events of August 18th immediately preceding the collision of the opposing forces: the latest intelligence relating to the enemy, and the orders issued by the staffs of the 1st Division and its brigades are set out in No. 5. The movements of various Belgian units and the positions occupied by them are described in some detail.

Chapter III deals with the action taken by the Belgian High Command to meet the situation. The intelligence received at the Belgian G.H.Q. was of a character to indicate clearly that the enemy could not be successfully held on the line of the Gette by the Belgian Army, and orders were, in consequence, issued for the latter to retire. The telephonic and other instructions issued in relation to the withdrawal from the Gette position are given in No. 6 of the *Bulletin* in considerable detail.

Emploi des mitrailleuses du bataillon du premier échelon dans l'offensive. The original article appears in No. 4; it is an official commentary explanatory of the doctrine relating to the handling of machine-guns promulgated in the Belgian *Règlement de l'infanterie au combat.* An attempt is made in the article to illustrate the method which should be employed in practice to give effect to the general principles laid down in the official manual aforesaid.

Le Siège de la Citadelle d'Anvers en 1832. The original article, which is illustrated by plans, etc., is contributed by Major Delvaux; the first three chapters appear in successive numbers of the *Bulletin* under review.

Chapter I contains the early history of Antwerp; an interesting extract is given therein from the memorandum prepared by Vauban in September, 1702, criticizing the old fortifications. Among other matters dealt with in No. 4 are the Walcheren Expedition (1809); a description of the former Citadel, and its bombardment by the Dutch Fleet in 1830; the defence works constructed by General Chassé in 1831; the intervention of an Anglo-French Fleet (to succour the Belgians) in 1832; and the operations carried out against the Dutch Fleet which attacked Antwerp.

Chapter II sets out the role assigned to the former Citadel of Antwerp, and contains an examination of the essential features of this work. The views existing in the early part of the nineteenth century in relation to problems connected with the attack and defence of fortresses are briefly stated, and a description is also given in No. 5 of the various types of armament in use at that epoch.

Chapter III is devoted to the Sieges of Turin (1706), and Pampeluna (1823); both these centres possessed works the design of which closely resembled that of the Citadel existing in 1832 at Antwerp.

Les aspects militaires de la Révolution de 1830. The first three parts of an article under this title by Capt. Wanty appear successively in the numbers of the *Bulletin* under review. The political and other causes which led to the Revolution of 1830 are not gone into by Capt. Wanty, who confines his attention to the military aspects of the situation arising from this upheaval.

A brief description of the Netherlands Army in 1830, and of the military system in vogue in the kingdom at that period, is given in No. 4. The disturbances which took place in the Belgian capital and in the Provinces during the early days of the outbreak; the ineptitude of the authorities; the action taken by the troops; and the attempts made by the civil population to re-establish order are dealt with in the first part of the article. The formation of a Town Guard—*garde bourgeoise*—in Brussels, and the part which it played, are also touched upon therein.

The events of the period August 28th/September 20th, 1930, are dealt with in No. 5. The character of the Town Guard is examined therein. This body, it is pointed out, was in no way anti-dynastic, but consisted of loyalists who had assumed control of affairs, because the authorities seemed powerless to deal with the disturbances, which had assumed a serious aspect. The Prince of Orange, who was popular in Belgium, had received instructions from the King to restore order in the revolting provinces, and, in consequence, proceeded to Brussels. The various measures adopted to maintain order and the reasons why they failed are discussed in the second part of the article. Serious disturbances occurred in Brussels on September 20th, and the banner of revolt was at once raised. A Dutch Army was then already on the march to deal with the insurgents.

The preparations for the attack on Brussels are described in the third part of the article, which also contains a short description of the Dutch Army, and of the plan for the attack on the Belgian capital.

Chronique de l'infanterie. Two parts of an article under this title appear in Nos. 5 and 6 of the *Bulletin:* the French doctrine in relation to the employment of machine-guns in the offensive—based on the *Règlement française de l'infanterie* and the *Instruction provisoire pour les unités de mitrailleuses* (1929)—is dealt with in No. 5, and the British doctrine on the same subject in No. 6.

Avec la garde prussienne sur la Sambre en août, 1914. The original article appears in Nos. 5 and 6 of the *Bulletin:* it is contributed by Lieut.-Col. Van Egroo, who points out that the causes which led to the Germans meeting with a serious check on the Sambre in August, 1914, were of a general and also of a special character. The main cause of the failure of the Germans to obtain a decisive victory in the battle of the frontiers is traced to the defects of the German High Command; its organization was faulty, and it also left important matters relating to leadership to too great an extent in the hands of the Army Commanders, and, in consequence, the armies of the German Right Wing failed to co-operate effectively with one another: in other words, decentralization was overdone. The special causes to which the check is attributed are also discussed by Colonel Van Egroo; he considers that the German Commanders in many cases mishandled their troops, and were guilty of committing serious tactical errors.

The developments on the front of the German Second Army leading up to the contact of the German advanced guards with detachments of the French X Corps in position along the Sambre, south of the line Tamines–Jemeppe, are described in No. 5 of the *Bulletin.* The events of August 21st and 22nd are dealt with in No. 6, which also contains an instructive criticism of the German operations.

W.A.J.O'M.

REVUE MILITAIRE SUISSE.

(1930.—Nos. 1 to 6 inclusive.)

L'infanterie de l'avenir. Articles under this title appear in Nos. 1 and 5 of the *Revue:* the first is contributed by Col. Lecomte and the second one by Gen. Rouquerol. Col. Lecomte's article deals mainly with the views contained in the volume entitled *Infanterieangriff und Strategische Operation* by Col. Sonderegger, recently published by Hubert et Cie, Frauenfeld. The volume in question contains a plea for the re-armament of the Swiss infantry, which, it is contended, could not, as organized at present, force a position defended by well-placed machine-guns. Col. Lecomte does not entirely agree with Col. Sonderegger's views, but considers that the latter's proposals are worth following up not merely as a matter affecting the Swiss Army alone, but as a general proposition relating to the problem of providing the infantry generally with an armament of a character which will enable it to play its proper role in modern warfare. Col. Lecomte considers that the organization advocated in the volume referred to would convert infantry into a "heavy arm," and make it too cumbrous for field warfare.

Gen. Rouquerol refers in his article to Col. Lecomte's views and also to Col. Sonderegger's book; he then proceeds to carry out an independent investigation with a view to solving the problem of a suitable organization for the infantry. It is inevitable, the General thinks, that improvements in armament must in the future give a marked advantage to the side which, in the opening phase of a campaign, elects to utilize its land forces in defensive operations; the preliminary offensive movements must take place in the air, and it must be from a "manœuvre par infiltration" that a lightly equipped and highly mobile infantry should seek "des succès de surprise." "Heavy infantry" must necessarily be unsuitable for the type of manœuvre proposed.

Quelques remarques sur l'emploi des sapeurs dans nos manœuvres. The original article is contributed to No. 1 of the *Revue* by Major Pache. He points out that his experience at manœuvres has been that infantry commanders frequently find a difficulty in assigning useful tasks to the Sapper units attached to them; further, it would appear that the Swiss *Service en campagne* practically omits all reference to the Engineer arm. For these reasons, Major Pache puts forward a few useful suggestions on the subject.

La guerre aérienne et notre aviation suisse. The original article is contributed to No. 1 of the *Revue* by Premier-lieutenant E. Naef, who urges that credits should be voted with a view to placing the Swiss air arm in a position to play an effective part in a future war.

Quelques réflexions sur l'aviation de chasse. An anonymous article under this title appears in No. 2 of the *Revue.* It is said that erroneous views in relation to aviation in general and fighting machines are widely held in Switzerland, not only by its citizens, but also in the Army. This is partly due, it is suggested, to articles on the subject appearing in the Swiss Press; the good faith of the authors thereof is not questioned. Consequently, with a view to enlightening its readers on this important matter, the editors of the *Revue* have caused a summary to be prepared of the opinions expressed on the subject of aviation in general and in relation to fighting machines in a recent number of the French *Les Ailes*, and publish the same under the foregoing title.

1914 *et l'utilité de notre armée.* In Switzerland, as in other countries, there is a group which opposes all measures framed for the purposes of national defence. A member of this group has addressed Col. Feyler on the subject: the former raises a number of questions, and, *inter alia*, asks to be furnished with evidence which shall conclusively show that Swiss territory was not invaded by one or other of the belligerent Powers during the Great War alone because a mobilization of the Swiss Army was carried out for the purpose of guarding the frontier, and that the immunity which Switzerland enjoyed was due to no other cause.

The text of the communication received by Col. Feyler is published in No. 2 of the *Revue*. The Colonel has sent his correspondent a little volume entitled *L'antimilitarisme en Suisse*, which contains copies of certain German and French documents, the perusal of which ought to leave no doubt in the mind of any intelligent person as to what would, in all probability, have happened had the Swiss Government neglected to adopt the course it followed by showing that the Swiss Army existed for a specific purpose, and would be utilized for that purpose in the event of the rights of its people being violated. The original article also contains categorical replies to the several questions put to Col. Feyler by his correspondent.

Guerre de chasse. The original article, which appears in Nos. 3 and 4 of the *Revue*, is contributed by Col. de Diesbach, who deals therein with the Swiss problem of home defence. He refers to the changes in the strategical situation which have come into existence since the conclusion of the Great War. The possibility of a future war in which Switzerland may become involved cannot, he says, be ignored. What his country has most to fear is an "attaque brusquée." He explains the difficulty which the Swiss Government would find itself in should it order a timely mobilization of its Army, even if convinced that war was imminent, and that the invasion of Switzerland was definitely projected in the plan of campaign to be put into operation. Col. de Diesbach thinks that the best way to deal with an invader, in the event of an "attaque brusquée," would be to resort to the type of guerilla warfare which he describes in some detail in the original article. He discusses the ethical aspects of his proposals, and also deals with the question of the reprisals which would probably follow should his suggestions be put into practice. Finally, he endeavours to meet the possible criticisms of those who may argue that it is difficult, if not impossible, to prepare for and organize the type of warfare advocated by him. He points out that during the Swiss manœuvres of 1928 and 1929 this very type of warfare was "tested out," and that it "proved in."

