THE ROYAL ENGINEERS JOURNAL.

Vol. XXXIV. No. 4. OCTOBER, 1921.

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THE INSTITUTION OF ROYAL ENGINEERS.

All communications for the Institution should be addressed to :—

The Secretary,
The Institution of Royal Engineers,
Chatham.

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 [2075—1. 10. 21].

MONTGOMERIE PRIZE.

CONDITIONS.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the Council of The Institution of Royal Engineers in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. From the beginning of 1920 it has been decided that the Prize shall be confined to Officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions:—

(*a*). Descriptions of works actually carried out in peace or war
(*b*). Inventions.
(*c*). Design (excluding works of defence).
(*d*). Labour organization on work.
(*e*). Scientific investigations generally.
(*f*). Accounts of exploration work and surveys.

THE R.E. KITCHENER SCHOLARSHIPS FUND.

THE original recommendation of the Education Sub-Committee of the General Committee of the R.E. War Memorial for the institution of this fund was stated in the following words:—

"They recommend that a sum of £2,000 shall be put aside from the "capital to form the nucleus of a permanent fund from the interest on "which Scholarships shall be given annually as a perpetual Memorial to "our Comrades who fell in the Great War, and of the part borne by the "R.E. in the War. It is hoped that this permanent Fund may be "increased by special gifts as time goes on."

This permanent Fund has now been established and subscriptions and donations to the R.E. Kitchener Scholarships Fund may be sent at any time to the Secretary, The Institution of Royal Engineers, Chatham.

ERRATA.

Page 154, line 40, *for* Tarn *read* Zam.

Page 159, line 39, *for* section *read* feature.

Page 160, line 25, *for* Clinai *read* Chirai.

Page 163, line 5, *for* cause *read* source.

Page 164, line 26, *for* had formed *read* bed forms.

Page 164, line 34, *for* Nutter's *read* Kutter's.

A FRONTIER MOTOR ROAD.

By MAJOR A. H. BELL, O.B.E., D.S.O., R.E.

"LORD Montagu of Beaulieu on Tuesday in the House of Lords asked for information about the North West Frontier, which is still disturbed. He urged the Government to improve the roads and to extend the railways, so that by the use of motor and rail transport the garrisons might be more easily supplied than they are now when long and unwieldy camel caravans invite attack from raiders."

The above appeared in a well-known periodical a few weeks ago. No one will dispute the aptness of Lord Montagu's remarks, except perhaps the Finance Member of the Government of India.

About six years ago it was recognized that there were better ways of moving supplies from one place to another on the Indian Frontier than on the backs of camels or mules or in two-wheeled carts drawn by oxen. It is true that the camel or mule does not require an elaborate road and can walk through shallow streams, but the normal pace of a camel, which is the primary means of transport on the Frontier, is only two to three miles an hour, his useful load is 400 pounds, and his normal day's journey is about fifteen miles. The camel and his attendant require food which has to be carried. The Army Transport cart carries 800 pounds, the two animals that draw it and their driver require food, and the pace at which it travels is about the same as that of the camel.

The humble motor vehicle known on the Frontier as a Ford vanette weighs unloaded 13 cwt.; its useful load is 800 pounds; it is driven by one man; it can carry its load 40 miles or so and come back the same day. It requires a track of some kind, but not a very elaborate one. It is not far wrong to say that a Ford vanette can carry double the load a camel can, five times as far, and return to its starting point the same day. On this basis it may be said that for transport purposes a Ford vanette is worth 10 camels.

Apart from considerations of transport capacity motor vehicles on the Frontier have other obvious advantages over four-footed animals. The motor vehicle is by reason of its speed less vulnerable

and less likely to be disabled. A Pathan would have some difficulty in starting up and driving off a motor vehicle at night, but appears to have none whatever in stealing half a dozen camels from inside a barbed-wire enclosure. The weight of stores required to keep a motor vehicle on the road must be far less than the weight of food for the equivalent number of camels.

The policy of making roads for mechanical transport in the North West Frontier Province from railhead towards the Durand line is now a well-established one, and a programme exists which will take many years to complete.

For nearly three years I was concerned in the making of one such road, and possibly a short description of the work may be of interest not only to the R.E. officers who in the hot weather of 1897 took three days to perform a journey which can now be performed in less than half that number of hours, but also to others who would appreciate a job more interesting than that which usually falls to the lot of the D.O. in the British Service.

One of the recognized routes between India and Afghanistan is that which begins in the Tochi Valley. The country at the source of the Tochi is unsurveyed and the river is there shown in the map by dotted lines. Probably no European has ever been to Afghanistan by this route.

In neither the first nor second Afghan Wars was the Tochi Valley used as a line of advance into Afghanistan. For all that the motor road which now starts from Bannu may one day be continued beyond its present head at Dardoni and end up at Ghazni.

The Tochi Valley first became of interest to the British Empire when Bannu was occupied after the Sikh wars. The house John Nicholson lived in is still the Deputy Commissioner's bungalow, and a man who was John Nicholson's bearer died only a few months ago.

Bannu stands on the right bank of the Kurram River at a point about eight miles from the Tochi. It is about 50 miles due west of Mari Indus, which is at the railhead on the left bank of the Indus. A steam ferry plies between Mari Indus and Kalabagh opposite to it on the right bank. From Kalabagh a narrow-gauge railway-line runs to Bannu, but not in a straight line; it describes roughly speaking a semicircular route eighty-six miles long before it reaches Bannu; at the most southern point of the semicircle is Lakhi Marwat, from which a branch goes south-west to Tank, the starting point for two other frontier roads, one up the Tank Tarn into Mahsud country and one up the Gumal, another route into Afghanistan and one much used by nomad frontier tribes.

This narrow-gauge line which connects Kalabagh with Bannu and Tank, was finished about the end of 1915. (Previous to that Bannu was reached by seventy-eight miles of road from Kohat).

Like many other things in India it was constructed cheaply rather than efficiently. It does not afford a reliable means of communication. As a matter of course every August certain portions of it were washed away. In 1919 I walked over three miles of country smooth as the sea shore. The railway-line was lying twisted and bent a few yards away and broken lumps of brickwork and stray girders bore witness to the bridges and culverts which had once been there.

A railway-bridge at Kalabagh over the Indus was begun last year, and when a broad-gauge line has replaced the narrow-gauge, communication between the Tochi Valley and India will be easy.

For many years after Bannu was first occupied British influence was not felt in the Tochi Valley. In 1872 a punitive expedition was carried out against the people, called Dawars, who inhabit the lower Tochi Valley. It comprised about 2,000 men of six different units and two howitzers. The column went about 30 miles from Bannu up the valley and the operations were all over in two days. It is recorded that ammunition wagons as well as the howitzers accompanied the column, so it must be supposed that some sort of road for wheeled traffic was made, probably a clearing up the river bed.

In 1894 and 1895 in the operations against the Mahsuds, whose country, roughly speaking, lies between the Tochi and Gumal Valleys, the Tochi Valley was one of the lines of advance. These operations were the outcome of an attack by Mahsuds on the British camp at Wana.

In 1895 the lower Tochi Valley was practically annexed by the Government, and a military force was established at Miranshah, thirty-nine miles from Bannu, with posts at Idak and Saidgi, twenty-seven and fourteen miles from Bannu respectively. Saidgi was the first stage, Idak the second and Miranshah the third stage on the road up the Tochi. In the autumn of 1896 civil and military headquarters were moved to Datta Khel, which is 25 miles beyond Miranshah.

On June 10th, 1897, occurred the treacherous affair at Maizar, from which incident arose the Tochi expedition in the hot weather of 1898.

The intermediate stage between Miranshah and Datta Khel is at Boya, at which point the track crosses the Tochi River. Normally a shallow stream whose waters are fed from the snows of Afghanistan, in times of heavy rain it becomes a mighty torrent impassable sometimes for days together.

A military force remained in the Tochi until the Northern Waziristan Militia took over the guardianship of that part of the frontier

about 1891. Militia Posts were built at intervals along the Tochi Valley between Bannu and Datta Khel, the first being a small block-house at Marzail, nine miles from Bannu near the boundary line of the North West Frontier Province.

In 1901 and 1902 columns again operated in the Tochi against the Mahsuds.

In 1915 a military force was sent to Miranshah to repel an army of tribesmen which entered the Tochi Valley from the district of Afghanistan called Khost, which forms a salient in the eastern boundary of that country north of the Tochi. A battle in which the slaughter was greater than is usual in frontier warfare was fought near a village called Dardoni, and the remainder of the tribesmen quickly returned to Khost. The military force remained at Miranshah and settled down in an unhealthy camp made under the walls of the militia post. This camp was in 1918 replaced by a more commodious and sanitary one on the plain a mile beyond the post and is known as Dardoni. It is now provided with electric light and fans, a piped water-supply and an ice factory, in fact with all the luxuries which one can reasonably expect outside British India.

In 1917 took place the fifth organized expedition against the Mahsuds, the main operations were conducted from Tank, but the force at Miranshah was strengthened and mechanical transport was used for the first time (without counting a few touring cars) on the Tochi Road. Active operations in the Tochi Valley were limited to the capture by stratagem of a Militia Post near Datta Khel by some Mahsuds, two of whom disarmed suspicion by disguising themselves as women.

On May 6th, 1918, the third Afghan War began; we evacuated the Upper Tochi, burning the Militia Posts as we retreated and concentrated at Miranshah.

The false impression of weakness produced by this retirement and the ties of religion and kinship proved too strong for the loyalty of the Militia. They deserted in gangs (chiefly Afridis), taking their rifles with them and setting fire to their posts. One large and four small Militia Posts were abandoned in this way, and for about a fortnight Miranshah was cut off from Bannu, and the post at Idak isolated. Reinforcements soon arrived, and on the opening of the lower Tochi the burnt-out posts were soon repaired.

In the autumn of 1919 a considerable force was concentrated at Dardoni and advanced to Datta Khel, where our terms were given out to the Wazirs, who had thrown in their lot with the Afghans, and were accepted. The column then returned to Miranshah. Mechanical transport was again used in the Tochi for supplying this column, but was withdrawn with the column to Tank for operations against the Mahsuds.

The first metalled road up the Tochi was begun about 1900. It was good enough for light two-wheeled vehicles, but in many respects fell short of the ideal motor road. The alignment was with three exceptions satisfactory, and there were no gradients steeper than about one in fifteen. Culverts however were far too few, and what there were were mostly too small. Two narrow irrigation canals had been bridged, but no attempt had been made to bridge any of the wider nullahs, though there were several at which traffic used to be held up for many hours, during the prevalence of heavy rains. The metalling, which was in many places nearly worn out, was only nine feet wide and there was no soling. There were several very sharp salients and re-entrants. In many places metalling had been laid on the natural surface of the ground without any banking or cutting.

The most important points of the specification for mechanical transport roads as issued from Simla were briefly as follows:— Metalling was to be 12 ft. wide and 6 in. thick over 6 in. of soling; with an earth berm 6 ft. wide on both sides. The width of metalling was later altered to 16 ft. with a 4-ft. berm on both sides, but not till after many miles of the 12-ft. width had been laid. The metalling was to be laid in two thicknesses of $4\frac{1}{2}$ in. consolidated to 3 in. Soling was only to be laid where there was not a sufficient thickness of old metalling left to form a foundation for the new metalling, or where the natural soil was not sufficiently hard. Culverts were to be 20 ft. wide between parapets. All nullahs were to be bridged in cases where serious delay from floods might result. In other cases causeways were to be made. The width of bridges between parapets was to be 16 ft. The steepest gradient allowed was, I think, 1 in 12, but I made nothing steeper than 1 in 15.

With two exceptions which will be described later the alignment of the old road was followed and the new metalling was laid on top of the old, the extra width being obtained by laying a foundation of soling on both sides of the old metalling. Every opportunity was taken of eliminating unnecessary minor curves by putting the increase in width sometimes on one side and sometimes on the other or partly on both. With very few exceptions all the old culverts had to be rebuilt and many new ones added, and in connection with the latter many small embankments had to be made. Small undulations were removed by banking and cutting. In all hill sections much cutting had to be done to obtain the increased width.

I will now give a short description of the country the road passed through, and of the more interesting works carried out.

For five miles from railhead at Bannu the road traverses an almost level stretch of heavily-cultivated land irrigated by water from the

Kurram River. The soil is "putt," a mixture of sand and light clay very easily eroded. To facilitate irrigation many culverts are necessary. At a point five miles from Bannu a wide nullah, called Baran, is crossed. It is normally dry, but is filled by an impassable torrent after heavy rain. A bridge consisting of five spans, each about 86 ft. long, made of old railway girders, was constructed over this nullah. The piers and abutments were made of brick, the roadway was of ferro-concrete slabs laid straight on the cross girders. The right bank was well defined, but the left bank was subject to erosion at every flood. The left abutment was therefore built well out into the nullah and the bed confined by a long training bund of stone pitching based on a lime concrete drop wall carried down below the calculated depth of scour.

The character of the soil changes about this point from the light "putt" to a hard gravel in which big boulders are embedded, forming an excellent foundation for metalling. For the next four miles the road runs over a barren stony plain, past an aerodrome and landing ground at mile six, till about mile nine it crosses the boundary line between the North West Frontier Province and the territory beyond which is administered by Political Agents. The road gradually rises to this point and then drops suddenly to the Tochi River bed, which it follows for the next ten miles. For the first five miles the foothills in the left bank are a mile or so from the river, and the road is on the undulating plateau between. At 11½ miles from Bannu a small bridge of three 20-ft. arches was made, replacing a paved causeway which had been partly destroyed by floods. The arches themselves were made of moulded concrete blocks. Whilst this bridge was in course of construction a sudden flood washed away and drowned two *badraggas* (Pathan guards) who had taken shelter from the rain under the arches. As the right bank of the nullah was very vaguely defined, a long embankment was made on this bank as an approach and a rough stone wall built to guide the flood under the arches.

At about 14 miles from Bannu the hills on both banks close in on the road, and form a gorge. On the top of the hill about 200 ft. above the river is the Saidgi Militia Post, overlooking the river at the edge of a small plateau. The R.E. officer who originally laid out the road (then Lieut. G. P. Campbell, R.E.) had wisely chosen an alignment over the hill on this plateau; but the engineer who constructed it had taken it at the bottom of the hill at the very edge of the river a few feet above high-flood line. On August 1st, 1917, the summer rainy season opened with a violent storm. I tried to take a car along the road the next morning, and found it covered in places with several feet of mud and large boulders, which had poured down the steep hillside in avalanches at every place where a watercourse could form.