La guerre aéro-chimique et la défense anti-aérienne. Three further parts, including the final part, of the article under the foregoing title by M. S. de Stackelberg are contained in Nos. 3, 4 and 6 of the *Revue*—the article was begun in No. 2 for 1929.

In No. 3, M. de Stackelberg deals briefly with the problems of coast and frontier defence, particularly in relation to the advent of aviation as an offensive factor; the evolution of coast defence in the present epoch; and the organization of coast defence in some of the important countries. Under the latter head, the aerial defence arrangements in the U.S.A., France, Italy, Great Britain and Japan are described and compared.

In No. 4, the general principles upon which the arrangements for meeting attacks of hostile aircraft should be based are dealt with; the subject is treated under two headings: aerial defence and anti-aircraft defence. Under the former heading, aerial obstacles and aerial "smoke-curtains" are touched upon; under the latter heading, reference is made to recent developments in anti-aircraft artillery, and the subjects of aerial smokescreens and camouflage are also dealt with. In this part of the article, M. de Stackelberg also discusses the tactical problems of aero-chemical warfare.

The final part of the article is devoted to anti-aircraft fire-discipline;

acoustical apparatus used for the detection of the approach of aircraft; and the disposition of "warning-posts." The article concludes with a brief review of the arrangements made, or contemplated, in France, England and Italy for the protection of the civil population during hostile air-raids.

W.A.J.O'M.

JOURNAL OF THE ROYAL SOCIETY OF ARTS.

February 14th, 1930. 1s.

This number of the *Journal of the R.S.A.* contains the Trueman Wood Lecture by Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.SC., LL.D., F.R.S. The subject of the lecture is the "International Movement of Mineral Products in Peace and War," in which the possibility is discussed of preventing war being resorted to simply by ensuring as a certainty that essential minerals shall be lacking to the combatants: in fact, the "mineral sanction" would be a first stage of the "economic sanctions," under Article XVI of the League's Covenant. The advantage would be that this restriction would not involve the general upset of the world's commerce and finance, but at the same time the recalcitrant nations would realize that, after their present stocks of minerals were exhausted, there would be no replenishment available. No power is naturally self-contained in the mineral sense and no nation could hold sufficient stocks of all minerals required for a serious war.

The lecture would be of use to those reading for Staff College and other exams.

P.H.K.

HEERESTECHNIK.

(*August* 1929 *No. continued.*)—*The Screening by Smoke of Industrial Establishments.* A short article deals with this subject, not generally, but giving an account of a full-scale trial. At the instigation of the representatives of the East Prussian towns and in the presence of ministerial officials, an attempt at screening from air attack took place on the 27th May, 1929, the object chosen for screening being the Water Power Works at Friedland, one of the most essential undertakings to be kept going during war. The smoke-producing apparatus consisted of two adapted fire extinguishers, furnished by the Total Co., Ltd., of Charlottenburg, Berlin. Each of these comprises a container of chlor-sulphuric acid, and a high-pressure cylinder containing either carbon dioxide or nitrogen, under the pressure of which the acid is driven through the ejector and broken up fine by the sprayer. Immediately on issuing from the jet the chlor-sulphuric acid combines with the air to form a thick white mist, the density of which is in proportion to the water content of the atmosphere. Strong sunlight affects the production unfavourably. The complete absence of wind is a disadvantage. With a wind velocity of over 9 metres a second the smoke is carried away too rapidly: the best strength is 2 to 3 metres a second.

The exact covering of the object to be screened, and no more, with a smoke-screen would serve only to betray it to the airman. The object aimed at must rather be to cover a much larger area with smoke, so that the airman does not know where in the smoke to drop his bombs. At power works, like those at Friedland, this is the more important, since the airman can already locate them fairly well by the aid of the converging power lines.

Photographs are given of the works before the trial started, immediately after the commencement, and twenty-two minutes later. Aeroplane photographs (not reproduced) also show that the trial was a success, and that the works were screened for thirty minutes. No mention is made of the number of containers used or of the cost of the trial, but the advantages are pointed out of having easily movable containers, and good communications, by road or water, through the establishment to be screened.

Air Records. The Fédération Aéronautique Internationale, which is the only recognized authority for all records in the air, awarded twelve world's records between February and June, 1929. Of these, six went to Germany. This brought the percentages of world's air records gained by the leading countries, out of a total of 82 records acknowledged, to: Germany, 40; U.S.A., 20; France, 16; Great Britain, 9; all remaining countries, 15.

Piercing Artificial Smoke-Screens. The British Admiralty is reported as having utilized a scientific discovery for rendering smoke-screens transparent. In 1919, it was discovered that the ultra-violet and the infra-red rays, not directly accepted by the human eye, possess great power of penetration through mist. The idea of using such invisible rays for secret signalling had already been recognized as of high military value, and some progress made in the appropriate means of reception. The reflection of the infra-red rays after penetrating mist offers further possibilities. The untiring activities of the British Admiralty scientific staff and especially of the eminent physicist, Baird, have brought about a successful reception of these reflected rays. Practically, the proceeding appears to be this: the invisible rays sent out from a ship, suitably equipped, pass through the smoke or mist, but are reflected when they strike a ship concealed by the mist. On the transmitting ship a sensitive cell is acted upon by the reflected rays and brings a buzzer into play. From the strength and from the pitch of the sound, one is able to draw certain conclusions as regards the nature of the concealed object, its shape and size; and this can be done with a remarkable degree of accuracy. It is even said that, by means of a system of lenses, the reflected rays, like Röntgen rays on a barium platinocyanide screen, can be made visible. One would thus be able to recognize the ship's profile.

Such an invention is eminently suitable for war purposes and especially for night work at sea. The enormous distance at which ships fight in daylight would limit its utility; but at night, when ships have screened lights, when there is no moon, when it is cloudy, when there is fog, or when smoke-screens are used, the invention should prove invaluable. It is worthy of study for application to land warfare.

Möller's Shadow Line Pointer. This article describes an instrument for the rapid plotting of intersections of bearings, whether obtained optically, acoustically or by wireless direction finding. The D.F. stations of whatever sort are represented by small pillars, each placed in position on the map by means of a central base pin, and containing a small 12-volt glow lamp. The base of each pillar is graduated in degrees and is oriented so that a central line of shadow thrown by the lamp can be directed as ordered.

The instrument is made by the Askania Works Co., Friedenau, Berlin; each pillar being 10 in. high and 5 in. in base diameter and weighing 2 lb. They are delivered in wooden boxes, 11 in. x 6 in. x 6 in.

For permanent direction finding, certain improvements are possible. The graduated bases are replaced by large graduated circles, drawn on the map. The tall columns having the lamp on top, which is reflected through an opening in the base, also disappear, being replaced by small slotted cylinders, while the lamps are now placed underneath the board on which the map is mounted, thus giving a much neater appearance.

(*September* 1929 *No.*)—*The Improvement of Infantry Weapons.* The interesting series of articles just concluded on the influence of the technical development of the rifle on infantry tactics has given rise to much discussion on the improvement of weapon performance, and has called forth two articles in the present number, *Bullet Velocity and Tactics* by H. Gerlich, and *Explosive Bullets of the Smaller Calibres*, by A. Focke. The former gives us the ideas of one who has been recently engaged in practical work and investigations. He agrees entirely with the author of the original article, that the technical development of the rifle, constructively and ballistically, is far from having been completed; and also that it is a waste of fighting power to look upon the rifle merely as a weapon of precision for short-range use. Trials and photographs prove that the new 7-mm. rifle, firing a Halger ·280 H.V. Magnum bullet with a muzzle velocity of 1,186 metres a second, is superior to the larger calibre service rifles, both in precision and in destructive effect.

The second article describes the Russian infantry explosive bullet of 1915, the 2-cm. Germany infantry explosive bullet and the French *Matter* explosive bullet. The two former are flat-headed and fire by means of a cap which sends a flame down a hole to the charge, in the one case compressed picric acid, in the other highly compressed smokeless powder. Compared with these, the *Matter* is a great improvement; having no cap, it is brought almost to a point. It is fired by a percussion fuse, the striker of which is driven down on to a fulminate primer.

A number of photographs show what the 7·9 Mauser carbine bullet can do to the shrapnel helmets of various nations, a picturesque and impartial form of advertisement.

The author pleads for the small-calibre explosive bullet that it is a necessity against tanks, that its effect upon human beings is more humane than numerous small perforations by machine-gun bullets, and, in any case, that war, the nations' *ultima ratio*, is no Easter holiday excursion.

Air Affairs in England. A list of firms exhibiting at the Aircraft Exhibition at Olympia, and the number of types shown by each, is given without comment; then a detailed list of the R.A.F. exhibits, with notes. Mention is made of the Vickers' Victoria troop transport biplane, which carried 600 people in 83 flights between Cabul and India; and of Short Brothers' flying-boat, *Singapore*, similar to the one used by Sir Alan Cobham in the round Africa flight, the first all-metal flying-boat made in England, with two Rolls-Royce 800 h.p. engines and maximum speed of 130 m.p.h.

Further evidence of England's interest in the air follows in a description of the great air display at Hendon.

The reporter who is always at pains to point out as *avis au lecteur* the military value of what he sees, was specially taken with the Hawker Hornet, said to reach a height of 3,000 metres in four to five minutes, and to fly at least 200 m.p.h. at heights of three to four miles. Nearly the same achievements are claimed for the Hawker Hart day-bomber.

(*October* 1929 *No.*)—*The Great German Wireless Exhibition*, 1929. It would be more correct to call this a broadcasting exhibition, since it contained this year, in distinction from all foregoing exhibitions, only instruments and equipment directly or indirectly connected with broadcasting. The majority of the visitors will hardly have noticed the omission, but it is a moot point whether other branches of wireless should not be represented in future.

A main centre of attraction was the section "Distant Vision," equipped by the Government Post Office, the firm of Telefunken, the Telehor Company, and the Distant Vision Co., Ltd., the two latter working the Mihaly system and the Baird system respectively. The report of last year's exhibition gave an outline of what is necessary in order to provide vision at a distance by electrical means (*vide R.E. Journal*, September, 1929, p. 526). The question to be answered this year is a more advanced one, viz., How can distant vision find a place in broadcasting? All those who participated use the photo-electric cell at the transmitter, break up the picture with the Nipkow disc and use a glow lamp as source of light at the receiver; except Telefunken, who use Weiller's reflector disc and the Kerr cell.