I decided that a road at the foot of the hill was to be avoided if possible and put up a scheme for taking the road over the plateau, down the face of the hill, over a small gorge, on a 45-ft. bank over another small plateau and back to the old alignment. This deviation from the old alignment was a little over a mile long, and had the advantage of affording direct access for vehicles to the plateau on which the Militia Post stood, an excellent camping ground for troops passing up the road. The new road down the face of the hill was at a slope of 1 in 15 ; in order to make it straight, a great advantage on a steep incline, two small depressions in the hillside were blocked up with dry stone retaining walls. The larger of the two was over 40 ft. high in the middle and 11 ft. 6 in. wide at the bottom, and had an outer batter of four in one. Good limestone was used for the face and softer sandstone, which appeared in outcrops in the locality, was used for the inside. A cutting 19 ft. deep at its worst, had to be made at the top of the hill, the soil being hard gravel with huge boulders embedded in it. The bank, 45 ft. high at the bottom of the hill, was made on the top of a long bridge consisting of two 15-foot arches. The arch rings were made of a concrete in which lime and cement were mixed in the proportion of 4 to 1, the aggregate being river gravel. The mixture was satisfactory and set quickly.

The aspect of the Tochi Valley about this locality is wild and rugged in the extreme. The strata have been tilted up vertically, so that within a few yards a variety of soils and rocks are met with. On both sides of the river are stony hills intersected by numerous watercourses which afford a safe means of approach to raiders and outlaws coming from the north to attack convoys or cut off a picket. For this reason the road between Saidgi and Khajuri, the place 20 miles from Bannu where the road leaves the Tochi Valley, is more liable to attack than any other part.

At a point about 16 miles from Bannu the Tochi has apparently cut through a vertical stratum of rock ; the width of the river bed at this point is about 210 ft., though in many places above and below this point it is over 600 ft. wide.

Upstream of this vertical band of rock the left bank for a distance of about 400 yds. is formed by an almost vertical precipice of solid clay. The old road had been cut at the foot of the slope and ran at a height of 40 ft. or so above the river bed. Half a mile further on, an under section of a lofty hill called Shinkai, projecting towards the south, had forced the river to describe an elongated loop ; the road leaving the river bed had naturally been taken over the kotel at the head of this loop, and met the river bed again on the other side.

The road at the bottom of the clay slope was in a most precarious position. The clay softened under the action of rain and slid down

the hillside in avalanches, submerging the road ; at the same time the river bank itself below the road was liable to erosion by the river when in flood. In fact a short length subsided bodily a few years ago, and wheeled traffic was cut off for several days.

To make a satisfactory motor road it was necessary to avoid this alignment altogether, and as it was impracticable to take the road over Shinkai Hill, it was decided to bridge the Tochi twice and make a diversion on the right bank. This necessitated the construction of two fair-sized bridges. The lower of the two, known as Lower Shinhai Bridge, was made at the point where the Tochi had cut through the vertical stratum of rock. It was made of old railway girders and took the form of two cantilevers with a suspended span in the middle. The span between the two piers was about 208 ft. The approach to the bridge on the right bank involved the cutting of a road along an almost vertical rock face for about 150 yds.

The upper of the two bridges is also of old railway girders in three spans. It was not finished at the time I left the Tochi. The approach to this bridge on the left bank involved much heavy cutting near the kotel which the old road had made use of.

The alignment of the old road between Shinkai kotel and Khajuri needed no alteration except for the elimination of two bad salients by through-cutting.

A new bridge of 64-ft. waterway was made to replace a culvert of 12-ft. span over a nullah called Clinai, about 17 miles from Bannu. A tonga was caught by a sudden flood in this nullah whilst the bridge was being built and a pony was drowned. The bridge was made of I rolled-steel girders with ferro-concrete slabs on the upper flange. Six inches of earth, and the same thickness of soling and metalling, was laid on the slabs.

At Khajuri there is a fair-sized Militia Post, and a landing ground for aeroplanes on the hill overlooking the river. The hillside is full of springs ; green patches of cultivation and numerous palm-trees form a pleasing contrast to the awful desolation of the Saidgi defile.

Below the hill on which the Militia Post stands a fair-sized nullah with a perpetual flow of water meets the bank of the Tochi. A bridge of eight 19 ft.-6 in. spans was made over this nullah. Like the bridge mentioned above, the piers and abutments were made of limestone spanned by rolled-steel girders with a ferro-concrete slab on top. A long embankment had to be made to form the approach on the Bannu side.

The old crossing had been by a causeway, *i.e.*, a flat paved or concreted surface about 12 ft. wide on a level with the river bed. Unless very carefully made, any causeway may at the worst be washed out by floods, especially at the two ends, or at the best have a deposit

of stones or mud left on it by the retreating waters. This particular causeway being at a point about half-way between Bannu and Miranshah was a favourite spot for watering animals. One can now cross the nullah on a level road at 30 miles an hour, where formerly one had to jostle one's way through a struggling crowd of tonga ponies, camels, bullocks and donkeys, an operation in which much time might be lost.

At Khajuri the road leaves the Tochi and, after climbing a steep hill from the bridge, traverses a wide plain for about seven miles until Idak, the next Militia Post, is reached. Parts of this plain are heavily cultivated, irrigation water being obtained from the Tochi. For three miles the road runs through cultivation, and many old culverts were rebuilt. Except in the cultivated areas where the soil is " putt " it is generally speaking a hard gravel.

Between Idak and Miranshah the distance is twelve miles, a stretch of absolutely barren country. Eight miles from Idak the road has to cross a long rocky spur by a pass called the Isha Narai, but before reaching this hilly mass the country is fairly open.

About a mile beyond Idak the road crosses a wide and straggling nullah bed of a kind which is typical of the frontier. The bed is dry except in times of heavy rain, when it becomes quickly filled with a raging torrent. The banks are well defined where the nullah leaves the foothills, but as it reaches more open country one or both its banks become less and less distinct, until it would be hard to say where dry land ends and nullah bed begins.

In this particular case the left bank was well defined, but was gradually being eroded as the main force of the current inclined towards this side. The total width at the road was about 1,200 ft., although a mile higher up it was but 500 ft. There had been a paved causeway over the deepest part of the bed near the left bank, but it had met the usual fate of such works when carelessly constructed, and had been outflanked at one end and partly washed away in the middle. A bridge of 20 arched spans of 20 ft. each was made on the old alignment. The piers and abutments were of local limestone, three of the arches were made of bricks burnt on the spot, but the proportion of bad bricks turned out of the kilns was so large that the remaining arches were made of cement concrete with a camouflage of brick on the exposed faces. A training bund was made along the left bank to prevent further erosion at right angles to the bridge, and a similar bund on the right bank, the upper end turned back in a curve to guide the stream towards the bridge. The total width of waterway between the bunds was about the same as the width of the nullah a mile higher up, where both banks were well defined.

From this bridge for the next eight miles the road gradually rises

till it approaches the Isha Narai by a steep and winding ascent containing five bad re-entrants. The hills in this locality were of a particularly hard kind of grey-blue limestone.

A better alignment for the road exists through a gap which is some 200 ft. lower then that which was selected, but the expense involved would not have justified an alteration.

From the Isha Narai the road descends rapidly to a nullah called Chasmai, 36 miles from Bannu, in which there is a perpetual flow of water. The crossing of this nullah had been by a causeway which was rendered impassable by floods just about the same time the bridge was finished. The site for the bridge was fixed about 500 yds. above the causeway, where an outcrop of rock which formed an excellent foundation for the right abutment seemed to cross the river bed. This necessitated an entirely new piece of road as an approach to the left end of the bridge, entailing much blasting through a kopje of very hard limestone, and a small 15-ft. arch over a side nullah. The right end of the bridge was made to coincide with the apex of a particularly bad salient on the old road.

The bridge was built of six spans of old pin warren girders, each about 65 ft. long, on piers and abutments of local limestone, the roadway, as in the case of the Baran Bridge, being made of ferro-concrete slabs.

From this point the road passes over a cultivated plain through an avenue of tamarisks to Miranshah Militia Post, the headquarters of the Northern Waziristan Militia.

It was always a refreshing sight to see the Union Jack flying above the mud brick parapets, even though it was hung upside down.

Such is a brief description of the country in which this frontier road was made. It will be seen that there were no real engineering difficulties to be met. What difficulties there were were of another kind. Want of labour was the chief. There was no local labour worth mentioning. The people who inhabit this part of the valley are too much occupied in agriculture to care about taking contracts for roadmaking. By far the best workers in this part of the world are the people wrongly called Mahsuds (it should be Mahsid). In 1917, when the reconstruction was started, they were under a blockade which developed later in the year to a small expedition. When this was over, Mahsud contractors swarmed in to Bannu seeking contracts for excavating work, and many such contracts were given out. This people cannot work in the valleys in hot weather, so the Mahsud season only lasts from about October till April.

In the autumn of 1917 a Labour Corps was sent to the valley, and is probably there till this day.

All masonry work was done by Mahommedan contractors from

Peshawar and Nowshera; Hindus were afraid to work in the valley owing to the risk of being killed or carried off by outlaws. As there was no competition, much higher prices had to be given then those prevalent in India.

A further cause of trouble was the chronic state of danger caused by outlaws and raiders who resided in the district of Afghanistan called Khost, 40 miles away to the north, and treated the Tochi Valley as a happy hunting ground.

Previous to the Afghan War the road was picketted for six hours daily by men from the Militia Posts and blockhouses along the road, no traffic being allowed outside these hours. Working parties were accompanied by guards (*badraggas*) taken from the local Wazirs. Whenever an important bridge was made, a blockhouse had first to be built near the site to protect the stores collected there and workmen who lived alongside it.

There was always considerable delay in obtaining stores from down country, local material was of course used as far as possible, but such things as steel girders, pumps, cement, steam-rollers, water-carts, took many months to collect. When work was started there were only three large steam-rollers available at Bannu, and it took two and a half years to bring the total up to 19.

One of the minor difficulties was the constant stream of traffic along the road during the six hours it was open. The garrison of Miranshah consisting as it did of two battalions and other smaller bodies of troops, required, to feed it, a convoy three miles long consisting mostly of camels, once every ten days. The convoy took three days to go and three days to return, so there were only four days in ten during which the road was comparatively free.

In addition to convoys there were always tongas on the road and numerous small caravans of frontier tribesmen carrying timber down the Tochi to sell at Bannu.

Below I give a few details regarding methods of construction and materials used.

The hard blue limestone boulders which abound in most of the nullahs were used as material for soling, if none was procurable nearer, and when broken up, for road metal. Where nullahs were too far away the nearest outcrop of good limestone was quarried for road metal. All stone was broken by hand. I found that stone breaking was something of an art, as an unskilled Labour Corps man could not break half as much as an experienced Pathan in the same time.

Culverts varied in waterway from 2 to 15 ft., the width depends not only on the water expected but on the amount of mud and stones which, falling from the hillside above, have to be carried under the road. For this reason elaborate calculations for waterway based on expected rainfall are a waste of time. It was found by

experience that in the case of larger culverts a basis of 20 ft. of waterway for a square mile of collecting area was satisfactory. It was often cheaper and just as good to make culverts in two short spans instead of one larger one. The floors of culverts were generally paved to save depth of foundation, and were sloped as much as possible. The foundations of culverts were usually made of lime concrete. The walls were of masonry 18 in. thick in lime mortar. The tops were usually of ferro-concrete slabs for short spans with a 6-in. layer of earth between the slab and the soling. For longer spans (5 ft. and over) old rails or girders were used, with jack arches of lime cement concrete or with ferro-concrete slabs. The roadway was 20 ft. wide. The parapets were 18 in. high with a cement concrete coping on top about 4 in. thick.

Corrugated iron had been used in a lot of the old culverts, most of it had perished through the action of saltpetre, with which the soil is impregnated.

Stone for building culverts and bridges was quarried in the nearest limestone outcrop, but in the section between Saidgi and Khajuri it was obtained from huge limestone boulders, which were found in the river bed. These boulders had originally been embedded like currants in a cake in the clay formation already referred to as being conspicuous at Shinkai.

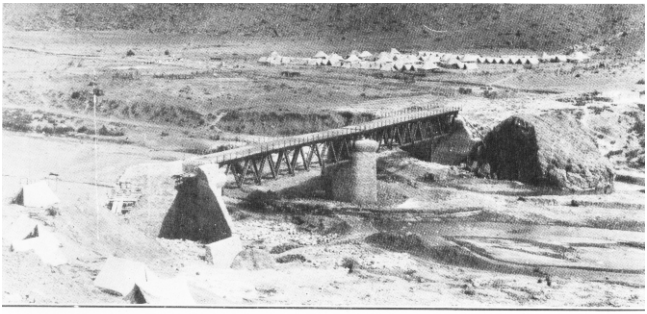
Lime was burnt at convenient places along the road, it was slightly hydraulic, and specimens from old culverts showed that it got very hard in the course of years. Sand was always easily obtainable.

The possibility of narrowing a nullah had formed an interesting study in connection with the bridging of it. As already pointed out, the appearance of a nullah bed on the frontier is apt to give an entirely erroneous impression of the quantity of water which comes down it during a flood, especially when the banks are vague and ill-defined.

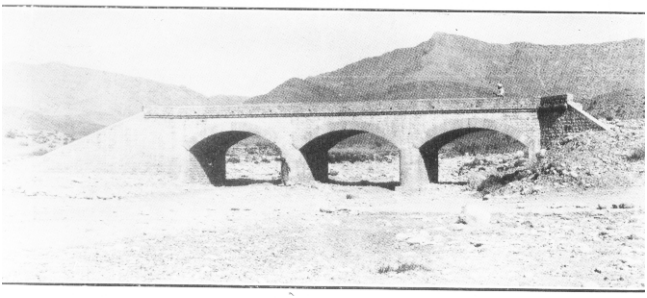
In nearly every case calculations were made to ascertain the waterway required, by noting high flood marks, taking the fall of the river bed and sections at various points and applying Nutter's or Manning's formula. The waterway having been decided on and the velocity found, the probable scour was obtained by an adaptation of Kennedy's well-known formula for standard silt. The results appeared to be satisfactory.

In the case of the four bridges in which old railway girders were used, the girder erection was carried out by a gang from the North Western Railway, the abutments and piers having been built by contract.

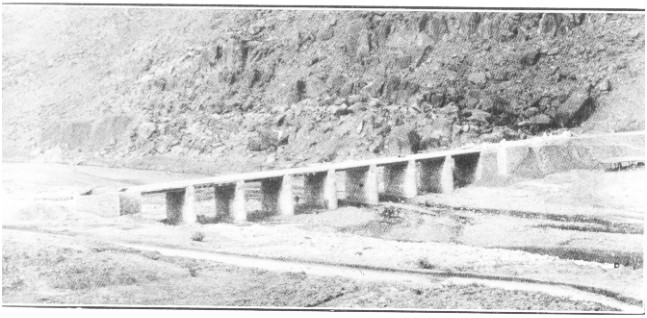
The wing walls of bridges and also of culverts received a good deal of attention; I have seen many cases of bridges in which the wing walls fail to properly contain the whole width of road, owing to the



Upper Shinkai Bridge.