The necessity of distant vision transmission by means of a normal broadcasting sender, and of its reception by means of an instrument that can be switched on to a normal broadcasting receiver, imposes firm limitations on the goodness of the picture.

At 12·5 pictures a second (and this speed, though adequate, is only half that of a flicker-free film) not more than 1,200 picture elements can be shown at a time. At 1 square millimetre per element the picture would not be larger than 3·5 cm. x 3·5 cm., or 1½ in. each way. That is just large enough to show two human heads clearly enough to be recognizable. Any larger picture would be lacking in detail.

In this respect, what can the development of the near future do to improve things? Unfortunately, there are no immediate essential improvements to be expected, since, to get rid of flickering and to improve the pictures in fineness of detail, frequencies ought to be increased at least six times, and the ordinary broadcasting sender of to-day can neither handle such frequencies, nor does the present distribution of wave-lengths permit of such.

As regards results, the post office broadcast a film on 2,000 metres, which was only partially satisfactory, owing to a slight swaying of the pictures, and this in spite of the fact that an impermissible solution of a great difficulty had been adopted, viz., the production of synchronization frequencies by a common generator and their distribution to all receivers. Again sacrificing reality to simplicity, these frequencies were sent out over wires.

The Telehor Company and Distant Vision Co., Ltd., both showed receivers for sale to the public at about £15, a price which will not yet make distant vision popular.

More as a curiosity than otherwise, the post office had installed in communication with each other two telephone call-boxes, in which the speakers could alternately see each other.

Picture telegraphy this year has taken a distinct step backwards. The public seems to have little use for a permanent picture, which takes some time to come through. The uses of picture telegraphy, the sending of photographs for newspaper and police purposes, of meteorological diagrams for aviation, etc., will remain, but for broadcasting to the public it lacks the actuality of the ordinary broadcasting of sound, or of electrical vision. It may amuse, but it is not vivid.

Amongst other items there was this year no outstanding novelty. Much use was made of screened grid valves, especially for H.F. amplification: and it was noticed that most receivers were designed also for electrical gramophone reproduction, both number and quality of "pick-ups" having greatly increased.

Air-Compressors for Army Purposes, by Major Kubitza. The first half of an article deals with this subject under the sub-heads, "Increasing Motorization of the Army: Pneumatic Tools as Necessary and Effective Complement of Engineer Equipment," "Comparison Between Compressors Used for Civil and Military Purposes," "Consequences Derived from the Foregoing." The author points out that, the engineers being the chief bearers of the technical war work in the army, it is with them, before all, that a lack of proportion, between the number and extent of works to be carried out and their existing modest physical working strength, must be made good by the machine. He enumerates many of the engineer's tasks in war, rules out the use of steam and water power, as things to be utilized naturally where found but otherwise having no place in the engineer's war equipment, and reduces the sources of driving power of all the necessary tools to three: (1) the explosion engine, (2) electricity, (3) compressed air.

Of the latter he says: "Pneumatic drive possesses, compared with the explosion engine and electricity, special advantages for military purposes." During the war, mighty rivals to compressed air arose in purely mechanical and in electrical drives, which successfully established themselves in certain fields of activity, a fact chiefly explained by the peculiarities of position warfare. Since the war, however, a movement in the other direction has set in, and compressed air drive, owing to its great advantages, is again taking the first place, and is even prevailing where the circumstances are not unfavourable to purely electrical drive.

Specially suitable for pneumatic working among engineers' tools are rams, borers (for all materials), and tools for earthwork. The necessary compressed air is furnished by compressors for which explosion engines are used, or, where transport difficulties are great, electric motors.—(*To be continued.*)

A Short Historical Retrospect of the 75-mm. Gun tells the story of how the French managed to outwit the Germans in the production of this gun. Both France and Germany were experimenting at the time to get an improved field gun, and in both countries there were opponents of barrel recoil. These opponents in Germany gained the upper hand, when bad reports, confirming their ideas, came also from France. Meanwhile the barrel recoil quick-firer was approved in France, the money for it was voted secretly, and the artillery had been armed with it before the Germans discovered that they were on the wrong track.

The writer of the note has nothing but praise for the action of the French, and consoles himself by pointing to the complete surprise caused by the German 30·5 and 42-cm. howitzers in 1914.

Air Affairs in England contains a full account of the Schneider Trophy race and England's great success. It concludes with a complete list of the types of the privately owned aeroplanes, 115 out of 169 of which are Moths. In the remaining 54 there are 2 Klemms and 1 Junkers F13, so that Germany has managed to get a place in what is overwhelmingly British, both as regards machines and engines.

(*November* 1929 *No.*)—*The Pedersen Automatic Rifle*, with 11 photographs and diagrams of velocity, time of flight, trajectory and energy of its 7-mm. bullet compared with the 7·92 Mauser bullet. This is a translation of a pamphlet by Vickers-Armstrong, submitted by the Company to *Heerestechnik* as a contribution to the subject of the increase of effectiveness of infantry weapons, interest in which was aroused by H. Schmidt's series of articles on the effect on tactics of the development of the rifle.

The Pedersen automatic rifle is particularly neat and pleasing in appearance, weighs 8·8 lb., and fires at least 50 aimed rounds a minute in the hands of a trained soldier. The actual firing is not automatic, a point of great importance, both as guarding against excessive expenditure of ammunition, and on psychological grounds as conducive to aimed fire.

Field Fortification, depicted by examples from the history of war, by K. Linnebach, for the Ministry of Defence; with 44 sketches, published by E. S. Mittler & Son, Berlin, 1930, price, marks 7.50.

Out of twelve historical examples extending from 1701 to the Great War, and eminently suitable to his purpose, the author deduces the correct or incorrect use of field fortification as a means of attaining operative and tactical ends. On account of the constantly changing forms of field fortification (of which the Great War furnishes many instructive examples) the author in general omits details of technical execution, except where they are necessary for the understanding of a particular case. In the introduction he says: "Like permanent fortification, field fortification is also a sphinx. Whoever puts himself in her power, without having solved her riddle, she destroys." That the riddle had not been solved at the beginning of the Great War by many German leaders, everybody knows. They could only make up their minds to field fortification with difficulty, even when it was necessary. They could only make up their minds with greater difficulty to the abandonment of fortifications, even when the latter had ceased to have any purpose. Before the War, one had not troubled about the solution of the riddle owing to underestimating its value: hence unnecessary and bloody sacrifices. "Field fortification must strengthen the power to attack, not weaken it. Its supreme object is attack." The author has been particularly successful in proving the truth of this extract from the present manual, from the wealth of example in the history of war. The study of this book will make easier the mastery of field fortification, the solution of the sphinx's riddle.

Air-Compressors for Military Purposes (*concluded*). As contrasted with the civil requirements of an air-compressor, viz., low cost of production, high performance, long life (so that as little of the prime cost as possible has to be written off each year), economical running, supervision and maintenance, there is a long list of military requirements: (1) mobility, (2) high output, combined with low weight and small space occupied, (3) raw material for manufacture and fuel to be safeguarded in war time, (4) low petrol consumption, (5) ability to stand rough treatment from man and weather, (6) to be applicable to as many different purposes as possible, (7) requiring little attention, since really well-trained personnel will seldom be available, (8) repairs to be executable without workshops, as these can only be found farther from the front, (9) engine parts to be easily accessible, so that repairs can be carried out on the spot with standard spare parts kept in readiness.

Although the military and civil requirements thus differ considerably, much of the difference is only in degree of importance. Also the same point may be desirable but for different reasons, *e.g.*, economy in running, of obvious importance to the civilian financially, is to the soldier important because of the urgent necessity of keeping as low as possible the amount of transport and the amount of supplies.

The military uses of pneumatic tools are: boring and breaking stone, ramming concrete, boring and sawing wood, drilling, riveting, cleaning and painting iron, excavating and ramming earth. They are required for making dugouts, for mining, for making communication trenches, for pile-driving, for quarrying, for road repair, for hutting and water supply. They must be capable of being carried by mule transport; and they must be issued in peace time so that the engineers are thoroughly accustomed to using them.

A Small English Dirigible gives a short account of AD1, built by the Airship Development Co., as an experiment for social purposes. She carries one-third of a ton besides the crew, has a mean speed of 45 m.p.h., and is in fact an old friend, the Blimp. The makers recommend the type as suitable for private persons, picnics (seats for four) and advertising purposes, for which there are two surfaces, 76 ft. x 24 ft. The engine is an A.B.C. Hornet and can drive the AD1 75 m.p.h. through still air.

F.A.I.

MILITAERWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*September–October*, 1929)—The first two articles, *The Development of Turkish Power* and *The Siege of Vienna by the Turks in* 1529, are published to commemorate the 400th anniversary of Vienna's first successful resistance against siege by the Turks. The editor feels that he ought to apologize for going back quite so far, and excuses himself on the grounds of the wide-reaching results of the Austrian victory, viz., that it saved Eastern Europe from sharing the fate of the Balkan States as Turkey's vassals. This alone might render the achievement important enough for commemoration, even without additional reasons, such as pride in the fact that a town of less than 60,000 inhabitants, the capital of an Austria no larger at that time than the diminished Austria of to-day, maintained itself for weeks against the efforts of a Turkish Empire, extending from Trieste to Persia, from the Don to the Nile, and thence nearly to the Pillars of Hercules. These efforts were expressed in an army 300,000 strong, and containing in 40,000 Janissaries the only regular troops at that time in existence.

Armoured Trains in Action. Three examples of very bold and successful action by armoured trains. They form an appropriate addendum to Capt. Wagner's historical article on the subject, which appeared in the January–February number. The first occurred in August, 1915, on the Austro–Italian front, and was of the nature of a raid, pure and simple, the armoured train breaking through the Italian outpost line and retiring after having shot up Monfalcone railway station. The second example is the destruction of a strong point. This latter was in an occupied tunnel, near Gorizia, and the garrison was 100 strong. The armoured train made a night raid, and made a clean sweep, capturing 10 prisoners, 2 machine-guns, 29 rifles and causing 30 casualties. The third instance occurred in June, 1916, and was the rescue of two Austrian battalions, which, in retiring on Kolomea over the Pruth, had been practically surrounded by the Russians.

The indication appears to be that an armoured train boldly handled may do excellent service by intervening at the right moment in open warfare, and can carry out *coups de main* in static warfare.