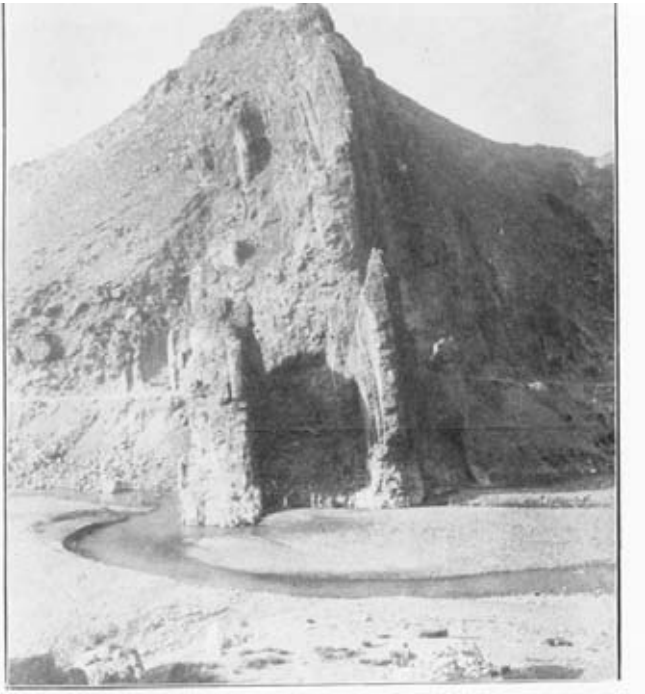


Lorisa Bridge.



Khajuri Bridge.

BRIDGES



Site of Lower Shinkai Bridge.

A FRONTIER MOTOR ROAD

walls being built of insufficient height to admit of the bank standing at its natural slope.

Before the Afghan War the road between Miranshah and Datta Khel was being made fit for mechanical transport, and considerable progress had been made with the first ten miles. But the valley beyond Miranshah has been entirely abandoned for the present, and until it is again occupied and protected there will be no possibility of continuing the work.

ENGINEER SERVICES WITH THE NORTH RUSSIA E.F., ARCHANGEL.

Extracts from a Report by Lt.-Col. G. B. HULL, O.B.E., R.E., C.R.E. Base and Local Forces.

WHEN the British Forces occupied Archangel in the late summer of 1918, and the Bolsheviks withdrew to positions up the river Dwina and along the Vologda Railway, the outstanding demands for Engineer work were for the reconstruction of destroyed bridges, accommodation for Infantry, R.A.S.C., R.A.O.C., R.A.F., at base, on the L. of C. and at the fronts, defences, and the maintenance of the existing municipal services in Archangel, such as water supply, lighting, and tramways.

Practically nothing in the way of stores for Engineer work was brought to Archangel with the Force, and recourse was made to the stocks of general building stores held in Archangel, chiefly at the Customs House and Port Depôt, for war and general purposes.

An examination of these stores showed that they would be insufficient to meet the demands for Engineer work and that they would have to be supplemented by stores from home. Indents for a six months' supply of stores likely to be required were, therefore, prepared and dispatched to London, and it was hoped that some of this material would be delivered in Archangel before the port froze. Large stocks of sawn timber of all sizes were immediately available locally, and it was possible to send early supplies to the river and railway fronts for use there.

The Engineer personnel available for work at that time consisted chiefly of the 310th Battalion U.S. Engineers. One company was kept in Archangel working on barrack construction, operating a saw-mill, and doing general Engineer work at the base, and the remaining companies were sent to the front for forward work, defences and accommodation, etc., the work there being controlled by R.E. officers. The British Engineer personnel was very limited in number and was used for the most part in supervising Russian civilian labour which at that time was largely used.

Much of the base work, such as hospitals and hangars, was given out to contractors, and some was carried out by civil labour administered and controlled by R.E.

One of the factors in the efficient administration of civil labour was

the devising of a suitable rationing scheme. The civilians in general were rationed by the civil authorities and received a meagre ration, but workmen employed by the military authorities on essential services, received an " essential service " ration card with which they could purchase additional foodstuffs from R.A.S.C. depôts, the value of the ration being deducted from the amount due as wages. In the case of men temporarily employed a " bonus ration card " was issued which enabled them to purchase a limited amount of food from military sources.

Until supplies were received from England considerable quantities of stores and material of all kinds were obtained from the Custom House and from the port authorities. In the case of stores held in the Custom House, the Governor General was requested to authorize the requisition of the particular articles required. No direct payment was made, but an account was kept of the transaction for later settlement between the two Governments through the Claims Commission eventually instituted for this purpose. The stores requisitioned through this service consisted of nails, sheet-iron, plain wire, paint and oils, axes, cordage, oil engines, etc. Stores of a different class, such as manufactured iron work, etc., were obtained from the port. In this case application was made direct to the port authorities to furnish or manufacture the article required and the account was referred to Claims Commission for later settlement.

Considerable quantities of sawn timber were acquired locally. A naval officer was acting as representative of the Timber Controller, and purchased timber for home use on a large scale. He was frequently able to hand over small lots of this Government timber to the R.E. for local military purposes. In other cases timber was purchased direct from the mill-owner and paid for in cash on a sterling basis, and details of such transactions, quantity and price, were always given to the Timber Controller, at his request, before the transaction was completed.

In addition to these two sources of timber supply, the output from a mill owned and operated by the port authorities at Bakharitza was used entirely for military work ; no direct payment being made for the timber supplied. Most of this timber was used at Bakharitza, which lies on the opposite side of the river from Archangel, or sent from there up the railway to the front. Timber required in Archangel itself, was sawn by the U.S. Engineer personnel at a local mill from logs purchased from the Northern Railway. The logs were found stacked for sawing at this particular mill, and an arrangement was made with the mill owner for use of the machinery, etc., to do the work.

In order to strengthen the Engineer personnel available for work, civilian tradesmen who enlisted in the Slavo-British Legion were drafted into a unit known as No. 1 Engineer Training Company.

Not more than 30 or 40 recruits were obtained, however, though these performed very useful work throughout the whole period of the unit's existence. Later, an establishment was approved for this company, and it became the 383 E.T. Company.

Other companies R.E. formed at this time were the 381 Works Co., R.E., and the 382 E. and M. Co., R.E. Both were considerably below the normal strength of such companies, but it was hoped that reinforcements would bring them to a strength more in keeping with the work there was for them to do. In spite of low strength both companies later on did remarkably good work; the Works Company supervised and administered most of the extensive work in Archangel, and the E. and M. Company, besides the shop work at base, installed lighting sets and searchlight sets at base, on the L. of C. and at Force headquarters, and maintained the lighting over a very large area.

The maintenance of the existing municipal services was of great importance and demanded special attention. A *liaison* officer for municipal services was appointed for this work, and he and his staff kept in close touch with the heads of the various municipal departments controlling water supply, lighting, tramways, roads, etc. It was his duty to make himself acquainted with methods of operation and maintenance, and to furnish the municipality with any essential supplies, not locally procurable, required for the upkeep of these services, as well as to arrange for rations and exemptions from military service for essential employees, and to provide tram transport for military supplies as required. In this connection tramway extensions were laid to hospitals and R.A.S.C. main depôt; and in order to provide fuel for winter use by the troops in Archangel, an extension four miles long was laid to an up-river saw mill and fire wood in very large quantities delivered over this line to the R.A.S.C. distributing centre in Archangel.

In the autumn of 1918 arrangements were completed for the formation of Russian Engineer units on the same lines as R.E. Field Companies. These units were designed to take over, eventually, the Engineer work with the Russian army then about to be formed. Two companies of 1 H.Q. section and four other sections were formed. They were commanded by an English-speaking Russian Engineer officer of considerable experience and were, of course, administered by the Russians, but trained along British lines by British instructors. An experienced Russian-speaking British officer was appointed as *liaison* officer, and the training was arranged and supervised by him. These companies eventually proved very useful, and one company in particular did remarkably good work on the railway front during a critical and trying period. At a later date, a Russian Engineer Works Company was formed to take over the work which was being done by the 381 Works Company R.E.

The map shows the areas occupied by the Forces during autumn and winter, and the disposition of the R.E. personnel.

The R.E. work at the fronts during the autumn consisted chiefly of building and fitting up accommodation for troops, including hospital accommodation, general sanitation, defence works of all kinds, including block houses, M.G. positions, wiring, etc., and preparation for coming winter conditions. On the railway front very little existing accommodation was available, the villages being very few, small, and far between. Box-cars were lined with match boarding, fitted with stoves, bunked for 16 to 18 men, and so converted into very suitable quarters, which possessed the advantage of being movable. On the river front, villages were close together and afforded, in general, adequate accommodation, though the houses taken over had to be fitted with bunks and sanitary arrangements.

No standard type of block-house was adopted, as circumstances and conditions varied in different localities. Except along the railway itself the most general type on the Vologda front was one built of logs in walls 4 ft. thick, giving a space of 15 ft. by 15 ft. inside. The logs used were 23 ft. long and about 6 in. thick, heavier logs being too inconvenient to handle. When the walls had been brought up 2 ft. above floor level the log floor was laid, covered to a depth of 2 in. with moss, and then covered with the true floor of 2-in. planking. The walls are strengthened with upright poles wired together at corners and entrance, the spaces between logs being well filled with moss and earth. The Russian workmen are particularly good at this type of construction.

At a height of 4 ft. 6 in. above the floor a loophole or slit, 6 in. high inside and 10 in. outside, is left for almost the full length of the wall, and is covered with a hinged board fitted with two small windows. The flaps can be swung open immediately any action commences. The roof is sloping and is made of a layer of splinter-proof logs, covered with 2-in. planking and finished with roofing felt. The house is fitted with a stove and bunked for eight men. This type of block-house, with solid log walls, was evolved for use in forest country where the difficulties of transporting sand for filling between single walls, were abnormal. With the long slits provided, all-round fire can be obtained, and the fact that they are difficult to conceal is unimportant in forest country, compared with the advantages of wide field of view and of fire, and of the strength of fire which can be brought to bear in any required direction. The tactical strength is greatly improved by lanes cut through the trees, and wired, enabling block-houses to be grouped into defended localities so that adjacent block-houses are mutually supporting against attack from any direction.

On the river front, where sand is usually available, the most general type of block-house was one consisting of two single log walls

with 3 ft. of sand between. The outer log walls are 6 ft. high only, and the loopholes are built into sand bags laid on the sand filling. A splinter-proof log ceiling is covered with sand and a double slope roof built above this. Entrance is afforded from a trench leading to a trap door in the floor.

Modifications of the above types were often built when local conditions and requirements demanded. Provided the block-house has the essentials of good loopholes, bullet and splinter-proof walls and roof, and is as low as is consistent with sufficient head room above loop holes, there is little need for rigid adherence to a particular type It is the siting of the block-house which calls for most skill and good judgment, the appraisement of the topographical features of the country and the likelihood of the direction of attack.

Machine-gun emplacements were of the type evolved by experience in France, but were log constructed, one-way or three-way as required.

Knife-rest or double-apron wiring was generally used. A special W.R.E.F. pattern, double-apron fence was evolved during the winter which required no pickets, was built on the snow and which sank as the snow melted and remained rigid and upright when it rested on the natural ground.

Special efforts were made in the autumn to forward adequate supplies of stores for Engineer purposes, sawn timber, etc., for the front before the river froze. All departments were equally desirous of doing this, and although only a limited number of barges were available, a considerable quantity of barbed and plain wire, nails, timber, glass, roofing felt, sandbags, explosives, felling axes, tools, heating stoves, etc., were delivered at various centres on the river front, and good stocks were, therefore, available by the time winter set in. Lighting sets had been installed at troop centres along the L. of C. and at Force H.Qs., and the necessary wiring to offices, hospitals etc., completed, before the beginning of winter.

The information furnished locally concerning the winter conditions which could be expected, showed that the depth of snow in the open varied between 3 and 7 feet; and that temperatures averaging 20 degrees below zero F. could be expected over lengthy periods; and block houses were built with these depths of snow in view. The actual conditions varied considerably from the anticipated, and records of snow depths kept by Engineer officers showed that the depth in open country varied between 10 and 30 inches, and block houses proved in many cases to give a higher command than was generally desirable. Minimum temperature in January, February and March varied from 18 degrees to 36 degrees below zero F. though lower temperatures were recorded for short spells. Contrary to expectation based on popular reports, the temperature did not average 20 degrees below zero for any cold spell of three days or more during the whole winter.

When winter set in and the river froze, all stores and supplies, except those for the railway front, had to be sent by sleigh, and the maintenance of the L. of C. became a most important feature of winter R.E. work, as it involved work over a total line of about 700 miles.

It was necessary to provide rest houses with accommodation for officers and men at each stage of approximately 20 miles, along sleigh routes. In most cases, village houses were taken over and completed with bunks and sanitary arrangements for this purpose. In one case, however, a large log-house had to be constructed in the forest, remote from the nearest village. The house was built by about 30 Russian axe-men in charge of a R.E. corporal, and rations and supplies were sent by sleigh to the party from a depôt 60 miles away. It provided sleeping, cooking and heating accommodation for 60 men and 12 officers, and its construction gives an idea of R.E. administration on the L. of C. with the very limited R.E. personnel available. The N.C.O. spoke no Russian and had no interpreter.

Only 4 R.E. officers were employed on the River L. of C., each administered, as D.O., R.E., an area averaging about 70 miles long, and was responsible for rest houses, sanitation, defences, repair and maintenance of bridges, buildings and fittings for R.A.O.C. and R.A.S.C. stores, Y.M.C.A., hospitals, etc. Each officer usually had a N.C.O. to assist him and the work was done by civilians, in some cases by contract, and in others by direct administration. Stoves and sheet iron work for sanitary purposes were also made on the L. of C. The lighting was installed and maintained separately by the E. and M. Co. with a R.E. N.C.O. or sapper in charge of the set at each place, and very few cases of breakdown occurred.

The winter roads are carried over numerous ravines by wooden bridges, all of which were examined by a R.E. officer and, where necessary, repaired and strengthened to carry guns.

The R.E. work on the L. of C. was in general administered and inspected by an O.C. R.E. under the C.R.E. An inspection of the river L. of C. necessitated three weeks steady travel by sleigh.

During the winter a review of the stores situation was made, and indents on London prepared for a six months' period from June, 1919, on the assumption that an offensive would begin when the river became navigable and reinforcements arrived. At no time during the winter was there any serious shortage of stores for Engineer work at the Front, those that had been sent up before the river froze, with limited additional supplies sent up by sleigh during the winter, proving just about sufficient to meet the demands. Any special workshop article required was made in workshops at the Base and could be delivered to a point 200 miles up river in three to four days.

In order to be prepared for a possible advance along the railway in the spring, a timber trestle bridge was prepared at the base ready to

replace the Emptsa bridge, a structure of considerable size, which had been demolished by the enemy in his retirement from Obozerskaya. The enemy occupied a position on our side of the bridge, and direct access to it for examination was not, therefore, possible. The railway plans of this bridge as it stood before destruction gave length and height, and drawings were prepared with this information. The bridge members were constructed by a party of U.S. Engineers working under the R.E. officer responsible for the design and construction of the bridge, and were assembled, marked, dismantled and loaded into trucks complete with bolts and fittings, ready to be sent forward to the site as soon as the enemy was dislodged.