Participation by Aircraft in Ground Fighting. Capt. Ritter, late of the German General Staff, treats this subject at first historically, from its commencement by the British in the battle of the Somme to the end of the War, when he describes the way the German fighting squadrons were organized and tactically trained for co-operation with infantry in their great offensive of 1918. He then investigates some foreign post-war ideas on the subject. The Americans, for instance, are trained systematically and thoroughly for flight at the lowest heights, only about ten metres above the ground, using machine-guns and small bombs. As regards the French, the author discusses at some length the ideas of Général Armengaud in his book *Quelques enseignements du Riff en matière d'aviation*, which, carried to their logical outcome, demand the creation of independent air troops solely for co-operation with the infantry in ground fighting, in fact *une aviation de ligne.*

These ideas Capt. Ritter combats on the grounds of economy, of their sacrificing the strategical co-operation by air forces, or war conduct, to tactical co-operation, or battle conduct; and generally on the ground that ideas of tactical co-operation based upon the French experiences in Morocco, where the enemy was both entirely inferior in armament, and especially was not in a position to undertake offensive counter-measures against the French home territory, cannot be applied to European warfare. He considers that the answer to this question lies in whether, in European warfare, quick tactical success having a decisive effect on the outcome of the War is ever likely to occur. The historical sketch followed by samples of modern ideas is intended to stimulate the reader to think out the problem for himself. As regards what the troops on the ground are to do to guard against low flying aircraft we are referred to Major Angeli's article in *Luftflotten*. (*Vide R.E. Journal*, March, 1929, p. 149.)

Effect of the Heaviest High-Angle Fire Ordnance with Fixed Carriages, by Major-General Ellison-Nidlef. This article has been called forth by Major Heigl's excellent series of articles on the development of artillery material since 1914, which started in the January–February number. It is in the first place an attempt to show that Major Heigl's historical picture of a clear purposeful development of high-angle fire ordnance does not correspond with reality, and that, on the contrary, the development of these weapons has been little thought out and spasmodic. Further, exception is taken to Major Heigl's claim, based upon the capture of the Belgian forts, that only one weapon is decisive, since the fate of a campaign may depend upon the performance and mobility of that one weapon—the heaviest siege mortar. Against this, General Nidlef adduces two lessons from Port Arthur, viz., that brave and skilful defenders, in spite of bombardment by the heaviest artillery, can hold their own; and, secondly, that brave and well led attackers can, even without the aid of the heaviest artillery, break through every position. One is permitted to doubt whether many supporters could be found for either of these propositions. The author himself supports them by citing two examples from his own experience, the first in August, 1915, when the Austrians repelled the Italian attack on the plateau of Lafraun, although it was preceded and accompanied by the heaviest bombardment, and the second in May, 1916, when the Kempel Barrière was captured by an Austrian brigade without heavy artillery assistance.

These are interesting examples, which confirm similar happenings at Port Arthur, but it is not wise to found lessons upon exceptions, or we may find ourselves proving anything, from the utter uselessness of heavy artillery to a superiority of man over material, which enormous casualty lists would easily confute.

As regards books, it is clear that Major Franck is far from agreeing with that Gothic conqueror who, destroying all else, still left the Greeks their books "to consume their vigour and destroy their martial spirit," since he recommends books as character builders, and would have the soldier read in his own time and out of it.

The Development of Artillery Material since 1914 (*continued*). This instalment is full of plums under the sub-title "Some New Inventions."

They are capped projectiles, the turbo-gun, rifled projectiles and rocket projectiles. As regards the first-named, although armour-piercing projectiles belong properly to the navy and coast defence, the necessity of combating tanks has introduced the capped projectile to field warfare. The author confidently assures all sceptics that even to-day, and on Austria's own frontiers, light tanks are to be found carrying 30 mm. of armour, sufficient to defy ordinary shells. He then describes the Firth cap of soft steel, with concave top covered by a wind hood, which, disappearing itself entirely on impact, causes the same shell to penetrate which without the cap goes to pieces without penetrating. This cap is said to have been improved recently both in England and in the United States.

The turbo-gun was invented by a French lieutenant of artillery in 1917, and embodies a complete revolution in projectile propulsion. As its name implies, it works on the principle of the steam turbine, in that a fairly large charge is subjected to combustion in a chamber so that the gases stream out through a small opening, their potential energy is converted into kinetic, *i.e.*, a great velocity is attained, and they strike the base of the shell and drive it forward, escaping through lateral openings after doing their work.

The inventor promised abnormally high muzzle velocities, and so ranges. He also promised—what in 1921 seemed inexplicable, since muzzle brakes were then almost unknown—reduced recoil, extraordinarily light carriages, and even the possibility of large-calibre automobile guns of extreme lightness.

The French, during and after the War, also the Belgians, then the Americans, and it appears also the Italian Navy, have all had thorough and by no means unsuccessful trials with the turbo-gun. These trials have all been kept strictly secret. Only with the French has publicity been given to certain facts, *e.g.*, that 75-mm. guns and 155-mm. (howitzers?) have both been built. The results with the field gun were most interesting, and even though they did not come up to the inventor's expectations, the astonishing thing is that this entirely revolutionary invention worked at the very first attempt. The reduction of recoil to a minimum, by giving the gas outlets the best shape for the desired braking effect, is a far-reaching advantage of the turbo-gun.

The most promising modern artillery invention is, however, the rifled projectile. The idea originated in France in 1917, and the well-known artillery technician, Général Charbonnier, has been occupied with its working-out for twelve years. Meanwhile, the Germans had put the idea into practice for the 8·4 in. shells of the Bertha built for bombarding Paris at hitherto unheard-of ranges. They found themselves compelled to this step, because no copper driving bands, however broad, could stand up to the rotation accompanying a muzzle velocity of 1,500 metres a second. For the Germans, the matter rested there, and they derived no further advantage from the grooved projectile, which is, of course, expensive and makes loading troublesome. With the French, it has been quite a different story, and Général Charbonnier started immediately attacking the great problems involved.

The results of the trials in figures are staggering. In 1918, in Calais, Charbonnier obtained with the 155-mm. calibre a range of 19 kilometres with his shell weighing 60 kilos, against the 16 kilometres for a 43-kilo shell of the normal 155-mm. Field gun results were still more wonderful. The M1900 shell of the C97 field gun weighs 5·4 kilos. Charbonnier fired with the same range and the same precision a shell weighing 12 kilos. Its length was 9·4 calibres, or 27 in.!

After the war, the trials were continued at the Centre of Artillery Studies in Metz, and Charbonnier designed a new 155-mm., known as the 155-mm. gun G.P.C. (Grande Puissance Charbonnier) with all modern improvements, including muzzle brake and the Filloux splayed carriage. Charbonnier is said to have got a range of 32 kilometres with this gun, firing a shell weighing 60 kilos. That happened as far back as 1920. Now it is reported from France that the army is being equipped with a new 155-mm. gun having the range mentioned, but with a shell weighing over 70 kilos. This would seem almost incredible but for our knowledge of what Charbonnier had already achieved.

Against the increased cost of the ammunition must be reckoned the saving on barrel wear. Charbonnier claims that there was no wear after 1,500 rounds.

In the matter of loading, Major Heigl is convinced that Q.F. ammunition will be produced.

The fourth invention, rocket shell, is a revival, since it is quite a century old. In the last few years it has been taken up by three Italian engineers, who have, as with the turbo-gun, obtained very high velocities with very light weapons. The chief trouble is that the shell arrives with less than half the weight it had at starting. There is also the difficulty of the trail of light or smoke betraying the gun's position. It is not known how far the trials have been a practical success, but we may well obtain also from this an improved performance of the lightest artillery.

The article closes with two appendixes containing extra notes and corrections of certain details of the Vickers' mortars, the British 9·2-in. howitzer and Russian 12-in. howitzer (July–August number) and of the heaviest Italian and American guns (November–December number.)

Infantry Special Weapons, by Col. Fischer. Some plain thoughts upon the necessity of plain thinking. It is putting the cart before the horse to construct a new weapon upon hypothetical grounds and then present it to the troops. This fault, however, is generally made. Whenever a new weapon is about to be constructed, or a new weapon has to be judged upon, there are two points which should be quite clear :—

(1) What do the troops *need?*

(2) What will the new weapon enable the troops to *do?*

Col. Fischer puts his finger on the spot, and at the same time shows how the trouble is to be avoided. "Since an infantry company cannot drag about a whole arsenal of defensive weapons for all purposes, stout opposition must be offered to too great specialization and over-construction, and all possible simplification must be striven for. This is possible only when the objects and performances of the weapons are not screwed up beyond the real needs of the troops and beyond what is feasible."

Psychotechnics and Its Military Significance, by Capt. Fechner. This is another of those hard words, forbidding or intriguing, as the case may be, the meaning of which is perhaps not evident at first sight. The word has been invented apparently to cover the utilization of applied psychology, or as a name for the science of the practical use of psychology. Hence psychotechnics—without its name—has been used as long as men have united in the prosecution of any undertaking, from exploration and the chase to industry and war, or as long as the selection of any man for a job to be done has depended to some extent upon a consideration of his mental characteristics.

Every-day examples are simple mental tests applied to would-be air pilots, girls wishing to become telephone switchboard operators, and candidates for Royal Navy cadetships.

The first example of the use of psychotechnics on a large scale was in 1917, when $1\frac{3}{4}$ million men in the United States were, in addition to their physical examination, subjected to certain psychical tests to ascertain both their fitness for the army then being raised for service in Europe, and the particular branch to which they should be posted.

These tests, owing to pressure of time, can only have been of the simplest nature, and yet the Americans said that the results were very good.

The Italians took up the idea, and documents relating to tests were found on Italian prisoners after the vast break-through of the Austrians and Germans at Caporetto. The matter was thus introduced to Germany, where it found a warm welcome, and according to Lieut.-Col. Rendulic, in his book *Military Psychological Studies*, the Germans even went so far as to attach psychological experts to the headquarters of the higher commands.

Capt. Fechner in pointing out what has been done already, and how much more may be done to improve and extend these tests, warns us that, precisely in respect to soldiers, psychotechnics has grave limitations, since two of the soldier's most important attributes, character and temperament, are things for which it is very difficult to devise tests.