The work at the front during the winter consisted largely in elaborating and extending defence works, etc. commenced in the autumn; constructing new defence systems, clearing forests for fields of fire from block-houses, wiring, etc.; and in general Engineer work. Villages were usually encircled by mutually supporting block-houses, numerous carefully sited M.G. emplacements included in each system and the whole wired with knife-rest and double-apron wire. Existing houses in forward villages were frequently sand-bagged and converted into block-houses.

The Engineer work with each force was controlled and administered by an O.C. R.E. attached to Force H.Q. and having under him several officers as D.O. R.E. in charge of defence and other work at the front. The long sleigh journeys involved made frequent inspection by the C.R.E. an impossibility, and the appointment of an O.C. R.E. having ample discretionary powers in the administering of the large area, to represent him with the Force, was essential. The officers of the 310th U.S. Engineers lent at all times admirable support, and the U.S. Engineer sections employed on the different fronts did uniformly excellent work. As far as possible civil labour was used, and work in the rear of the front line was largely done by peasants supervised by Engineer officers or N.C.O.'s. The system had its drawbacks as it was comparatively simple for any pro-enemy person to cross the line with useful information. But the circumstances demanded that as much use as possible was made of civilians.

The long lines of communication and the limited number of troops available for guarding them, enabled the enemy to attack, and in one or two cases, to occupy villages on the L. of C., so constituting a threat to Archangel, as well as temporarily cutting off supplies from the base to the Force. Such attacks made rapid construction of defences essential, and all available forces were concentrated on the particular locality to be defended, until the work was completed.

The occupation of Bolshe-Ozerki by the enemy during the winter led to the construction of a rear line of defences some 10 to 15 miles south of Archangel. The line was about 20 miles long and consisted

of solid log block-houses about half a mile apart, with M.G. positions, wire and many acres of clearing for fields of fire. When the system was nearly completed, the enemy was dislodged from Bolshe-Ozerki and the work suspended. Later, in the summer, when the mutiny at Checuevo and Onega gave that and additional territory again into enemy hands, the line was completed and extended to Kenetzbor on the sea coast to the W. of Archangel.

The approach of the winter was marked by a general softening and breaking up of the sleigh roads, and the transportation of supplies to the front became increasingly difficult. Local information indicated that there would be a period of two to three weeks when the ice was breaking up in the river and the snow roads had disappeared, when the forces would be completely cut off, as it would not be possible for supplies to be delivered either by road or river. It was thought that this might prove a critical period as the clear water in the upper reaches of the river would enable the enemy to attack our villages on the river banks with gun boats. Special efforts were therefore, made during the last few weeks preceding the thaw, to add as much as possible to the then rather low stocks held in dumps near the front, and although the ponies were wearing out and sleigh transport strained to the utmost and in spite of the urgency for ammunition and food, sufficient Engineer stores were delivered to carry the forces over the difficult period and to provide for the hasty construction of defences in case of need.

Towards the end of the winter preparations were made for accommodation in Archangel and district, for the Relief Force expected to arrive in May; and as the Russian Army had considerably increased in size and required much of the accommodation already available, much new barrack work for British troops was required and completed. The mobilization of the Russian civilians had produced a dearth of labour which was general over the whole area occupied by us, and construction work at this time was done under considerable difficulty. In addition to barracks, etc., provision had to be made for storing the large quantities of stores, ordered for the offensive, which were expected to arrive when navigation was resumed. This entailed the construction of eight or nine additional transit and store sheds 200 ft. long by 70 ft. wide, at Bakharitza.

Many thousands of duckboards were made at Base R.E. shops for use at troop centres near the front to facilitate transit over the swampy ground in spring; and sufficient quantities of tent-bottoms for bell and hospital tents, were made to accommodate the British and Russian reinforcements for the forces.

On May 26th, 1919 the first Brigade of the Relief Force arrived, and the second Brigade arrived shortly afterwards. The two Field Cos. were sent to the river front within a few days of their landing and relieved the U.S. Engineers, who returned to base

and prepared for their departure to U.S. They left in June after a year of valuable service with the Force. In addition to defence and general work, the U.S. Engineers had, in the absence of a mapping section, taken over the work of surveying, mapping, and map production for the entire force, and produced maps of several hundreds of square miles of territory. Most of the surveying was done in the winter, sometimes in temperatures as low as 30 degrees to 40 degrees below zero. The survey information was compiled at G.H.Q., maps made, lithographed, and sent to the Intelligence Dept. for distribution.

By this time the two companies of Russian Engineers had completed their training and were ready for work. The first company was sent to the river front and the second to the railway front, each under its Russian officers assisted by a British Engineer *liaison* officer. The time and energy put into this formation and training bore its fruit, and both companies did very creditable work; and during the mutinous period which developed later among the Russians, they remained loyal, although subjected to the same pernicious mutinous influence which undermined other Russian regiments.

During the formation and training of "Dyer's" and "Burke's" battalions, it was felt that a Russian platoon from each battalion, would do much towards meeting the requirements of the battalion for Engineer services. The proposal received sanction from G.H.Q. and about 60 suitable tradesmen were therefore detached from the infantry and formed into a pioneer platoon. The men were put to work under an Engineer officer and trained in barrack erection and general defence work. They performed very useful work both before and after the mutiny of "Dyer's" battalion.

As soon as the ice had gone and navigation was resumed, the stores indented for during the winter began to arrive from England in large quantities. Barge loads of Engineer stores, such as C.G.I., roofing felt, water pipes, dogs and spikes, etc., as well as stores of ordnance supply, as barbed wire, sandbags, nails, shop iron, etc., were prepared by the Chief Stores Officer R.E. for dispatch to the river front and sent as early as possible to stock the R.E. Advanced Park which was established at Bereznik upon the opening of the river. The water in the river fell rapidly after the first thaw flood and navigation became increasingly difficult with the heavy draught tugs available. In spite of low water, however, several barges of Engineer stores and material, as well as timber barges, were delivered at the park, and by the time the plans for the advance on Kotlas were completed, the park had ample stocks.

The change in policy from winter defence to summer offence to join with Koltchak at Kotlas, led to G.H.Q. moving from Archangel to Bereznik, and necessitated a reorganization of R.E

administration. Appended are two charts which showed R.E. organization before and after the move of G.H.Q.

The unusually low water and the scarcity of light draught tugs made the question of getting supplies up the higher reaches of the river towards Kotlas, a difficult one. A few self-propelled light draught barges were available, and one of these was secured for Engineer purposes and was loaded with carefully selected stores and material from the advanced R.E. park as a supply barge for the Field Cos. It was intended that this barge should follow up the R.E. in the advance, and that stores required for offensive purposes, etc. should be issued from it.

The forward work on the river front at this period included the construction of several landing stages and piers. These were built of log trestles with sawn timber superstructure. Also corduroy roads, laid to facilitate the transportation of stores from the river to dumps; as well as accommodation and general work.

The uncertain situation on the Pinega River, about 100 miles in the rear of the Dwina front, led to the transferring of certain British troops to Usb-pinega, to check enemy raids in that neighbourhood, and one Field Co. was withdrawn to that point for the construction of defensive and other works there.

About this time mutiny amongst Russian troops gave Checuevo and Onega into the hands of the enemy. From Checuevo he was able to threaten the railway near Obozerskaya, and from Onega he marched along the coast road towards Archangel. This necessitated the completion and extension of the defence line about 10 miles south of Archangel which had been commenced and partially completed during the winter. Small parties of R.E. were sent to Lyavla, Metchka, V. 581 on the railway and to Konetsboz. The whole line was reconnoitred, paths leading to block-houses, etc. cut and marked by sign boards, block-houses and M.G. positions completed where necessary and clearing done for fields of fire. In addition to this, local defences were constructed on the road between Obozerskaya and Checuevo, as well as at points along the railway between Obozerskaya and Archangel, a section of Field Co. engineers being sent up for that purpose.

When Admiral Koltchak's advance on Viatka was checked, and he retired to positions east of Perm, our own plan of advancing to Kotlas to meet him was abandoned and G.H.Q. returned to Archangel.

The railway front was held, at this time, entirely by Russian troops with a few British Engineers, Artillery, and Technical units in support, and enemy agents in the ranks of the Russian troops had organized a mutiny on the front beyond Obozerskaya and on the left flank near Seletskoe. The right flank at Checuevo had already become Bolshevik; and although, this time, the enemy intentions

were frustrated, the general uncertainty as to the behaviour of the Russian troops led to the preparation of schemes for demolitions along the railway in case the line broke and the Bolsheviks advanced. The plans included the burning of timber bridges, and the demolition of iron bridges, earth embankments, water towers, etc. The mutinous period passed, however, and no demolitions proved to be necessary. The Russian Engineers employed on the railway front worked loyally with the British and performed very useful work, especially in connection with the constant repairs to the track, which were made necessary by enemy action.

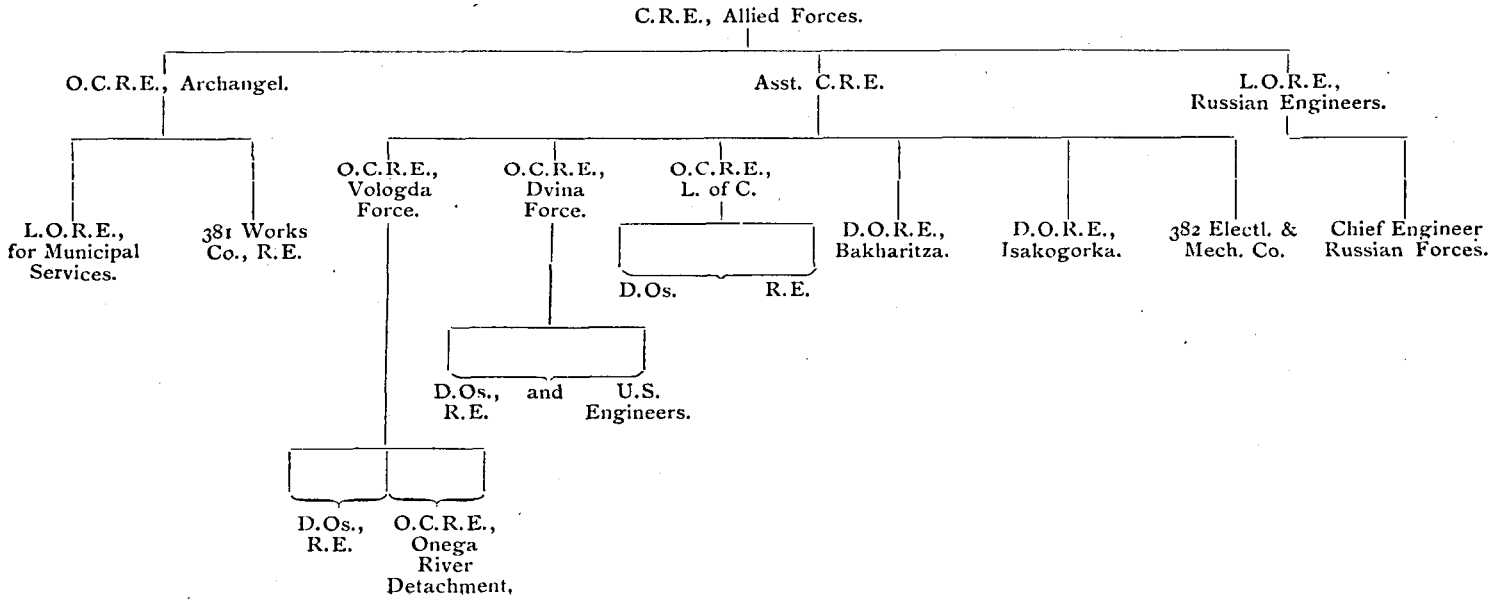
When the decision to evacuate was finally announced, arrangements were completed for the removal to Base of stores held at the advance R.E. park. Such stores as were urgently needed by the Murmansk force were sent to Murmansk, and part of the saleable stores shipped to England.

To enable rear-guard actions to be fought in case of necessity during our withdrawal down the river, piers and landing stages, sufficiently strong to carry 18-pounder guns, were constructed at some twenty places between Bereznik and Archangel. This work was done chiefly by local contractors under the supervision of the O.C. R.E. L. of C. By this time, August, the river was on the rise and navigation and the movement of troops, etc. became less difficult.

When the N. Russian Government decided to continue operations against the Bolsheviks after the evacuation of the British the existing stocks of R.E. stores and material, sawn timber, etc. were handed over to the Russians.

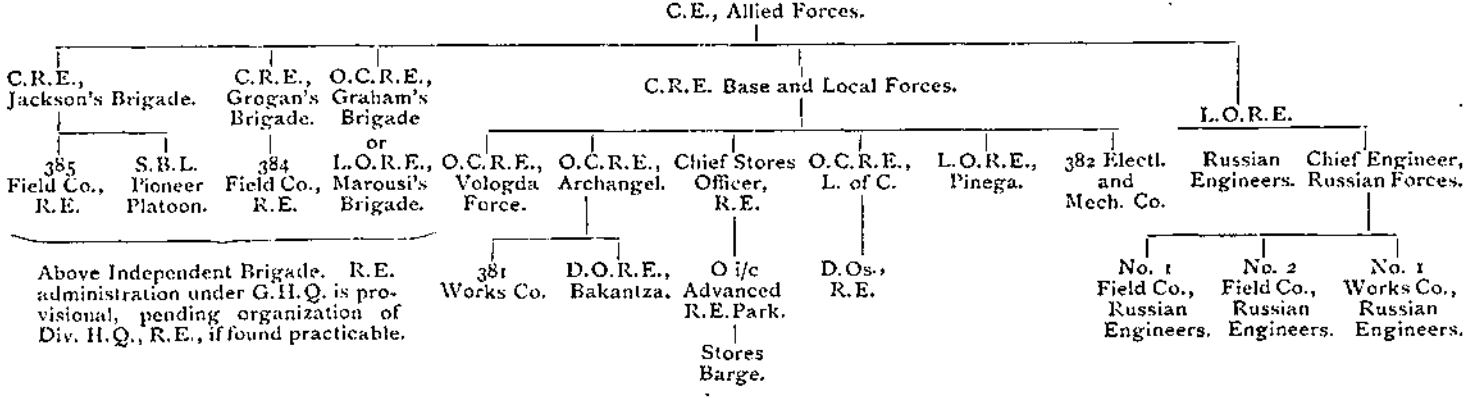
R.E. ORGANIZATION CHART.

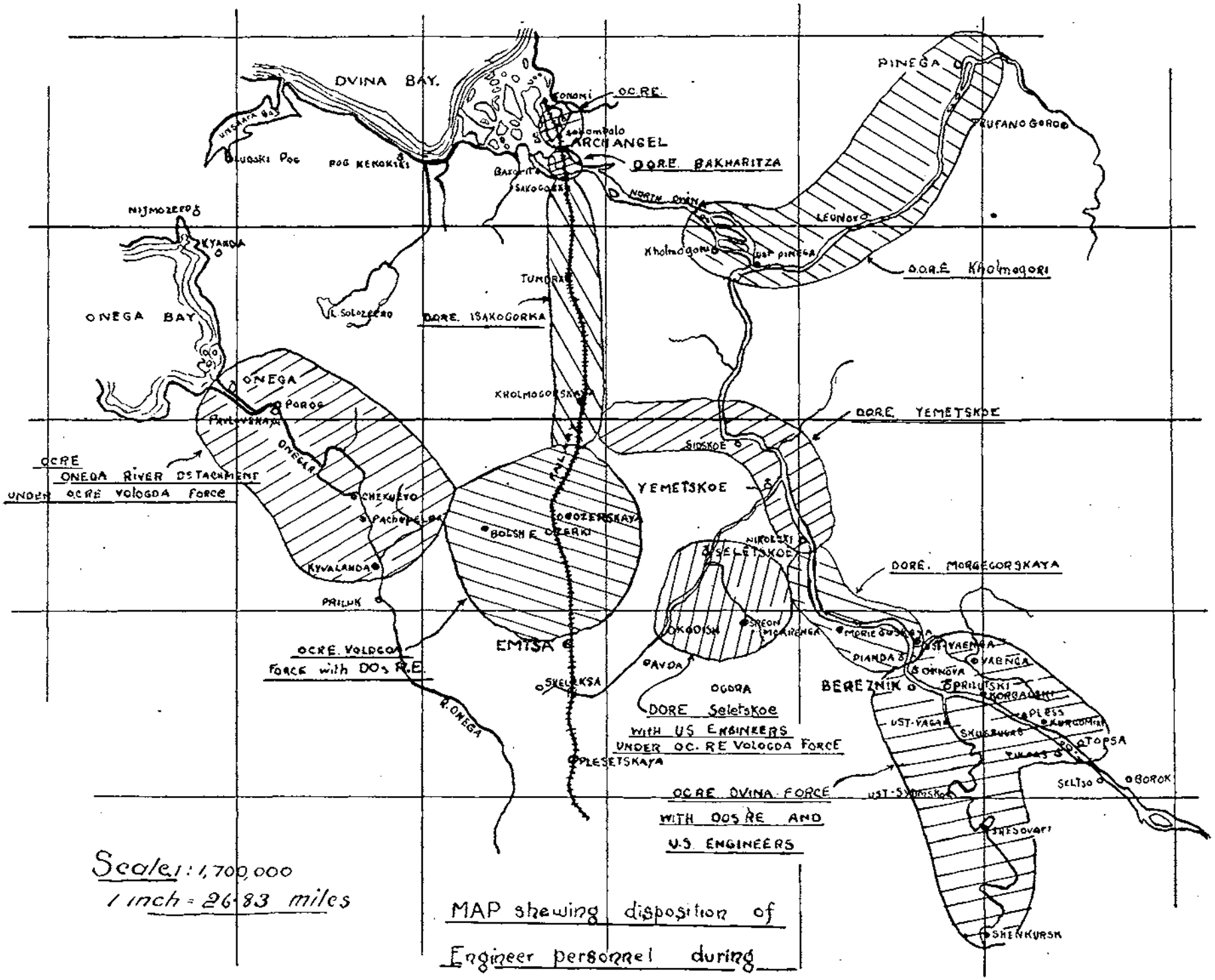
BEFORE MOVE OF G.H.Q.



R.E. ORGANIZATION CHART.

AFTER MOVE OF G.H.Q.





Scale 1 : 1,700,000
1 inch = 26·83 miles

MAP shewing disposition of Engineer personnel during winter.

THE EVOLUTION OF FIELD FORTIFICATION DURING THE LATE WAR.

From an article by Capitaine Botte, published in the May-June number of the Revue Militaire Générale. By Colonel A. R. REYNOLDS.

THE Author commences with a sketch of the principles ruling before the war, and shows how these were modified by instructions issued in December, 1915, again in August, 1917, and lastly by the decisive events of 1918.

The pre-war principles were enunciated in a general and rather inconclusive manner in the F.S. Regulations of December, 1913, article 146 of which states, " Positions to be defended, centres of resistance and supporting points to be occupied, will be decided upon by the commander in accordance with the object to be attained. The organization of a supporting point will be regulated by the officer appointed to its command." The infantry should have a clear field of fire up to medium ranges (800 to 1,000 metres), invisibility is to be studied, and the construction of dummy trenches is recommended, while the occupation of the edges of localities and woods exposed to enemy artillery fire is deprecated, and, although this is not distinctly stated, it is evidently intended that reinforcements should be under cover close to the firing line. Chapter IV of the same regulations says that " a centre of resistance may comprise one important or several neighbouring supporting points." The idea then held of a supporting point will be shown later. Mutual flanking from supporting points is enjoined.

This is all that the infantry officer could find in the regulations for his arm in regard to the organization of the ground he had to defend. A course of field fortification was part of the curriculum of every military school, but in view of the unpopularity of the defence courage was required to follow it attentively. Engineer officers received fuller and more precise instructions. In the *Aide-Mémoire de l'Officier du Génie*, after an enumeration of the conditions to be satisfied, amongst which will be noted a field of fire of 200 to 300 yards only, a general description is given of a fortified position. The principal position will generally consist of two lines, one for infantry, the other for artillery, the former 500 to 600 metres in front of the latter, so that the guns would be secure from enemy infantry fire and be left free to develop their own fire. The main infantry line of defence will be marked by supporting points, each

consisting either of a group of works made entirely with the spade (*retranchements élevés de toutes pièces*) or of a locality or wood placed in a state of defence. Machine-guns will be used to flank the intervals. The choice of sites for the supporting points must depend on the lie of the ground, but for mutual support they must not be more than 1,200 metres apart. The long distance between supporting points should be noted.

The "supporting point consisting of a group of works made entirely with the spade" was intended to hold one or two companies according to its importance, and was to consist of trenches of full or half section linked up by communication trenches to a closed work in rear constituting the keep. In short, it may be deduced from the pre-war regulations that the main position of defence was to consist of a series of strong points called "centres of resistance," or "supporting points" according to their importance, and that these strong points were to be separated by intervals of about a kilometre, access to which was interdicted by flanking fire from the strong points; in other words, a series of bastions flanking imaginary curtains, since the strong points were not interconnected. This disposition facilitated command, the strong point was crammed with defenders all under the eye of their commander, and was intended to economize troops, although it should be noted that one battalion per kilometre of defensive front was required. To-day, with very different principles, no more troops are required, and, if the number of automatic weapons has increased the appliances of the assailant have developed equally. It is interesting to note how much the organization of the position resembled that of a fortress.

As to organization in depth there was, first, the advanced position which would delay the enemy's march and give the defenders of the main position time to reach their stations; second, the main position on which the enemy would be brought to a standstill; and lastly, a second line intended finally to limit his progress. This organization somewhat resembled that of a fortress, but more nearly the dispositions laid down in the regulations for outposts, the advanced position corresponding to the sentry groups and sentries, the troops of the main position to the piquets, and the second line to the outpost reserves. The organization was logical, and it is interesting to note that, abandoned for the greater part of the war, it was again adopted in the summer of 1918.

Now as to the application of these principles. In the first battle in August, 1914, the infantry distributed itself over the ground by occupying with constituted units, company or battalion, points considered to be favourable for defence, such as well-defined ridges, woods, farms, villages, *i.e.*, supporting points separated from each other by about a kilometre. Generally speaking these points were

only occupied, and not prepared for defence, since all ranks thought too much of the offensive to have patience to dig trenches. Whether in consequence of aerial reconnaissance, or because the enemy divined these methods, the result was that a systematic artillery fire burst over the particular localities in which the troops were massed, and not only this, but the great distance between the supporting points entailed their fall by enabling them to be surrounded. Such are the deductions to be drawn from the battles of the end of August, 1914, and the problem to be solved—how to camouflage the occupation of a position—required no less than three years to solve.

After the battle of the Marne the occupation of a position assumed a new form. At first the assaulting waves established themselves elbow to elbow in sections of trench; the first days were passed on the watch behind the parapet in hopes of a resumption of the offensive, the most optimistic holding that the enemy would never remain stationary in this way, and that one day he would decamp. After some days of waiting, during which the troops were tired out, the necessity for organization became apparent, and from early in the stabilization period the continuous trench came into existence. Although not prescribed by regulation it was adopted everywhere, since it facilitated communication and supervision, the defenders felt themselves less isolated and no longer feared that their position might be turned. The long, thin, continuous line seemed to present great capacity for resistance; it possessed the advantage of impenetrability, it was difficult to damage, the destruction of 100 yards of trench calling for as great an expenditure of ammunition as that of a company supporting point, and if a section of trench was lost the gap could be quickly closed by the reserves stationed some 1,000 yards in rear. The disadvantages were that it required a very large force to hold, and being close to the enemy's line many lives were sacrificed from a pure spirit of emulation in holding a few yards of often unfavourable ground. The necessity for connection with the rear soon led to the construction of communication trenches, a work of such magnitude that at first some hesitation was shown in attempting it.

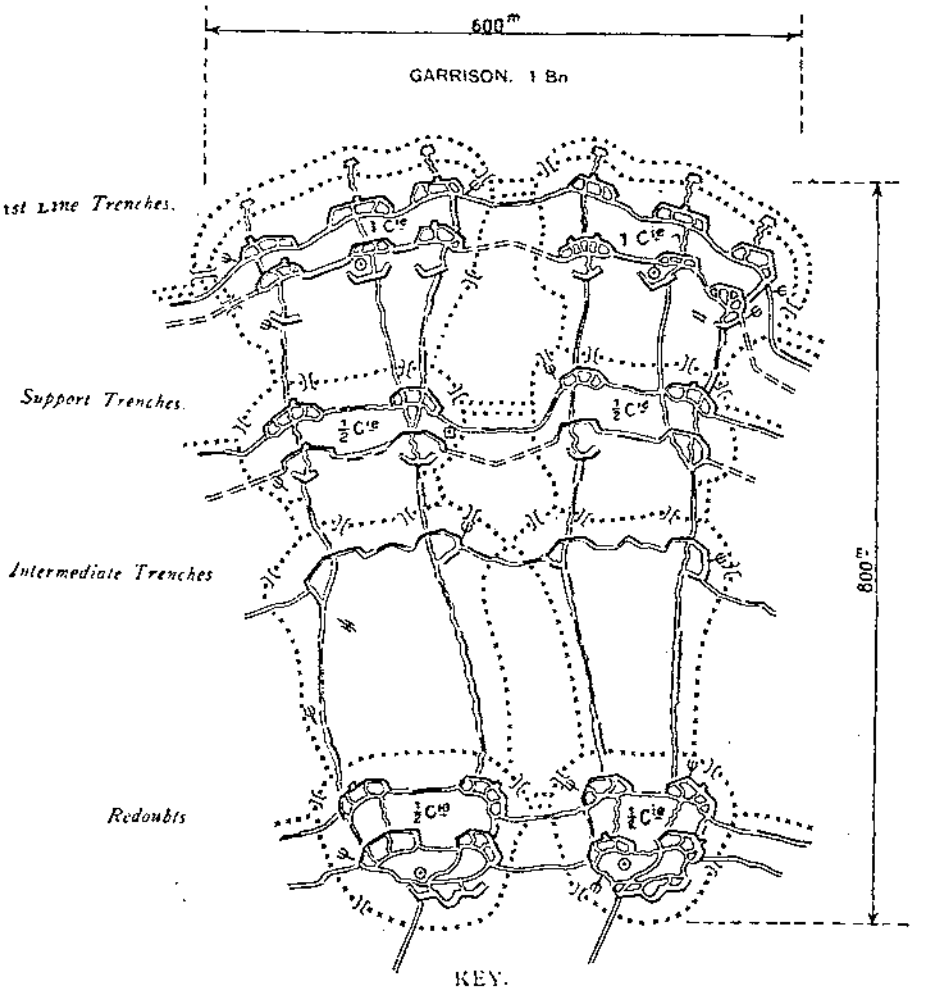
In January, 1915, a pamphlet entitled "Field Fortification in accordance with the First Lessons of the War" regulated certain details, but did not confirm or invalidate any of the general principles existing before the war. The writer states that he is unable to procure a copy of the pamphlet, and all that he remembers of it is the statement that two layers of round spars 15 cm. (6 in.) in diameter, separated by 30 cm. (1 ft.) of earth, was proof against the 150 mm. shell. The result was an acute crisis in the field parks which lasted the whole of the war, and raised against the engineers much ill-feeling which was no less lasting for being undeserved.

Early in 1915 some armies doubled the first line by a support line, established a line to cover the artillery and prepared second positions. After the offensives of 9th May and 16th June two notes from G.H.Q. gave important directions drawn from their lessons. Admitting that the assailant could always capture the first line if he would face the necessary expenditure of ammunition to completely destroy the trench, it was considered indispensable to organize the defence in depth by establishing a second-first, or support line, about 200 yards in rear of the first. This could be strongly organized under the protection of the first line, might often escape observation from the ground, and at least the provision of artillery ammunition at that time did not admit in the ordinary way of the complete demolition of two lines; from it counter-attacks would start to re-capture lost portions of the first line. By this means less was to be feared if a sudden attack effected a breach in the first line, and from this time organization in depth continued to develop until the end of the war. The offensives of September, 1915, furnished further lessons, for instance, that in Champagne near Navarin Farm. Here the almost intact defences of a second position were met on a reverse slope, and the efficiency and surprise effect were experienced of machine-guns sited in the open, which later on induced a tendency to withdraw all vital weapons and other defensive appliances outside the network of entanglements and trenches.

All defensive organizations during 1915 were based on pre-war principles. After the linear organization at first imposed followed the constitution of a front formed of centres of resistance or supporting points (which expressions at that time had no precise signification), separated by intervals only passively defended. These strong points closely resembled the pre-war design and were referred to as "*fortins*" or "redoubts." The works showed up clearly on aerial photographs; in fact, the distribution of the troops was written on the ground, and the works being of small dimensions, with the vital weapons and other defensive appliances crowded together, could be destroyed by comparatively few rounds, and were regular "shell-traps."

The Instructions of December, 1915, imparted to all the idea of G.H.Q. on defensive organizations. The pre-war principles were modernized, and although centres of resistance were retained they were connected by continuous trenches, the centres or active zones always being separated by passive zones. On the sketch (copy attached) of a type centre of resistance was a note, which, apparently only of secondary, was of primary importance, and read, "It is essential, in order to disguise from the enemy the scheme of occupation of the position that the intervals should appear similar to the neighbouring supporting points," *i.e.*, that the centres should be connected together by communication or dummy trenches. From

TYPE PLAN OF CENTRE OF RESISTANCE.



KEY.