Types of War Book. After recent "realistic" war books it does one good to read a book like Dr. Meyer's *Experiences of a Regimental Surgeon* (Lehmann's, paper covers, 2 mk. 40 pf.), in which one finds again belief, devotion, hope. These are what one misses in the writings of Mr. Remarque and those of his school—belief in something higher than the individual's small, treasured, self-seeking existence. The author gives us all the horrors, suffering and death, destruction and demoralization, human failure and discontent. He conceals nothing, gilds nothing over. Nevertheless, the war appears quite different from the pacifists' pictures. We experience it once again as a struggle between nations, in which the individual's will to live is subordinated in firm belief and willing devotion. We feel it as the finest and proudest time of the writer's life, when courage, self-sacrifice, faithful service, comradeship, were the pillars upon which one's whole attitude to life was supported.

F.A.I.

REVUE DU GÉNIE MILITAIRE.

(*May*, 1930.)—In an article called "Economic Work of the Engineers in 1930," an account is given of the military and civil works carried out by the troops of the *Génie* in 1929 under the following heads: Roads and Paths, Bridges, Railways, Transmission, Various.

For example, in August, 1929, a company of the 1st Regiment constructed at Bitche a metalled road one kilo in length, five metres wide, with berms and side ditches.

At the request of the Commune of Deluz, a forest road four metres wide was constructed in the Bois des Charbonniers, by part of the 3rd Battalion of the 1st Regiment.

In September, a detachment of two officers and 99 other ranks of the 6th Regiment was sent to the Department of Ille-et-Vilaine to restore communications, which had been damaged by a series of storms. Amongst other works, they constructed at La Richardais a bridge which included 27 m. of wooden trestles, and 31 m. of ferro-concrete piers.

At the request of a civilian landowner of Pacy-sur-Eure and with the approval of the General Commanding the 1st district, a small detachment constructed a pile bridge over an arm of the Eure.

In Algeria, the 51st Company of the 45th Battalion continued the construction of the railway to the Tunisian frontier.

In March, at the request of a civil contractor, a small detachment refloated an 80-ton dredger which had foundered in a dock at Strasbourg.

An article entitled "Defensive Inundations,"* by Captain Mandaroux, is of interest, in so far as it deals with the inundations in Belgium and Northern France during the War, 1914–18.

THE YSER INUNDATIONS.

The region between Steenstraete and Nieuport forms a polder, the average level of which is two to three metres below the level of high tide. The land is protected by the Nieuport dunes and by locks.

Drainage is assured by a system of canals converging at Nieuport at the mouth of the Yser, where the whole system is controlled by locks. By opening the locks at high tide and closing them at low tide, the sea can be made to flow up the drainage canals and spread over the soil, and can be maintained at a constant level throughout the inundated area.

On three occasions, namely, during the sieges of Nieuport in 1647, 1658 and 1740, resort was had to this method. Nevertheless, no plan existed in Belgium for effecting the inundations; on the other hand, the Germans in their offensive on Calais did not appear to realize the danger which might be caused thereby.

The inundations were carried out progressively, according to the pressure of the enemy advance.

On October 17th, the creek of Nieuwendamme, immediately east of Nieuport, where was the point of greatest danger, had been flooded, but the Germans did not regard this operation—a purely local one—in the light of a warning.

* See also *R.E. Journals* of December, 1928, and March, 1929.—Ed.

Before the continuation of the enemy advance, conferences were held at the Headquarters of the Belgian Army, and it was decided, on the advice of the engineer officers, to extend the inundation to the east of the Nieuport–Dixmude railway. Preparatory measures were undertaken on the evening of the 25th, namely, the blocking up of the aqueducts and culverts through the railway embankment. During the night October 27th/28th, engineer officers, assisted by pontoniers, opened the lock of the old Furnes Canal, and the sea began to cover the land. Three days later, on October 31st, the Germans were definitely stopped.

The success of the inundations was therefore the consequence of an ordered plan; but there was an element of chance, in that the operation coincided with the time of spring tides. Eight days earlier or later, it could not have been carried out in the limited period available, as the water would not have attained a sufficiently high level.

The inundation when effected had to be maintained and adapted to the situation. The level had to be adjusted according to military requirements, in particular during the attack on Lombaertzyde in November, 1914. Inundations had to be made to the south of Dixmude, and locks and dikes kept in repair. The railway embankment was breached on several occasions during the winter of 1914–15, and the Belgian frontier endangered. The lock of the Furnes Canal was broken by gunfire, and, after being repaired, finally gave way in 1916 under the effect of scour. It was then replaced by a dam further upstream.

To carry on all this work the Belgian H.Q. organized a Service of Inundations, which included a company of pontoniers (in which were men of special trades, such as divers), a survey branch, a workshop and transport. The principal duties of this service were as follows:—

Clearing the waterways to ensure the flow of water in the areas not inundated. Construction and fixing of automatic apparatus for the daily working of sluices. Protecting banks against scour. Construction of emergency works, in case of destruction by the enemy of locks or barrages on which the inundation depended. Accurate levelling of structures; organization of a system for taking readings at critical points; drawing up of a table of tides. All this entailed much work carried out for the most part in the front line, but assisted by the passivity of the enemy.

Action on the part of the Germans was very feeble up to 1917, when destruction by bombardment of banks and other works for retaining the waters was first carried out. The only action which would have proved decisive would have been the destruction by bombardment in October, 1914, of the railway embankment. Directly the waters began to spread to the north of the Nieuport-Dixmude railway, the inundations had fulfilled their strategic role; the march on Calais had been stopped.

Inundations on the Northern Frontier of France.

Contrary to what had occurred in Belgium, the possibility of forming inundations on the northern frontier of France had been envisaged previous to 1914. The end in view was the creation of an obstacle in the zone of defence of the strong places of this frontier. The plan, which had been revised on several occasions up to 1899, included:

1. An inundated area in the quadrilateral formed by Dunkirk, Bergues, Gravelines and Calais.

2. An area in the zone of Lille and Douai.

3. An area Scarpe-Escaut (Shelde) in the zone of Condé and the forts of Flines and Maulde.

The organization of these inundations was intimately connected with the defence of the works in the areas concerned; and whilst it was essential to allow for a level of water which would provide an obstacle of military value, care had to be taken to avoid the flooding of an area of excessive extent and difficult to supply, and especially to confine the flooding within the limits of the frontier, which was very near at certain points. Finally, protection by the various garrisons of those works which controlled the inundations had to be assured.

Arrangements in peace time carried out in conjunction with the *Ponts et Chaussées* included modifications to the locks and dikes of the canals; special works such as weirs, culverts, races and shafts, the provision of timber scantlings, piles, pumps, etc.

Works in war time included the construction of dams, channels for flooding, the upkeep of structures, and were carried out by local garrisons.

1. *District Dunkirk, Bergues, Calais, Gravelines.*

The formation of the inundations depended on the utilization of the area of the wateringues, the average level of which was one metre, traversed by the Aa, the canals for drainage towards the sea, and the canals of Haute-Colme and of Bergues which joined the basin of the Aa to that of the Yser. Utilization of the sea-water had been ruled out by a ministerial decision of 1899, except for the immediate defence of Dunkirk.

In arriving at the number and extent of the areas of inundation, consideration had to be given to the necessity for the water being deep enough to form an effective obstacle, and to the fact that the flooding should not encroach on Belgian territory. The use of sea-water being barred, supply had to be obtained: (*a*) from the Aa; (*b*) from rain-water and soakage water, available when the pumps and windmills ceased to pass it into the drainage canals. This latter method admitted of an extension of the inundated area especially below Bergues.

The actual works to be undertaken were:—(*a*) The fixing of the levels of the locks and dikes; in particular, the French portion of the dike of Grandes Moëres; (*b*) The raising of the water level of the canal of Basse-Colme; (*c*) Construction of dams to limit the zone of inundations in the region between Hondschoote and Houthem (nine kilos S.E. of Ypres).

For the execution of the work the Governor of Dunkirk was responsible. A delicate question was raised in connection with the protection of the locks of Wattendam, near Watten, situated outside the Dunkirk area. "These locks placed under the sole protection of the mobile troops, will swiftly fall into the hands of the enemy if the troops suffer an initial check, and the places which are protected by the inundations will very soon fail to benefit by them—just when they most require their assistance." (Report of General Carette, president of the Technical Committee of Engineers, March, 1903.)

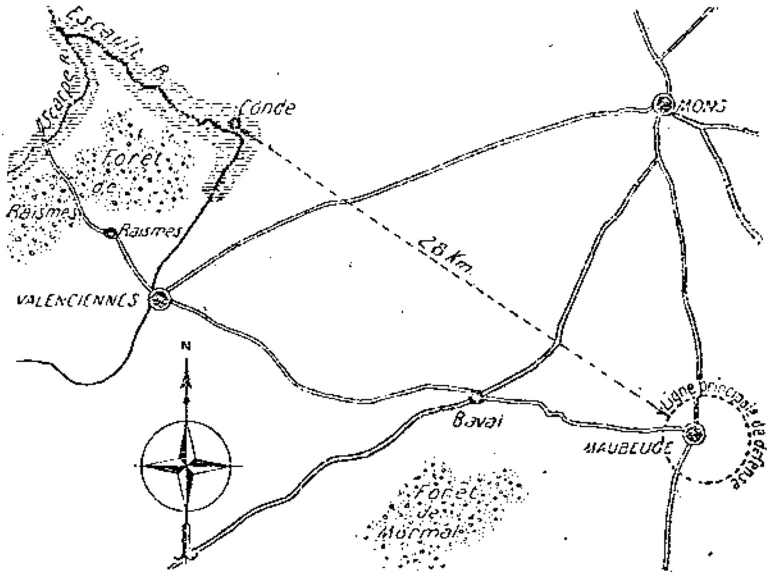
Thus, in respect of one lock arose the question of co-operation between garrisons of points and mobile troops; the solution had to wait till 1915, when Lille and Maubeuge were in the hands of the enemy.

2. *District Lille–Douai.*

The inundations of this area were limited to the flooding of the ditches of the fortress, to the flooding of the Deule in the area between Don and Wavrin, "without interrupting the navigation of the river."

3. *District of the Scarpe and Escaut* (Scheldė).

The supply to the different basins was assured by the Escaut, the Scarpe and their tributaries. Numerous dams and races had been constructed in peace time, others had been planned for mobilization so as not to hinder navigation.