- Fire Trenches.
- Dummy Trenches.
- Communication Trenches.
- Machine Gun.
- Gun for flanking fire, under cover.
- Company Command Post.
- Battalion Command Post.
- Entanglement, with gap.
- Listening Post.

the sketch can be seen the difficulty, not to say impossibility, of camouflaging a centre of resistance. It consisted of a series of supporting points, not of geometrical trace, but obvious owing to the density of the earth works, and to the surrounding girdles of entanglement. It was a delusion to think that it could be possible to construct all the works necessary for camouflage, the real works absorbing all the labour available; besides, even admitting the possibility of constructing them, the occupied portions must always have presented peculiar features of their own. Other reasons operated against complete camouflage. The existing obvious *fortins* contained shelters which could not be abandoned, and, besides this, the infantry had begun to understand and apply the pre-war principles of defence. The sappers had made adepts who were only too happy to oppose to the new regulations the knowledge they thought they had gained on the battlefield, and the writer states that early in 1916 his divisional general insisted on his constructing two closed works which realized completely the definition of "shell-traps."

In the December, 1915, Instructions organization in depth was accentuated, and in each *position* there were to be three *lines*—first line, support line and line of keeps. The pre-war arrangement of positions was abandoned and the advanced position had disappeared. The first, or position of resistance, was sometimes doubled by an intermediate position some two or three kilometres in rear, the defence of both of these falling on the infantry divisions in the sector. The second position, five or six kilometres in rear of the first, was held by the reserve Divisions of the Corps or Army, and sometimes a third position was made five or six kilometres in rear of the second, and garrisoned by the reserves of the Army or groups of armies.

In February, 1916, when the attack on Verdun began, the 1915 Instructions had not been completely applied, but the importance of camouflaging the occupation of a position was again demonstrated. The uncamouflaged centres of resistance were at once demolished by a bombardment of an intensity hitherto unknown, the flanking arrangements were destroyed and large gaps opened in the entanglements protecting the passive intervals, by which the enemy entered and turned the centres which still held out, much as in August, 1914. Also, owing to the omission of the advanced line the enemy was able to act with full power on the main position, and the suddenness and violence of his attack entailed heavy losses. At the beginning of the battle the weight of the artillery preparation at first led to admitting the impossibility of holding the first lines, and to considering the counter-attack as the sole means of resistance. The system of partial counter-attacks across the open against an enemy under cover was usual at Verdun in March and April, 1916. A valuable instrument of defence, it must not be hasty, disconnected and only beat the air, but must have a perfectly definite aim, and

be supported by infantry and if possible by artillery fire, and for these reasons should start from a pre-arranged position.

The battles of Verdun and the Somme quickly modified once more the conception of the power of resistance of the lines. A note by G.H.Q. of 3rd April, 1916, lays down formally the principles of the "infrangibility of the front," which can be obtained first by camouflaging the occupation which induces the enemy to disseminate his artillery preparation fire, and so diminish its intensity. (However, camouflage gradually became more difficult as aerial observation improved, but both at Verdun and on the Somme lines of snipers extended in shell-holes escaped the attentions of the enemy owing to the natural camouflage afforded by the numbers of shell-holes.) Second, by counter-preparation by the artillery. Third, by distributing in depth the troops entrusted with the defence, and organizing a step by step defence, for infrangibility of the front does not imply infrangibility of one line. Fourth, by foresight and pre-arrangement of the counter-attack, which is no longer considered as the beginning and end of the defence, but as a useful supplementary aid in case of rupture of a line. Lastly, the experience gained at Verdun of centres of resistance separated by passive intervals led to the adoption of a more continuous defence.

The Instructions of August, 1917, were inspired by these lessons. By them the position should consist of a series of centres of resistance connected with each other. The centre of resistance consisted of combat groups, grouped to form well camouflaged supporting points. The distribution of troops was not uniform and continuous, but the intervals between the active portions of the line were watched, and practically the passive interval had disappeared. Lastly, the era of camouflage had opened out. The great discovery of August, 1917, was the combat group, the practical value of making *the automatic arms protected by a few men* the backbone of the defence, since experience had proved that the section commander alone could exercise command, and then perhaps not over the whole of his section; it was the commander of the combat group only who could effectively command, hence the combat group became the elementary cell of the defensive organization. For reliefs, discipline, the transmission of orders and information, and for these purposes only, a certain number of combat groups were placed under one chief. It is unfortunate that the terms "centre of resistance" and "supporting points" were retained for these larger bodies; they awake in the mind ideas which had better be forgotten, and it is to this terminology that may be attributed the issue of some recent plans of defences showing centres of resistance and supporting points surrounded by girdles of entanglement which are non-existent at the present day —the girdles even emphasized by bands of colour which seem to

isolate the supporting points in the defensive system. That the want of exactitude in the nomenclature has received attention is evident, since some armies have coined new terms such as district (*quartier*) or sub-district (*sous-quartier*) for collections of combat groups of the strength of a battalion or company respectively.

From the teaching of actual experience it is proved that the passive zones are the danger points by which the enemy can often penetrate to act on the flanks and rear of the active zones, and it would be of great advantage if these passive intervals were formally forbidden. The August, 1917, Instructions are not definite enough on this point, they do not clearly insist on a continuous defence for fear that it may lead to a uniform distribution of force, but on the other hand in most cases such a distribution has to be adopted, since the resistance of the front must be uniform, and the want of definiteness in the instructions only complicates matters, while the defensive organization should be as simple as possible if it is to be grasped by infantry, who have little time for study, at any rate in time of war.

The August, 1917, Instructions made no alteration in the principles of the employment of the positions. Resistance is always to be made on the first, and the lessons of Verdun and the Somme led to the active construction of third positions, and to increasing the distances between the positions, with a view to preventing the enemy artillery preparation from taking effect on two consecutive positions without the necessity of changing the position of the guns. Six to eight kilometres in lieu of five to six is therefore laid down as the distance between positions, but further experience will prove that this does not meet the new offensive methods.

From October, 1917, to March, 1918, works of defence were pushed on with activity and appliances hitherto unknown, in preparation for the formidable attack expected in the spring when the enemy should have collected all the troops liberated by the defection of Russia. The principles laid down in August, 1917, were everywhere applied. The characteristics of the offensives of the end of 1917 (the British attacks at Cambrai) and of 1918 (German attacks of March, May and July) were the surprise obtained by the use of tanks on the side of the allies, and the extensive use of smoke and gas shells by the enemy. The results of these new methods were that, by means of heavy and sudden attacks, the assailant overwhelmed the first positions, and often arrived at the second before the defenders supplied by the reserve infantry divisions of the Army Corps. Thus on 27th May the enemy was able in a short time to overrun the first position on the Chemin des Dames, cross with rifles slung the well-organized but unoccupied positions on the southern slopes of the Aisne, and in a few days reach the Marne. It would be an exaggeration to say that this far-reaching success was solely due to defective methods of defence; there were other

causes, in particular the small number of troops in line and in reserve, for—and this requires emphasizing—in fortification as in many other matters the cheapest article is often the most expensive, the economy of force which a sound system of defence allows to be realized must not be allowed to pass a certain limit under penalty of becoming dangerous and sometimes very costly. However, if the principles of organization of a position were not invalidated by these bitter experiences, it must be allowed that the distribution of positions behind one another, and above all that of the troops entrusted with their defence, as laid down in the Instructions of August, 1917, did not meet the case of the sudden heavy attacks of the period, and again that in the position itself the necessity was felt of more continuous defence in order to escape penetration.

To deal with the new methods of offence it was laid down that the simple look-out lines must be replaced by a true outpost position, that the position to be held, the position of resistance, must be at some distance from the enemy's front, and that these two positions must both be held by the divisions in the sector. The position further in rear, the old second position, became the *barrage* position, and was in future to be manned by a simple safety garrison (*garrison de sûreté*), taken from outside the divisions in line, until the arrival of the reserve formations which should start from this position to reinforce the position of resistance, or recapture by counter-attack lost portions of that position. The *barrage* position, as its name indicates, would also constitute a *barrage* in case of rupture of the position of resistance.

All these guiding principles are to be found in notes from G.H.Q.; the following examples will show how they were put into practice. In the Fourth Army at the time of the attack on 15th July, there were no communications or notes illustrating the principles, but their application will remain one of the most memorable tactical events of the war, and was of the greatest use in the re-establishment of the situation. The methodical retreat from the position of des Monts, which had become an outpost position, on admirably organized positions of resistance, and the stubborn resistance on the new position, arrested the left wing of the German attack, and allowed of launching the counter-attacks which the two victorious battles of the Ourcq and Marne actually were. In the Third Army, just before the enemy's attack of 7th June, the army commander reminded the troops that success in the battle depended upon the inviolability of the position of resistance. The first line troops must fight for the retention or recapture of that position; they were not distributed in depth to resist on successive lines, but to constitute reserves intended to fight on that position by reinforcement or counter-attack. The decisive event of the battle would be the counter-attack delivered against the

enemy's troops when broken before the position of resistance, and would be carried out by the divisions in reserve, which, as far as possible, would not be engaged in the preliminary battle. Two days later the third German offensive commenced, and a few days afterwards General Mangin on the left of the Third Army launched his divisions in a counter-attack on the German right, stopped their advances on St. Just and Compiègne, and for the third time reduced their hopes to nothing.

From the documents just reviewed the organization based on their teaching may be stated as follows :—

A covering position to stop partial attacks, and to delay or break up larger ones. It is defended by a third or a quarter of the infantry divisions in the sector.

A main position of resistance, at least 2,000 metres from the enemy, on which the enemy must be beaten. It is held by two-thirds or three-quarters of the infantry divisions in the sector.

A *barrage* position 6 or 8 km. from the enemy, destined to put a limit to his success, and defended by the reserve divisions which must be stationed as close to the position as possible.

In this distribution the rôle of the positions corresponds to that of the lines in the position. The covering position corresponds to the outpost line, the position of resistance to the line of resistance, and the *barrage* line to the line of strong points, and lastly, the *barrage* position, like the line of keeps, should limit the enemy's progress, and furnish formidable counter-attacks. The principles of the Instructions of August, 1917, are consistently applied, at the same time the defence should be more continuous, and the passive zones or intervals should be suppressed. The normal combat group is the half section, and can be isolated, since it possesses all the infantry appliances. Thus the defence can be drawn tighter without increasing the effectives.

It will now be of interest to formulate the general principles which have governed this evolution; strong points separated by intervals have failed, while continuity of the defensive line is confirmed. The pre-war principle of withdrawing the main position of defence from the immediate neighbourhood of the enemy, and covering it by advanced posts has been returned to. Adverting to the comparison of centres of resistance to the bastions of an *enceinte* we see that at first these bastions, filled with defenders, were isolated; then early in 1915, the curtain, *i.e.*, the continuous trench, was constructed, and futile attemps were made to disguise the too conspicuous bastions. At last, after two years of trial, in August, 1917, the bastions disappeared, and gave place to smaller works scattered along the wall, *i.e.*, along the passive intervals; these are the combat groups hidden in the network of entanglements and trenches.

PROFESSIONAL NOTE.

TESTS ON BOX GIRDER BRIDGE. Designed by MAJOR G. LE Q. MARTEL, D.S.O., M.C., R.E.

(CONTRIBUTED BY THE R.E. BOARD.)

SINCE the report on this bridge, published in the *R.E. Journal* of July, 1921, the following tests have been carried out :—

(i.) *Light Bridge.*—2 girder ; 96 ft. long ; 93 ft. 6 in. clear span.

A pontoon wagon drawn by six mules and loaded with two ton on each axle was passed over the bridge.

The deflection was :—

1st run, 1½ in.
2nd run, 1 in.

It was noticed that there was a slight vertical vibration on the bridge. It is thought that stiffeners may prevent this, and they will be tried at the next opportunity with a 96 ft. bridge. (*Photo* I. shows the load crossing the bridge).

(ii.) *Tank Bridge.*—3 girders ; 48 ft. long ; 47 ft. clear span.

A Medium B tank (17 tons) was first passed over the bridge. The deflection was 1 in.

A 35-ton tank was passed on to the centre of the bridge and caused a deflection of 1½ in. only.

The bridge was quite rigid under the load.

There were horn beams at one end of the bridge only.

(*Photos* Nos. II. and III. show the two tanks on the bridge).

(iii.) *Launching.*—48 ft. long girder.

The launching gear consisted of a 20-ft. derrick, 9 in. in diameter with haulage tackle of 3-in. cordage on treble blocks and a preventer tackle of 3-in. cordage on treble and double blocks.

No difficulty was experienced in launching.

In Major Martel's notes he advised the erection of shears on the near bank to lower on to its seating.

In launching this girder it was thought that the horn beam would run down the rollers safely if the girder were held by the preventer tackle. This was tried three times and each time was successfully done, but on the last occasion, due to a faulty wire rope connection, the preventer broke. In this operation care must be taken to get a firm bearing for the rollers so that they are not pushed backwards when the horn beam comes on them. The rollers are also a little too narrow for this operation and rather too light.

A new design of roller is being got out which will make this operation quite safe for longer spans. This will save much time in launching.

(iv.) *Launching.*—96 ft. long girder.

The weight of the girder is about 8 tons. The launching gear was as under :—

Derrick—round spar 24 ft. long, 15-in. diameter.

Back guy—3-in. wire rope.

Side guy—2-in. wire rope.

Back anchorage—12 in. × 12 in. × 16 ft., buried 3 ft. 6 in. in ground.

Hauling tackle—3-in. wire rope on treble blocks.

Preventer tackle—4-in. cordage on treble and double block (no wire rope being available).

Preventer anchorage—12 in. × 12 in. log behind eight 2—1 picket holdfasts.

Hauling gear—5-ton winch, no other being available.

Preventer winch—5-ton winch, no other being available.

Lashing at head of derrick—9 turns of 1¼-in. wire rope, no derrick straps being available.

Rollers—Fixed rollers as designed for this bridge.

It took a long time to rig up the hauling gear as it was all extemporized material.

(*Fig.* 1 shows the launching gear as erected).

(*Photos* Nos. IV., V. and VI. show the girder being launched).

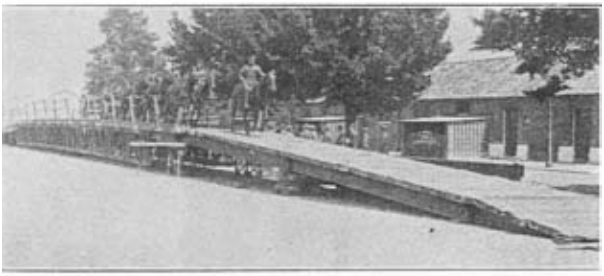
It was thought that the girder would be very whippy on account of its depth being so small as compared with the span, but this was not the case as no sign of unsteadiness was noticed and during the launching the girder could easily be controlled to an inch. When the centre of the girder was on the bank seat roller, and consequently the whole weight of the girder taken at the centre, it was noticed that the ends deflected about 2 ins. ; the top boom was then in tension and the bottom boom in compression.

It is not considered that this deflection during launching is excessive nor that any stiffening is necessary during launching for this span. It took an hour to get the girder across, but this was entirely due to the fact that only 5-ton winches were available and they are much too heavy for the job.

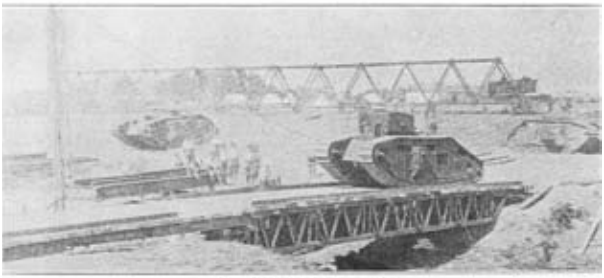
With 2-ton winches the girder could be put across in a quarter of an hour.

(v.) The handrail of this bridge is being re-designed, and further tests are being made to ascertain the effect of stiffening-frames and sway-bracing on the longer span bridges. Additional trials will also be carried out to test the maximum safe length of bridge attainable for each class of load.

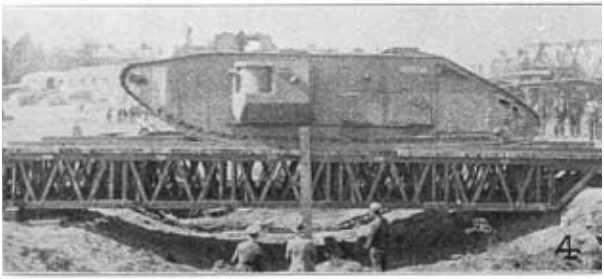
TESTS ON BOX GIRDER BRIDGE.



1.—Box Girder Bridge
96' long—2-girder bridge. Load—6 mules and 2 tons on each axle.

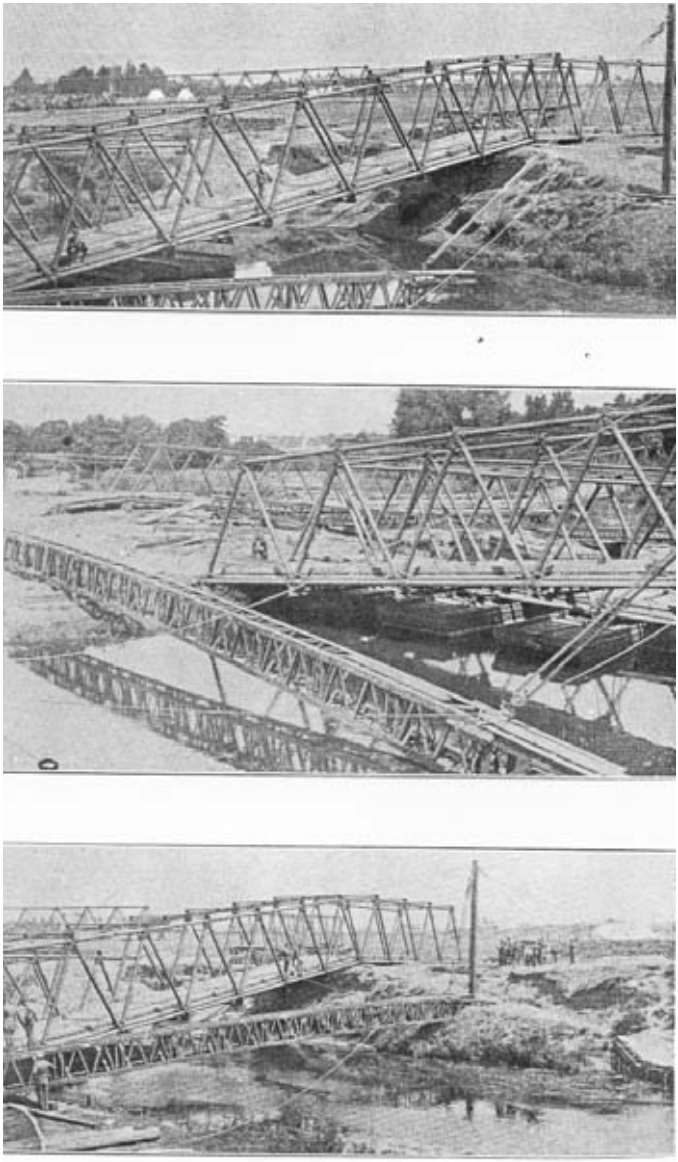


2.—Box Girder Bridge.
48' long—3-girder bridge. 17-ton Tank on bridge.



3.—Box Girder Bridge.
48' long—3-girder Bridge. 35-ton Tank on bridge.

GIRDER BRIDGE



4, 5, and 6.—Box Girder Bridge.
Launching 96' girder.

GIRDER BRIDGE

BOX GIRDER BRIDGE. LAUNCHING DIAGRAM FOR 96FT. GIRDER.

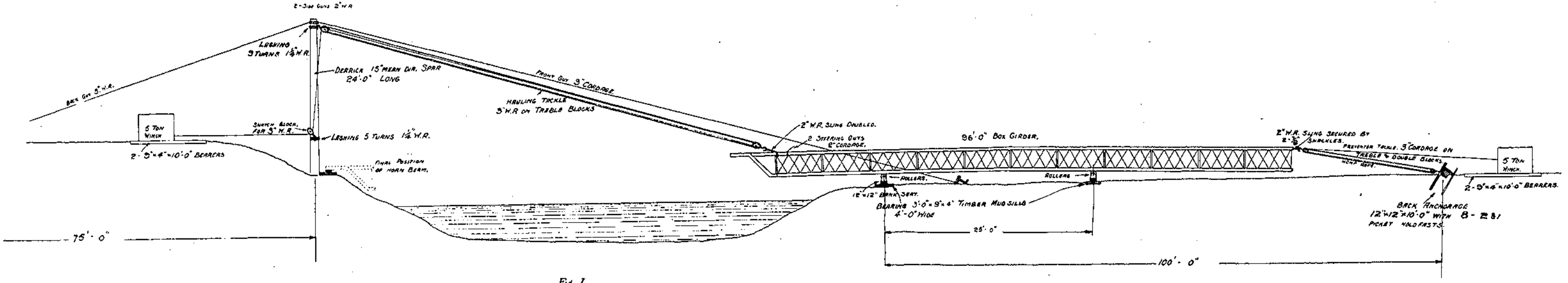


Fig. I

MEMOIR.

MR. WILLIAM JOHN SAMPSON.

It is with the deepest regret that I record the sudden death of Mr. W. J. Sampson, Sub-Editor of this *Journal* and Chief Clerk in the office of the Secretary of the Institution of Royal Engineers, which occurred at Gillingham in the early morning of the 6th September, as the result of an operation. This regret will be shared by a very large body of all ranks of the Corps. Mr. Sampson's long service in the office at Chatham, extending over 36 years, made him known to a large proportion of those who passed through the School of Military Engineering, and his unfailing courtesy and readiness to give unstinted help to all who asked it of him cannot have failed to win him the respect and gratitude of very many. He had become almost an institution at Chatham, and in many semi-official and social matters his advice and assistance were almost invariably sought. He possessed two qualities of the greatest value in such matters, almost unbounded knowledge and experience of all that concerned the personnel of the Corps, and the greatest energy and capacity for getting things done. His energy and activity to the last are the more surprising in view of the grievous state of his bodily health which was revealed in his last illness, but of which his cheerful and loyal personality would allow no sign to appear. His zeal for the *Journal* was immense, and his pride in it, which in its present form he had nursed from its first number, was almost a fetish. He had many influential friends and I believe he could have obtained with ease employment far more lucrative, but he was deeply attached to the *Journal* and I am sure that it was as he most desired that death should have found him at his post and engaged upon the work which he so loved and honoured. He took especial pride in the punctuality of its appearance and it is pleasant to look back upon the oft-recurring comedy when important "copy" would arrive at, and even beyond, the eleventh hour. It would be met by him at first with a mask of absolute impossibility, to be followed by most helpful collaboration and finally by such energy and management as could not fail to produce the amended number with its usual punctuality. His intimate knowledge of all branches of the printing and publishing profession was invaluable and he always gave of his best and in the most gracious manner. It is hardly too much to say of him that "he has made a chasm which . . . nothing can fill up."

F.E.G.S.

REVIEWS.

HINTS TO TRAVELLERS (10TH EDITION).

(Two vols.). Published by the Royal Geographical Society. Price 21/- net. (To Fellows of the Society 15/-).

In a Preface to the Tenth Edition of this indispensable *vade mecum* for explorers Mr. Arthur Hinks explains that the first volume, "Surveying and Practical Astronomy," has received no serious alteration, a few passages only that were obsolete have been omitted, and brief references to new methods, such as Longitude by Wireless Time Signals, have been inserted. This volume, it may be remembered, contains a grateful tribute by the author, Mr. E. A. Reeves, Map Curator and Instructor in Survey to the Society, to the assistance he had received from Sir Charles Close's standard work. In the second volume the notes on Photography have been thoroughly revised, a note on Anthropology has been added to the Natural History Section, and the memorandum on Glacier Observations has been revised. The Medical Hints which occupy 130 pages have been practically rewritten. Other interesting sections are on Meteorology, Geology, Industry and Commerce, Archaeology, Canoeing and Boating, Orthography of Geographical names, all written by first-rate authorities. The book has been placed in the Corps Library.

F.E.G.S.

MATÉRIELS ALLEMANDS ET AUTRICHIENS À GRANDE PUISSANCE.

(Paris, Berger-Levrault, 7.50 francs.)

This apparently official book—there is no indication of authorship but it is stated that "This study replaces the 'Notice sur les matériels allemands de gros calibre du 14. 7. 1917'—describes and illustrates with 117 Diagrams and Plates the German and Austrian guns and ammunition of 5·9 inch calibre and upwards, with their means of transport, platforms, etc. It forms a valuable book of reference at a very low price, and seems very complete except as regards the 21-cm. long-range gun which bombarded Paris in 1918. With reference to this only conjectures are offered, "on possède peu de renseignements sur la pièce" and "contrary to the stipulations of the protocol of the armistice accepted and signed by the German plenipotentiaries on 11th November, 1918, the Germans have not handed over to France any of the heavy guns which fired on Paris."

J.E.E.

NOTICES OF MAGAZINES.

JOURNAL OF THE SOCIETY OF ARMY HISTORICAL RESEARCH.

Whether the world itself is large enough to contain another Society or to support another Journal, may be a matter of conjecture, but the movement which is on foot in the Secretary's office of the Royal United Service Institution to form a Society of Army Historical Research will find many sympathisers. The proposal had almost materialized in August, 1914, and was recently reconsidered, with the result that a subscription list was opened at 10/- a head, and it was decided that if 80 subscribers were obtained two experimental numbers of a Journal, each containing 32 pages, should be published. The appeal produced 153 subscribers, and the first number of the Journal appeared on the 1st September. It bears the high standard of the publications which emanate from Sir A. Leetham's office, and has an attractive title-page copied from the English translation, published in 1560, of Machiavelli's "The Art of Warre." The contents are full of interest and the Journal, if it receives the support which it deserves, should become a military *Notes and Queries* which may be counted upon to contain information not only interesting but of high historical value. Major H. G. Parkyn, O.B.E., is Honorary Secretary of the new Society.

F.E.G.S.

MILITAR WOCHENBLATT.

No. 5.—*Law Dealing with Care and Re-settlement of Ex-members of the Reichswehr.*—In view of the fact that the officers of the Reichswehr will normally serve for about 25 years, and the other ranks for 12 years with the colours, it has been thought necessary to make special provision for them when they shall return to civil life. Help will be given under many different headings and the scheme has been devised so as to cover every deserving case. Re-settlement on the land is made a great feature. Officers' pensions seem to be on a fairly liberal scale, rising from 35% of their pay on retirement after a minimum of 10 years' service, to 75% after 35 years. The latter will, however, be only rarely attained.

The Sinking of the German Fleet at Scapa Flow.—"In the rush of events connected with the collapse of Germany, the passing of the German Fleet into internment passed almost without any outward expression of feeling; when, however, Admiral Reuter saved the victors of Jutland from ignominious surrender by sinking them to the bottom of the sea, the nation saw that its honour was saved and breathed a great sigh of relief." This is how the *M.W.B.* comments on Admiral Reuter's description of his exploit, which has just been published. The Admiral declares that the English officers never really believed that the German Fleet would actually arrive across the North Sea, and, as a patriotic

people, could not understand how such a miserable surrender could be made. The actual sinking was a difficult task, because the fleet was permeated with revolutionaries, whose interference had to be carefully guarded against.

No. 6.—*The Austrian Defence Force.*—Further progress has been made with its re-organization. By new pay regulations 19 rates of pay are instituted, to cover all ranks from private to general; the rates, however, depend on employment and not on rank. The whole cost of the force amounts to 3% of the national income, or rather of the national expenditure, which is a very different thing. Out of 49 milliards estimated national expenditure, pensions, etc., absorb 14 and food subsidies 10½ milliards, while the defence force uses 1½. Rations have recently been improved considerably, at a cost of 100 millions, and are now quite good. Insurance for all ranks is compulsory and, for all except the private soldier, is on a contributory basis.

The Soviet Army.—This is credited by the *M.W.B.* with a total of about 450,000 men, divided into six main army groups, as follows :—

In the neighbourhood of Petrograd	45,000
Between the Duna and the Pripet	90,000
South of the Pripet	100 to 150,000
In South Russia, excluding Budienny's Cavalry Army ..	40,000
In the Caucasus	70,000
In Siberia	70,000

The value of the Armies has considerably improved, thanks to the way Trotsky has been able to utilize the services of the old officers, and especially of Brusiloff, who is now reported to be in charge of large movements in the neighbourhood of Novo-Tcherkask, and Tzaritzin, destined to help the Nationalist Turks. So long as this unnatural alliance holds, the *M.W.B.* does not expect any attack will be made on Poland.

No. 7.—*The Raid of the 5th French Cavalry Division during the Battle of the Marne* (1914).—This division formed part of Sordet's cavalry corps which was under General Manoury's orders during the Battle of the Marne. It was still quite exhausted by the exertions of the past month, but nevertheless was ordered to send one division round the German right flank, to fall on von Kluck's rear about La Ferté Milon. The 5th Division accordingly rode off, and got right in rear of the Germans. The French declare that its action was of great importance, and that to it von Kluck's decision to retire was largely due. This opinion is strengthened by the story of a meal, prepared for 42 officers of von Kluck's headquarters at the Château of Ancienville, and left untouched because of the approach of the 5th Cavalry Division.

General von Kuhl, who was von Kluck's chief of staff, disposes of the dinner story by declaring that he was with the staff the whole time, and that they never entered Ancienville. As regards the influence of the cavalry on von Kluck's decision, he declares that what took place was as follows :—On the afternoon of the 8th September the whole of Army Headquarters was moving towards La Ferté Milon, so as to be in close touch with the right flank, where a decision was to be sought on the following day. As the long string of motor cars was nearing its destina-

tion some surprise was expressed at not seeing the heads of the columns of the IXth Corps, which were then expected. At the same moment a few gunshots were heard not far off, and the presence of hostile cavalry was at once suspected. The whole of the Army Headquarters got ready to defend itself, and some officers were sent out to reconnoitre. Before, however, these could get any touch with the French the head of theIXth Corps appeared on the scene, and was followed into La Ferté Milon by the Army Headquarters. Von Kuhl says it is true that the cavalry nearly captured Army Headquarters, owing to the carelessness of the latter in pushing ahead of their infantry, and a wonderful opportunity was let slip, but as things turned out their presence had no influence on von Kluck's decisions. The latter, as is well known, were due to the intervention of Lieut.-Colonel Hentsch and the withdrawal of the 2nd Army.