Position Valenciennes-Maubeuge

Of these three systems of inundation, only that of Dunkirk-Bergues was effective during the War of 1914–18. Between August 5th and 25th, the Governor of Dunkirk had the works strengthened. On the latter date, flooding began with the Uxem basin and was continued till October 5th. The other basins were flooded in September and October, and the inundation was maintained till December, by which time Dunkirk was no longer in immediate danger.

With the German attacks in the spring of 1918 the question of inundation again arose. A note of G.H.Q. of April 12th, 1918, marked out for inundation the basin of Dunkirk-Bergues, reinforced by the area St. Omer. The flooding was carried out between April 12th and August 17th, but was very difficult to maintain on account of the dry weather. In the event of a break on the Belgian front the inundation of the area between the Nieuport-Dixmude railway and the Canal de Loo was contemplated.

Of the other systems of inundation on the northern frontier, that of Lille-Douai had only the value of a local obstacle easily surmountable. The same cannot be said of the system Scarpe-Escaut. One can imagine what assistance it would have brought to an army retreating from Mons towards the south-west, intending to establish itself between Valenciennes and the forest of Mormal with its right resting on Maubeuge, its left on the forest of Raismes covered by the inundations Scarpe-Escaut. But the armies operating in 1914 knew no more about the schemes for inundation than they did about the fortresses.

When studied in detail, the French schemes for inundations seem to rest on too narrow a general plan. It relegated them to the part of obstacles to the permanent fortification, whilst the field armies did not know of their existence and could not profit by them.

Such as they were, they could have been used to better purpose, with results comparable to those obtained by the system of Dunkirk, which on two occasions, in 1914 and 1918, played a role in the protection of Dunkirk and Calais similar to that of the inundations of the Yser.

A.H.B.

REVUE MILITAIRE FRANÇAISE.

(*April*, 1930.)—Général Lemoine completes "*En relisant Clausewitz*" in this number. Having already dealt with the various stages of war which go to make up war as a whole, he now deals with the complete plan to be made at the outbreak of war. The three plans, complete offensive, restricted offensive, and defensive, are considered in turn, and as an example, Clausewitz's solution to an attack on France by a European coalition is considered. The writer concludes with the opinion that, although modifications since 1830 have been many, Clausewitz's ideas can still be adapted to modern conditions.

Lieutenant-Colonel Vauthier completes his important article, "*La défense du pays contre le danger aérien*" in this number. He first discusses the organization of the defence, a complicated problem to which it is hard to see the correct solution. In Italy, the Chief of the General Staff has control over all methods of war, and naturally, air defence comes under him; but in countries like England, where the Air Ministry and War Office, to say nothing of the Admiralty, are co-equal, a solution similar to the Italian will not work. Lieutenant-Colonel Vauthier sets out very clearly the complexity of the problem and the efforts made in the various countries to deal with it. The writer then concludes by pointing out that no one defensive method can be effective by itself, and points out how many branches of life, civil as well as military, are concerned in air defence. There is no doubt that in the future, any country going to war, without adequate air defence, is asking for defeat.

In Commandant Loup's interesting article, "*La famille Musulmane au Maroc*," the outstanding features of a Mohammedan family, as applied to marriage, birth and death, are described. The Mohammedan differs from the Christian in that the man is absolutely pre-eminent in his family, while the women are regarded purely as bearers of children, and otherwise of little account. Commandant Loup indicates the life of women in the various tribes of French Morocco, and describes the religious part of birth and death, as governed by the Koran.

Colonel Revol completes "*Initiation au voyage militaire des Alpes*," with a description of the systems of fortification built during history, and of the offensive and defensive operations fought up to the time of Napoleon, who wrote the following: "In the mountains, one finds everywhere a number of positions which are extremely strong and appear impregnable. The genius of making war in this country is to occupy positions on the flank or in rear of those of the enemy. Thus he only has two alternatives, either to retire without fighting or to attack." This lesson is so true that it should always be remembered. At the same time one must realize that special training is required for mountain warfare, and Colonel Revol concludes his article by stating that the country must be organized while the troops and the leaders are trained.

Lieutenant-Colonel Pugens completes "*Rossignol*" in this number. By the end of the action the Germans had been completely successful near Neufchâteau, in spite of a most valiant resistance by the French. The description of the fighting is not particularly interesting, but the writer has some useful comments to make. Although the German information was inadequate, the units were well trained to come into a battle formation quickly and to obtain information before becoming involved. They were also well trained for fighting in the woods. The French, however, showed a fatal tendency for attacking into pocket-holes from whence they were unable to escape. In fact, as pointed out by Lieutenant-Colonel Pugens, once the two forces become involved, it it is the lower commanders and troops who succeed or fail, and these must be well trained in peace or they will fail in war.

(*May*, 1930.)—Lieutenant-Colonel De Boisboissel begins "*Les opérations au Maroc*" in this number. This is a most interesting article, dealing with conditions which correspond enough with those of our own N.W. Frontier to make it worth study by British officers. This instalment deals with the enemy and with the efficiency of the various arms. The writer points out at the beginning that, in Morocco, the enemy of to-day is the friend of to-morrow, and therefore he must be defeated but not crushed. This particularly affects the use of artillery for general bombardment, and we may compare the use of our own aircraft in India. The writer then considers the work of the various arms, and it is interesting to find that he does not regard tanks as an unmixed blessing. In fact, certain parts of the country are so difficult that the presence of tanks rather delays than accelerates the infantry, who have the hardest work, as usual. Colonel De Boisboissel finishes with a short description of the various local levies, which again may be compared with our Khassadars on the N.W. frontier.

In "*La motorisation dans l'armée des Etats-Unis de l'Amérique*," Capitaine Cammas begins with a very short description of mechanization in England, followed by an indication of the different types of mechanical vehicles in the American Army. As he points out, both England and America, being industrialized countries with small professional armies, have naturally turned to mechanization for the improvement of their armies. In this instalment, the writer merely explains what types of vehicles, armoured or otherwise, are used in America, after describing how our own Armoured Force was formed.

In Lieutenant-Colonel Morin's "*De l'utilité de la fortification permanente*," the value of the fortifications of N.E. France is clearly set out. Colonel Morin is evidently a believer in permanent fortification, and he certainly does explain how the big fortresses both provided bases for operations for the French and also affected the German strategy. The great attack on Verdun was carried out on account of its value to France, while the original German plan of operations was partly caused by the forts covering the Belgian frontier having been neglected. It is probably generally realized that fortifications, if properly designed, will always be of value in trench warfare, but Colonel Morin considers that under all conditions, these fortifications, owing both to their material resistance and to their moral effect, will always be of great importance.

"*Guerre de mouvement et ravitaillement*," by Intendant militaire Chaumont, is a discussion of the method of supply to be employed in mobile warfare in the future. As the writer points out, supply was comparatively easy during the Great War, owing to its stationary character in the west, but in future we cannot anticipate a continuation of trench warfare. Without going into any details, the solution suggested is that the supply units of each division should be partly horsed and partly mechanized, so as to be able to work in any country, while a reserve on wheels should be provided for divisions in case of emergency. The composition of this reserve is not discussed in this article, but its provision is put forward as providing the best type of reserve for contingencies which are bound to arise in war.

Capitaine Tourret begins an interesting article, entitled "*L'armée espagnole du Maroc*," in this number. He first describes the country briefly, and then the early stages of conquest of Morocco by the Spaniards, four or five hundred years ago. The rest of this instalment touches briefly on the recent disturbances, culminating in Abd-el-Krim's revolt, which was finally defeated by the French and Spanish after an agreement between the two countries in 1925. Capitaine Tourret concludes the instalment with a short description of the vast effort required by Spain to maintain the necessary troops in Morocco.

(*June*, 1930.)—"*Du caractère*," by Commandant de Gaulle, appears in this number. The article is based on the theme that the French Army cannot live just by a prudent attention to the situation at any time, but that its leaders must have the character to act in defiance of orders when necessary. He quotes Lord Fisher's remark after Jutland about Lord Jellicoe: "He has all Nelson's qualities except one: he cannot disobey." We all know that there are occasions when something more than obedience is required, and Commandant de Gaulle writes to draw attention to the determined spirit of men like Napoleon, who did not obey rules, but who brought the French Army to its highest pitch of enthusiasm and efficiency.

Lieutenant-Colonel de Boisboissel continues "*Les opérations au Maroc*" by describing the action of mobile columns, the establishment of posts, and the construction of roads or tracks. It is interesting for us to compare our own operations on the N.W. frontier of India, as there is a similarity throughout. The French favour a mobile column based on six battalions, which is neither too weak nor too strong, and which can carry out extensive operations. The writer describes the various stages of operations by these columns, and each stage has its counterpart in India. He then goes on to posts, and their construction in this wild and desolate country, and one of the first things mentioned is that the post must be enclosed by a stone wall, just as in India. He finally touches on the construction of roads and tracks, based on a careful reconnaissance. To us it seems possible that the provision of good roads may have the same pacific effect in Morocco as it has had in Waziristan.

Capitaine Cammas completes "*La motorisation dans l'armée des Etats-Unis*" in this number. A series of manœuvres carried out by completely mechanized units are described, and the writer then goes on to indicate the progress of mechanization in the various arms. Capitaine Cammas' conclusions are of interest to the Englishman, as he generally compares mechanization in the British and American Armies. Both countries are the only ones to attempt manœuvres with purely mechanized units, but the writer points out that in England we are ahead of the Americans. The General Staff at our War Office has issued provisional regulations on the use of armoured vehicles, while this has not yet been done across the Atlantic. Again, Great Britain is ahead of the United States in considering complete armoured brigades, rather than infantry brigades put into mechanized transport. There is no doubt that, owing to their own types of army, these two countries are bound to take the lead in mechanization.

"*La Ire Armée française à la bataille de la Serre,*" by Commandant Thierry d'Argenlieu, is a description of one of the operations which helped to make up the great advance of the Allies in the autumn of 1918. General Débeney's 1st Army, on the right of the British, naturally was of particular importance to us; but the description given is of little interest except to someone who was actually taking part or who knows the country. The article is illustrated by three maps.