The cavalry spent the night of 8th/9th September about six km. N.E. of La Ferté Milon and marched off westwards to Verrines on the 9th. A few ammunition and supply columns were diverted or delayed on account of their presence, but there were no other results.

Von Kuhl says he was very much afraid that French cavalry would make a dash for the Aisne crossings about Soissons and that he despatched the 4th German Cavalry Division to forestall any action of this sort. He thinks that the raid as a whole was badly conceived and badly carried out, and that the proper place for the French cavalry was the decisive point, *i.e.*, the left of Manoury's army, and not on a wild-goose chase in the forest of Villers-Cotterêts. Above all was it the duty of the French cavalry to hold off Lepel's brigade, which was advancing from Baron to Nanteuil-le-Houdain and threatening Manoury's rear.

It is, however, difficult to see how the 5th Division could, without the most extraordinary good luck, have known of the proximity of von Kluck's Headquarters or be blamed for not going for the Aisne crossings, when a general German retreat was the last thing anyone was expecting. As for the German cavalry, von Kuhl says it was wrongly placed from the first, and in consequence was absent at the decisive moment, and did not fulfil the hopes that had been fixed on it.

Treaty between Poland and Roumania.—The *M.W.B.* is surprised that Roumania has identified herself with Polish interests. While she must sooner or later settle with Russia regarding the frontier of Bessarabia, yet her claims are so strong in this respect that she will almost certainly make them good. Poland, on the other hand, will never be able to maintain her eastern frontier, and does not deserve to do so. Roumania has, therefore, associated herself with a losing cause which even the French cannot support, without any adequate compensations, and Poland will be led once more to ignore realities and take up an impossible line of action.

No. 8.—*The Supply Situation in the German Armies on the Western Front in November*, 1918.—General Groener who was responsible for food supplies, told the Kaiser in November, 1918, that the German armies were in danger of starvation. This statement has recently been criticised and one writer has declared that stocks, that would have maintained the armies for several months, were left behind to fall into the hands of the Allies. The experience of the British Army certainly does not bear this

out, and the *M.W.B.* declares that Groener was quite right and that the armies were living from hand to mouth. Oats were practicablly unobtainable, and the condition of the horses was deplorable. Much embarrassment was caused by the terms of the agreement made with the Spanish-Dutch relief committee, which prevented proper exploitation of the resources of the occupied territory, and the revolution in Germany prevented the free movement of such supplies as were to be found in Germany.

No More Medals.—The Government has decided that no more medals are to be issued, even for life-saving, long service or any other reason.

Concealment of Arms.—Colonel Repington's statement, in the British Press, that many Germans are willing, for various reasons, to give away the hiding places of arms, and thus facilitate the work of the Allied Missions of control, makes the *M.W.B.* very sad. It says that no Englishman, Frenchman or American would act in such a way, and that Germany can never rise so long as she harbours such traitors.

No. 9.—*Re-Union of Front-line Fighters.*—A big meeting was recently held in Berlin to bring front-line fighters together again. General von der Goltz made a speech welcoming them, and General Ludendorff also. After much music, cheering and patriotic demonstrations the meeting, at which 25,000 men were present, dispersed.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE DU GÉNIE MILITAIRE.

March, 1921.

French Engineers in Poland, April to November, 1921.—This article describes the training of and the work done by the Engineers of Haller's Army. These engineers consisted of Poles from America, Polish prisoners of war captured on the French and Italian fronts, and a few French officers and N.C.O.'s. Descriptions are given of the construction of four bridges of 100, 70, 52 and 20 metres respectively.

April, 1921.

The Protection of Military Buildings against Fire.—Questions of construction are gone into, also fire fighting appliances, and finally fire discipline.

Organization of Work.—French Headquarters laid down very little about this subject—(1) Too great dispersion removes the men from the immediate and actual control of their officers; (2) work should be prepared and regulated.

Preparation means making a definite plan, marking out the work and supplying tools and materials before the arrival of the men.

Regulation means carrying it out as a military operation, under the orders of officers and ensuring continuity.

Organization requires (*a*) *orders*, which must be capable of being carried out; improvisation is the negation of organization. These orders must contain the result required and orders as to execution with details of personnel, material, transport, routes, etc. (*b*) A *definite plan*,

which must include the task of each unit and should be prepared by the commander concerned. (*c*) A *reconnaissance* of ground, resources, the conditions under which the work is to be carried out, transport difficulties and dumps. (*d*) A *commander* not to be changed during the progress of the work. Dual control must be avoided. This commander should be the commanding officer of the personnel.

Hence it is better to give a definite task to a complete unit rather than to detail so many men to a task.

Preparation of the Work.—1. The commander must get into touch with the man for whom the work is being done.

2. The commander should prepare his plan based on reconnaissance of ground and material, the order of urgency, the successive arrival of stores, and should arrange for a reserve both in men and material.

3. He will prepare detailed written orders for each task to avoid any possibility of mistake.

4. He will ensure continuity of work by arranging for (*a*) the tasks to be marked out; (*b*) the arrival of tools and materials; (*c*) the arrival of the personnel as required; (*d*) he will get into touch with the personnel to direct operations and to clear up doubtful points; (*e*) he will continually superintend the work so as to know progress, to equalize the work by using his reserve, to ensure the best use of his resources, to improve the organization and to develop the interest and the work of the personnel; (*f*) he will obtain progress reports which should be reports of total work done to date and not of work done per relief.

Execution.—This depends for success on the suitable subdivision of the work down to corporals and lance-corporals, the use of the right men for the right job, on avoiding alterations in the plan, and on constant supervision. Give immediate praise when deserved, never give too large tasks and give rests at regular intervals.

The Use of Engineers.—The engineer is the reserve to the Command and the help of other arms. He makes out the programme, prepares and, if necessary, shows the work to be done, takes his share of it, supplies materials and gives technical advice.

He should ensure continuity of work at times of relief, organize the work for the Infantry, but leave the carrying out of it to them under their own officers whilst supplying them with tools and materials.

More technical work, such as certain shelters, bridges, concrete engines, tracing of trenches, communication trenches, obstacles, demolitions, drainage, etc., may be given to him to do.

Also certain works of general use not actually in the sphere of any particular troops, such as main C.T.'s, roads, huts, command O.P.'s, Headquarters of Brigade and higher formations, aid posts, wells, streams, etc.

Also in cases of extreme urgency the engineer can be used as a reserve of labour.

The principal of engineer supervision by individuals is thoroughly unsound. On the other hand, an officer or N.C.O. can be very useful for *liaison* work and to ascertain requirements. He gives the Infantry the impression of material and moral help and at the same time keeps in touch with the situation on the front and the progress made.

Individual supervision leads to dispersion without increasing results, as it destroys the fundamental principal, the responsibility of the commander.

Engineers are troops like any other and should work in definite units under their own officers, the smallest, the section; the normal, the platoon; the ideal, the company.

Engineers are never numerous enough to undertake all that has to be done at the same time, consequently the commander should lay down an order of urgency and the numbers necessary for a task should be definitely earmarked for it.

If, as occasionally may happen, engineers have to be lent to another arm, it should not be so many men, but such a unit for a definite period.

At other times other units have to be attached to the Engineers to leave the latter free for technical work, and in this case each unit should have definite orders from one commander.

There are two extremes—battle, and stationary warfare—and the situation may be anything between these.

In the former the one objective is to obtain quickly a first result which may be improved later; the troops are ignorant of the ground, the work is urgent and under fire. This requires complete tactical units with their officers and N.C.O.'s. In stationary warfare more dispersion is allowable to obtain the full advantage of trades, but control must still be kept.

The senior engineer officers of Divisions, Corps and Armies have a triple rôle to play: commanders of troops, technical advisers and control over material, workshops, etc. As commanders their functions are to save their men from all unnecessary fatigue and to obtain the maximum result from their work. As technical advisers they should participate in the writing of orders, and, as an integrate part of the staff they should be as much the general's representative on questions of work as the artillery commanders are on questions concerning the use of guns. They are not only there to execute orders, they should help in their conception. The framing of a good order necessitates knowledge of how to carry it out. The solution is the inclusion of the Engineer Commander in Command Headquarters.

The article concludes with some remarks on Taylor's and Gilbreth's attempts to hasten work by the elimination of useless or badly carried out movements.

C. LA T. T. JONES.

REVUE MILITAIRE SUISSE.

No. 4.—*April*, 1921.

The Evolution of Methods of the Offensive.—The original article consists of a paper read by Lieut.-Colonel H. Corda before the Sociétés d'Officiers of Zurich and Lausanne in March last. The author of the paper traces the course of events in the western theatre during the Great War. Military doctrines and technique, the objectives of an attack and the methods employed in carrying the same out, the armament of the troops, etc., were, he points out, continually undergoing change, but all

the operations of the war pivoted upon the old principles, which still remained immutable. Some of the most remarkable features of the war were those which were due to the great developments which took place in the scientific and technical spheres ; almost every new month brought with it some new invention in the fields of chemistry and physics to the aid of the belligerents. However, the new engines of warfare which made their appearance retained their value but for a very short time ; indeed, only such time as an opponent required to discover the appropriate neutralizing agencies, generally a matter of a few weeks only by reason of the high state of efficiency of modern industry. Although, on the one hand, resort was once more had to weapons of antiquity (*inter alia*, the catapult and the cross-bow), on the other, considerable advances were made in the design of new types of artillery, which continued to make progress in matters affecting the calibre, power, and range of the pieces. Again, whilst hand-grenades and incendiary methods of the middle ages were re-introduced, all the latest improvements in the field of chemistry, *e.g.*, poison-gas shells, were also called in aid. Finally, every means were taken to utilize the features of the terrain ; concrete and all the refinements of permanent fortification were adapted for the purposes of field defence ; contemporaneously, all the old methods of siege warfare were also again seen in full use. Although, in the final stages, the war was brought to a close as it had been begun, that is to say, without the use of wire entanglements, without resort to trenches and approaches thereto, and, practically, without the use of siege artillery, nevertheless, the war was essentially an engineers' war.

The object Colonel Corda had in view in preparing his paper was to indicate the process of evolution which was going on throughout the war in the tactical domain, and more particularly in relation to the developments which took place in the methods of the offensive adopted by the French Army. He traces the various steps by which, both in the French Army and in the German Army, it was sought to attain the effect of surprise ; he further deals with the problems which were, in consequence, put up to the artillery for solution. The paper is an interesting one, and in it are discussed the "problem of piercing the enemy's front," a subject which was so much debated during the three years that trench warfare lasted ; the experiences of the troops of the Entente during the first winter (1914–1915) ; the events of 1915 ; the great events of 1916—Verdun and the Somme ; the events of 1917 ; views held towards the end of 1917 as to the methods by which the enemy's front could be pierced. The operations at Riga on the 3rd September, 1917, when the then relatively new invention of poison-gas shells was made use of on a large scale, and those at Cambrai on the 20th November of the same year, in which 360 tanks took part, are touched upon. This part of the paper closes with a short account of the evolution of ideas on the subject of the defence, as matters stood at the end of 1917. (*To be continued.*)

The Strategical Position of Switzerland as a Member of the League of Nations.—The article on the above subject, by Colonel Feyler, begun in the March number of the *Revue*, is concluded in the number under

notice. The strategical position of Switzerland is discussed under two heads:—(1) in the circumstances existing at the present time; (2) as it will be if and when Germany is admitted to membership of the League. By the Treaty of Versailles the victorious nations have reaffirmed their intention to respect the neutrality of Switzerland, and have, at the same time, imposed upon the defeated nations a condition that they too shall do likewise. Austria has expressed her willingness voluntarily to accept this condition, but Germany holds out against it. Colonel Feyler points out that in these circumstances Switzerland is threatened, at the present time, with invasion along about 150 kilometres of her frontier, roughly from Constance to Basle; he discusses what dispositions of the Swiss Army would best meet the contingencies of an European War—should one take place in the near future. He next deals with the situation (in relation to Switzerland's strategical position) as it will be if and when Germany is admitted to membership of the League. It is evident that Switzerland's position to-day is very different to that created by the declaration of neutrality made in 1815. Colonel Feyler extracts, from the Declaration of London, the following as being the essential points bearing upon the rights and obligations of Switzerland:—(1) the principle of neutrality is incompatible with the principles of the League of Nations; (2) Switzerland is now placed in an altogether unique position; (3) the League must abstain from moving its troops through Switzerland and also from making military preparations of any kind upon Swiss soil; (4) but the Swiss people can no longer remain inactive, in a military sense, when the question of defending the principles of the League is involved. Colonel Feyler recognizes that it is for the Confederation to consider how the claim of the Swiss Government to sovereign rights in military matters is to be reconciled with the obligations imposed upon Switzerland now that she is a member of the League of Nations.

NOTES AND NEWS.—*France.*—A special correspondent contributes a note upon the provisions made in the Budget for the maintenance of the French Army. The estimated expenditure upon the French Army in 1921 is expected to reach the sum of 6½ milliard francs, an increase of 1½ milliards as compared with the expenditure incurred in 1920. On the other hand, there is to be some reduction in the establishment of the French Army; as compared with 1920 there will be in 1921 8,584 officers, 9,070 men and 6,229 horses less. The dispositions of the French Army for 1921 are stated to be as follows:—In France, Algeria, and Tunis, 28,052 officers, 416,876 men, and 116,735 horses; in Morocco, 2,912 officers, 102,234 men, and 29,761 horses; Army of the Levant, 2,384 officers, 76,877 men, and 23,460 horses; Army of the East (in Constantinople and neighbourhood), 532 officers, 11,544 men, and 2,236 horses; Army of the Rhine, 3,094 officers, 84,948 men, and 23,783 horses; in territory to which the privilege of self-determination has been granted, 370 officers, 10,000 men, and 3,600 horses; in the basin of the Sarre, 266 officers, 7,193 men, and 1,671 horses; special missions to foreign countries, 858 officers and 1,374 men.

W. A. J. O'MEARA.

THE INSTITUTION OF ROYAL ENGINEERS.

As a result of the great increase in cost of labour and materials, it has been found necessary to raise the subscriptions of Members from 1st January, 1921.

General Officers, Colonels, and Lt.-Colonels	£2 0 0
Majors	1 15 0
Captains	1 10 0
Lieutenants, 2nd Lieutenants, and Quartermasters ...	1 5 0

The subscription for Associate Members will remain as before.

The yearly rates to Non-Members of the Institution for the following publications will be as under:—

R.E. Journal	£1 5 0
Supplement	5 0
R.E. Quarterly List and *Yearly Alphabetical List*	10 0

Or, if all three be taken, £1 10s. od.