Capitaine Tourret completes "*L'armée espagnole au Maroc*" in this number. A considerable part of the instalment is devoted to a description of the actual organization of the Spanish forces in Morocco, but the writer's conclusions are of interest. From 8,000 troops before the rebellion, the forces employed rose to no less than 160,000, and are now as much as 75,000. Capitaine Tourret pays a well-deserved tribute to the efforts made, both economic as well as military, to pacify the country, and he looks hopefully towards the future in Spanish Morocco.

H.A.J.P.

THE MILITARY ENGINEER.

(*July–August*, 1930.)—Major William M. Robinson, jun., contributes an interesting historical article on "The Confederate Engineers." We learn with malicious satisfaction that "the engineers were not mentioned in the General Staff Act of 1861," and that the first two Acts for raising volunteer forces omitted the Engineers entirely; they only became "permissible"—(what a concession!)—under the terms of the third Act. We rub our eyes and wonder if we are really reading about the crisis of 1861, or if we are merely listening-in to the hatching of a tactical exercise in 1930. "I suppose we had better put in some Engineers . . . not too many of course . . . goodness knows what they are going to do. . . ."

However, the Corps was recognized at last, and was given an establishment of ten officers and one Company. It seems that the officers did not form part of the Company, which was organized strictly for work. Thus, the sergeants were called *master workmen* and the corporals *overseers;* the privates of the first class were called *artificers* and those of the second class *labourers.* Two musicians were included, but in the absence of the appropriate G 1098 we cannot tell how they were equipped, nor do we know whether they were men of the first class or merely labourers.

A "Sapper and Bombardier Company" was next formed, thus raising the proportion of Engineers in the field army to one per cent. Small wonder that, in December, the Secretary of War complained of the paucity of Engineer troops. Congress accordingly proceeded to consider a Bill for raising four battalions of pontoniers, but did not succeed in passing it. In March, 1863, however, they authorized one Engineer company per division, and the comment is made that in so doing they had acted with "all reasonable promptitude."

An interesting exchange of opinions took place on the subject of forming the Divisional Engineer Companies into regiments. General Lee admitted the value of Engineer troops, but maintained that, by keeping them together by battalions and regiments, the Divisional Company would never be on hand when the Division needed it. To this Secretary James A. Seddon replied:—

"Is this objection well founded? In order to give dignity to the service, as well as *esprit de corps* to officers and men, will it not be eminently proper, whenever the army is in camp for any length of time, and no immediate movement or attack anticipated, that the companies should be brought together regimentally? It seems to me it is only thus that the field officers can have sufficient control and influence; only thus in great emergencies, that these troops can be made to act harmoniously together in large numbers, and that they can ever be of service as armed soldiers.

"If they are to be kept simply and always in company organizations, subject exclusively to the orders of the Major-General commanding the division, the probability is great that they will rapidly degenerate into mere drudges, scarcely better than camp-followers, to be employed in menial service, burying the dead, etc. As a natural consequence, the better class of officers (and great efforts have been made to secure efficient and accomplished ones) will soon resign, rather than be attached to a non-fighting corps of very mediocre reputation."

The Corps acquitted itself with distinction, and many of its members attained high rank as general officers.

Captain Kohloss gives an account of searchlight development, and describes the latest mobile unit, known as Model M-VI 1930. A truck type of power-plant chassis is provided, which carried the searchlight, comparator and crew, and tows the sound-locator and its detachment.

Among the articles which deal with Civil Engineering, there is an account of the laying of asphaltic-concrete roads in aviation camps, where the prevailing low temperature precluded the use of concrete or water-bound macadam.

The " Mammoth Saluda Dam " is an example of the semi-hydraulic fill type of dam, that is, one formed of two dry outer walls and a core of sluiced clay. Full details are given of the power plant and the article is well illustrated by photographs.

In an editorial review of the Indian situation, the problem of India is referred to as a world-problem. Later, however, the view is expressed that " we cannot criticize a colonial Power intent on retaining what it considers as its own. . . . One must admire the forbearance and adroitness with which the British are handling an exceedingly delicate problem, although this might have been expected from a people who have so uniformly demonstrated such wonderful efficiency as colonizers."

O si sic omnes!

I.S.O.P.

CORRESPONDENCE.

ENGINEER TRAINING IN NEW ZEALAND.

A CORRESPONDENT, Major W. A. Gray, of the N.Z.E., has kindly forwarded the following notes and photographs reproduced herewith :—

" This year, the Northern Depot, N.Z. Engineers, carried out their six days' annual camp at Ngaruawahia with a strength of 10 officers, 35 N.C.O.s and 160 men.

" The nearest waterway is the Waikato River, which, in this locality, is two hundred yards wide, up to twenty feet deep, with a current of three–four knots.

" The main bridging exercise was the construction of a flying bridge, composed of a pontoon raft, swinging on a cable which was anchored some 600 yards upstream.

" The accompanying photographs show the bridge in operation during the inspection of the unit by Major-General R. Young, G.O.C. N.Z. Military Forces.

" The average rate of movement of the raft was three minutes from stage to stage, the speed being greatly increased by the addition of a lee-board.

" The river work was made easier by an improvised motor-boat ; an 8-h.p. outboard motor on a stern bracket was added to a standard old-pattern pontoon. Unloaded, an average speed of 11 knots was obtained, and the craft handled well in all conditions. The maximum load carried was 22 men.

"An assault-bridging night operation was carried out, enlivened by smoke, guncotton 'shell-bursts,' blank ammunition, and Very lights. Apart from the training value, the affair was a real 'Brock's benefit' for the local inhabitants.

"The normal training in demolitions, use of spars, entrenching, etc., was also carried out."

Another letter on this subject has been received from Lieut. E. C. Schnackenberg, N.Z.E., who writes:

Onehunga, Auckland, New Zealand,
5-4-30.

DEAR SIR,

* * * * * *

"I have been away from home for the past seven weeks at Trentham Military Camp. I was one of those four lucky Territorial officers who, together with five N.Z.S.C. officers, were chosen to take to Samoa 250 men of the Samoa Military Police. However, after five weeks' training at Trentham, we were demobilized.

"We had a very successful Depot Camp this year. Our most interesting job was the erecting of a flying bridge across the Waikato. The river was 250 yards wide, about 20 feet deep, and had a 5-knot current on one side. We were helped by motor launch, made by fitting a 7 h.p. Elts outboard on a wooden bracket at the stern of a wooden pontoon. We got about 8 knots out of the craft, and travelled about 50 miles during the course of the camp."

SCIENTIFIC SOLDIERSHIP.

The Editor, The *R.E. Journal.*

DEAR SIR,

Some time ago you allowed me, through the medium of your pages, to put some questions to Brigadier Fuller on an article by him entitled "Scientific Soldiership," drawing attention to flaws in his reasoning which appeared to me to upset the conclusions he arrived at.

Theories, similar to those on which that article was based, are expounded in the paper entitled "The problem of the Last 800 yards," printed in your last number, and as similar flaws reappear in this, and seem also to permeate nearly all current literature on the subject of armoured warfare, I hope you will once more accord me the hospitality of your columns to draw attention to them.

Brigadier Fuller says (page 207), "above all we want a mobile force," and a little earlier he asks, "how can we resuscitate the mobility of infantry?" He replies, "tactically by armour . . . armour is the enemy of the bullet." Unfortunately armour is also the enemy of mobility, although he omits to say so, and the omission is significant in his argument.

He goes on to say, "half an inch (of armour) is what we want. It

Raft loaded with Staff, half-limber, and superstructure for far landing bay at near stage.

The completed raft for swinging, with lee board. C.O., padre (in cap), and Coy. Mascot.

Assault Bridging—built locally. Site of night operation.

Engineer training in New Zealand

Half-limber being lifted off for stage on to road—which was cut into hill on edge of river. Colonel Duigan (C.S.O., Northern Command), and Captain Clifton (Adjutant), in centre.

The motor-boat (improvised locally). An 8 h.p. "Johnson" on a 14" stern bracket bolted to stern of pontoon. Did 15 knots with, and 9 against, current, as loaded here. Controls brought to wheel in stern.

The motor boat

may not keep out the heavy bullet or shell, but this is not the immediate problem. . . ."

Unfortunately, if it is not the immediate problem, it is certainly the only one of any interest to the soldier, for otherwise we are left considering the action of tanks against an enemy who can neither run away from, nor injure them. Under such conditions no one will disagree with Brigadier Fuller that tactics will degenerate into mere "hunting the enemy," but we should lose interest in them.

Brigadier Fuller, however, himself contradicts his statement when he says later, "if frontal fire is too strong, they (*i.e.*, the tanks) swing to a flank." Here obviously he is considering the fire of "heavy bullets and shells," for fire consisting only of bullets which will not penetrate the tank's armour can hardly be called "too strong."

Any fire which is too strong for a frontal attack must surely be too strong also for the "swing to a flank." If tanks can escape the consequences of a too rash advance by such tactics, cavalry should have been able to do so also. He adds that they will "draw fire and deliver fire," and help the infantry to advance thereby, but as the only fire they are likely to draw is that of the anti-tank armament, and the fire they deliver has to be aimed at an enemy about which Brigadier Fuller has just said "all they know is the area from which fire is coming," it takes rather more than an optimist to believe that their action will produce the effect he expects.

In short, Brigadier Fuller suggests that if only a man will get into a tank, where he will be well warmed and shaken up and has only a small slit in an armoured plate to look through, he will see better and shoot straighter than an infantry soldier at targets which, as he himself says, "the infantry themselves can seldom see."

The argument is characteristic of many adduced in support of armoured warfare in its assumption that even if the enemy takes the elementary precaution of providing himself with anti-tank weapons, he will exhibit no skill whatever in their use. As Lieutenant-Colonel Baird-Smith says in the *R.U.S.I. Journal* (May, 1930, "Theory and Practice of Mechanization"), "there is hardly a limit to what an armoured force might be conceived as accomplishing given a sufficiently stupid enemy."

As to the "Problem of the Last 800 Yards," Brigadier Fuller asks if reliance can be placed on the artillery, and says that the answer is "obviously no." This answer is by no means obvious. Indeed, if the experience of the Great War is to be believed, the answer should be "certainly yes." At any rate, it can be stated as a fact that eventually the artillery succeeded in solving the problem in the last War. It is possible that if they were given the chance they might do so in the next. How they should do it is, as Mr. Kipling says, "another story."

Yours, etc.,
M. N. MacLeod.

25th June, 1930.

the latter Officer having hurt his hand, had competed for the Thames Cup at Henley Regatta, but unsuccessfully—although the performance of the Royal Engineers has been very satisfactory.

The start was fixed to take place as soon after noon as possible, and at a few minutes before that hour the Umpire's Boat took up her position in rear of the starting point, having on board in addition to the Umpire, Mr. W. Benson the President of the Oxford University Boat Club, Field Marshall Sir J. Burgoyne, Bart., G.C.B., R.E., Major-General Sir L. Simmons, K.C.B., R.E., Major-General Gambier, C.B., D.A.G., R.A., Major-General Brownrigg, C.B., Col. Hnble. H. F. Keane, D.A.G., R.E., Col. Herbert, C.B., A.A.G., Col. Gallwey, R.E., Mr. Woodgate, Mr. Wood, and about 20 others. Two other Steamers having on board over 200 Officers of the Corps with their friends followed the Race.

At 20 minutes past 12 the rival Crews paddled down to their Stations, the Royal Artillery who had won the toss selecting the outside berth. Mr. Searle officiated as Starter and after asking the usual preliminary question, without receiving any response dismissed them on level terms at the first attempt. Directly the signal was given the Gunners dashed away at a tremendous pace, rowing something like 47 strokes to their opponents' 39 and at once showed with a lead of a few feet which they increased to a third of a length half-way between Simmonds's and the London Boat House. The pace, however, was too hot to last and just above Bishop's Creek the Sappers, rowing a long steady stroke, came up to the leaders, and after rowing oar and oar for about a dozen strokes drew out hand over hand showing a clear lead just above the point. Between this and the Crab Tree they increased their advantage by another length and at the Soap Works point were fully two lengths to the good. At Hammersmith Bridge which was reached in 7 min. 58 sec., from the start the Royal Engineers had placed upwards of three lengths to their credit and were rowing well within themselves, while the Royal Artillery were all abroad and rowing wildly and the race was to all intents and purposes over. At the Doves the Coxswain of the R.E. Boat for some inexplicable reason took them right over towards the Chiswick bank which enabled the others to draw up nearly a length.

The error was however of no moment as the Gunners were at this point utterly incapable of making an effort while their opponents were to all appearance as fresh as when they started.

Half-way up the Eyot the R.E.s spurted and coming right away landed themselves easy winners by three good lengths which but for the faulty course between Hammersmith and the finish might have been doubled. The time from start to finish was 12 min. 49 sec.

SHELTER TRENCHES.

A shelter-trench is an excavation in a continuous line (earth thrown to the front) whereby hasty temporary shelter is provided for troops in line, and as such it comes under the heading of "Temporary Field Fortification." Fortification may be defined as the art of protecting combatants while preserving their fighting powers, and thus, by lessening their adversaries' power of inflicting injury, it strengthens or fortifies that side which employs it. * * * * * * *

By the introduction of the breech-loading rifle, the shelter trench has acquired much greater importance, since, with that arm, the soldier (while himself protected) can load and fire without betraying himself by any motion; and, while keeping his rifle steadily resting on the parapet, he can (if it be a Martini-Henry) load and fire at the rate of twenty to twenty-five rounds a minute if rapidity be required, or with deliberate aiming, he can attain great accuracy up to 1,200 yards. * *

The form of trench approved by the Drill Committee is 15 inches deep, 2 feet wide, with a parapet about 15 inches high. This will screen two ranks from sight—one in the trench and one lying behind. It will also, to a great extent, as already stated, protect them from fire. It can be made in from ten to twenty minutes, according to the nature of the soil, or, if more time be available, it may be widened to four feet in from ten to twenty minutes more, or to seven feet with a total labour of from thirty to sixty minutes. This trench offers no obstacle to troops advancing, and is, therefore, available when they are required to act on the offensive. Skirmishers' shelter-pits can be made in much less time, from two to four minutes being sufficient to obtain cover for one man lying on his side ready to fire or to crouch down, the pit being cut not more than two feet three inches broad in front and 1 foot 3 inches in rear, so as to just fit the body and legs of the skirmisher. * * *

It is obvious that the introduction of this system into European Armies will produce a complete revolution in the tactics of future warfare; yet, if we consider the matter, we shall find that it will necessitate less change in our own method of fighting than in that of Continental nations. This arises from two causes—firstly; that, as our troops are accustomed to fight in line, there will be no change of formation required in advancing from a line of trench, as will be the case with troops trained to attack in column; and again for us there will be nothing unusual in receiving a charge in line. In fact, the line being our order of battle, our troops are at once ready to advance or retire from their temporary cover without previous concentration or deployment. Another reason for our troops adapting themselves readily to the shelter-trench system is to be found in the fact that their temperament and discipline disposes them to excel in that system of tactics adopted by the Duke of Wellington, called by the French, "*La defense avec retour offensif.*" Acting on this system, the Duke was in the habit of keeping his troops as far as possible under cover behind the crest of a ridge, a hedge, or any other natural cover that might be available; then to allow the enemy's columns to approach pretty close—pour in rapid fire (*feu d'enfer*), and, when the columns get disorganized, charge them with the bayonet. These were precisely the tactics of Picton's division against the grand left central attack of the three French columns at Waterloo, where he received them with Krempt's Brigade drawn up in line behind the hedge along the Wavre road. After firing a volley the brigade charged, but were disordered in getting through the hedge (especially the 79th Highlanders, who suffered severely), and here Picton was killed. Now these, the tactics of our greatest general, will be the tactics of the future, but our troops must be trained not merely to take advantage of natural cover, but to supplement it by artificial cover, taking care always that when offensive movements are contemplated they should neither choose nor create cover giving obstacles to their advance.

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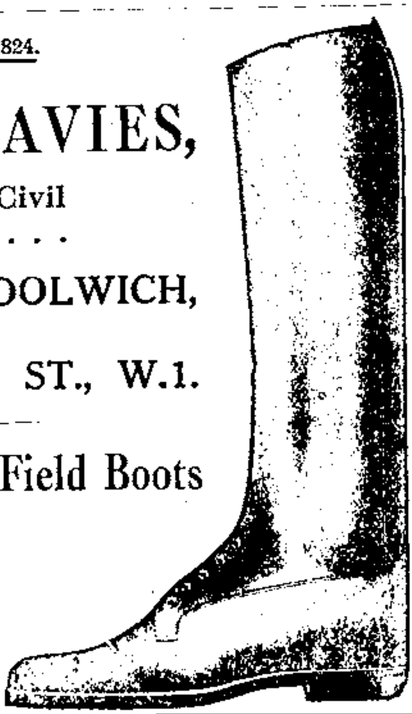

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COOMBE HOUSE, CROYDON.

R.E. OFFICERS are reminded that they and their dependents may be received at Coombe House as guests when they are in need of a rest or change. It offers a haven for a time to officers when retiring or going on half pay, or while looking for a permanent home on returning from abroad.

The house and grounds are delightful. Those who have been there have greatly appreciated them, and all the arrangements made for their comfort by the retired officer and his wife whose hospitality has prompted the scheme.

It may be desirable to state once again the few conditions which apply to Coombe House.

(1) Guests are not expected to contribute in any way.

(2) The maximum duration of a visit is 28 days.

(3) R.E. officers on the active and retired lists, their families (with the exception of children under 16), and the widows of R.E. officers are invited.

(4) Those who wish to go to Coombe House during a period of convalescence must have reached such a stage of recovery that they are able to return to normal diet, and do not require meals brought to their rooms.

The accommodation limits the number of guests to four at one time. With this limit it is necessary at times to arrange for selection among applicants, and adjustment of the dates for visits. The responsibility for these arrangements rests with the R.E. Corps Committee. Applications should therefore be made to the Secretary of that Committee in person, by telephone, or by letter. The address is Room 231, War Office, and the telephone number Victoria 9400, Extension 467. No particulars are normally asked of applicants, other than the dates which would be most convenient to them for their visits. Applications are, of course, treated as confidential.

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THE
ROYAL ENGINEER JOURNAL.
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AUGUST 1st, 1870.

AQUATICS.

ROYAL ARTILLERY *v.* ROYAL ENGINEERS.

On Monday, July 11th, the second of what will, it is hoped, prove to be a series of Annual Eight-oared Matches between the Officers of the sister Corps, took place at Putney, the course being from opposite Putney Pier to a Flag-boat moored about 100 yards above Chiswick Eyot. As will be seen by the following account of the Race the Sappers have on this occasion retrieved the laurels which they lost last year—with a few to spare—and this fact is, they feel, principally owing to the great care and attention of Mr. W. W. Wood, of University College, Oxford, who kindly undertook and ably performed the onerous task of coaching the Crew into something like good form, and whose labours have on this occasion resulted in the Corps being able to turn out a very creditable representative Crew. It is right here to mention that whenever Mr. Wood was prevented from attending, his place was filled by either Mr. Darbishire, Mr. Chambers, or Mr. Hall to each and all of whom the thanks of the Corps are due, and we may add were paid by that Officer of all others whom the Corps would wish to be their Spokesman, and whose thanks would be considered the most valuable—we mean Field Marshall Sir J. Burgoyne, who was, to the delight of all present, on board the Umpire's Boat during the Race, and who evinced the greatest possible interest in the proceedings throughout.

The Royal Artillery were as last year coached by Mr. W. B. Woodgate. The following are the names and weights of the two Crews—

ROYAL ENGINEERS.

		st.	lb
1	W. W. B. Whiteford	11	4½
2	C. Hoskyns	11	7
3	W. W. Darby	11	1
4	J. C. Barker	11	7½
5	A. Bogle	12	1
6	C. H. Brookes	11	10
7	A. F. Preston	11	13
	J. F. Brown (stroke)	11	5
	H. W. Clarke (Cox)	8	10

ROYAL ARTILLERY.

		st.	lb.
1	H. N. Jones	10	10
2	J. K. Trotter	10	11½
3	A. Logan	11	6
4	J. V. Baker	12	0
5	H. E. Preston	12	8
6	C. Le Mesurier	11	0
7	C. Larcom	12	0
	F. A. Aylmer (stroke)	10	5
	C. Jones (Cox)	8	12

The above Crews with the exception of Captain Le Mesurier, who at the eleventh hour took the place of Mr. Eustace Malpert on account of