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OBSTACLES.

THEIR TACTICAL USE, CONSTRUCTION, AND METHODS OF DESTRUCTION OR SURMOUNTING THEM.

A Lecture given by Bt. Lt.-Col. R. N. Harvey, d.s.o., R.E., *to No. 5 Senior Officers' Class.*

There are many reasons why the subject of obstacles has never received from the Army generally that degree of detailed study to which it is entitled; but the chief one is, I think, that few of us have ever had any practical experience either in the true effect which an obstacle, sited and constructed on sound tactical principles, has on the troops of the attack, or of the degree of security which such an obstacle may confer on the defenders.

Before going further, I want to lay down the following axiom :—

Obstacles are divided into two classes,

(1). Obstacles for hasty defences, when the time available for work is limited to a few hours.

(2). Obstacles for deliberate or permanent defences.

This may appear to some a fairly obvious statement, but I have found, when discussing this subject with other officers, that the experience gained in recent wars on the use of obstacles, is applied indiscriminately, without any regard to the circumstances under which the obstacles were made or the nature of the operations during which they were used.

For instance, the suggestion that a hedge might be made into an efficient though surmountable obstacle in a hasty field defence scheme has been swept aside by a reference to the effect of an 11-in. howitzer shell or to the possibility of the destruction of the obstacle by a torpedo, both of which are methods connected with siege operations, or at all events with operations of a deliberate nature.

Any scheme for the construction of obstacles must be considered under the following heads :—

1. They must be properly sited.

2. The purposes for which they are required must be clearly understood by those who make them.

3. The proposals must have reference to the material, time and labour available.

4. The enemy should be credited with all reasonable means for destruction, or for crossing them.

The principles which govern the first of these are the same for

both hasty and deliberate operations, but those which govern the other three obviously vary in very great degree according to circumstances.

For the first head "Siting." The principles to be observed are :—

1. The obstacles must be under the close rifle fire of the defence.

2. They should give as little cover as possible to the attack.

3. If the defences are concealed, the obstacles must be concealed from view too, otherwise they betray the approximate position of the defences.

The term "Close fire" is one that requires definition. It is, I think, the maximum range at which the obstacle can be effectively commanded on an average dark night, say 100 yards; this distance may be reduced, but, if it is under 50 yards, an attack by grenades thrown by hand must be anticipated.

The defence of the obstacle against creepers on very dark nights requires special precautions, such as sentries, alarms, etc., but it is suggested that the maximum security will be given by constructing rifle pits close up to, or within the obstacles. These pits will be held by specially picked men sent out after dusk, and withdrawn just before dawn.

I want to lay particular stress on the importance of siting the obstacles. I think it is almost as important as the siting of the fire trench. Nearly all of us have suffered, at one time or another, from having to occupy trenches sited by officers who remained mounted, or even standing, when they made their decisions; all ranks are now impressed with the importance of siting fire trenches by assuming the same level of the eye as that of the man who will occupy the trench. So also in siting obstacles, it is of supreme importance to do so from the level of the eye of the man whose fire is to command them. Let us now consider how the remaining three heads apply to obstacles of Class 1, *i.e.* in a scheme for hasty defence.

The second head is the purposes for which the obstacles are constructed. These are four in number :—

1. To break up the attack.

2. To hold the attack under the close fire of the defence.

3. To direct the attack into avenues of approach which may be more advantageous to the defence.

4. In some special circumstances, to deny dead ground to the attack.

The third head deals with the details of construction of obstacles, and is so very closely connected with the purposes for which they are constructed that I propose to take these two heads together. The principles which govern the construction of obstacles are as follows :—

(1). They should exhibit an intelligent use of the material available.

(2). They should be so strongly made that a special effort is necessary to remove or destroy them.

(3). The material chosen must not give cover to the enemy.

We want to break up, hold, and divert the attack. The first thing to do is to look round and see what material is available. Now the question of material is important. There is no doubt that to the Army generally there is only one material—" barbed wire," in fact barbed wire is almost a creed with all ranks, and its popularity may be said to be universal, as proved by its use even by suffragettes in the defence of their platforms. I date this popularity from the days of the South African War when the blockhouse wire fences stretched as far as the eye could see, and the supply of wire was apparently inexhaustible.

Barbed-wire fences *were* certainly provided for innumerable posts, every line of blockhouses, and along miles and miles of railway, so that at the end of the war there was something between 50,000 and 75,000 miles of barbed wire available for the Boer farmers to re-fence their farms with, and there is little doubt that nearly every officer and man of the Army in South Africa had been intimately connected, in one way or another, with this material. As a matter of fact the supplies of barbed wire in South Africa were by no means inexhaustible, the local supplies in what may be described as a barbed-wire country lasted but a few weeks, and our demands on the home market could never be met without great delay.

Just after the South African War came the Siege of Port Arthur, with its lurid tales of the ceaseless storming of barbed-wire entanglements by the Japanese; and later on similar tales were told of Adrianople (these latter were mostly fables). With these object lessons, no wonder that all ranks still think in " Barbed wire," and that the letters B.W.E. are so frequently met with in all paper schemes of defence. " It's so simple " to put a lot of criss-cross lines on paper, and put these letters against them, with a note added " Obtained locally."

But what are the real facts of the case? Take an average piece of country—how much barbed wire is there to be seen? An odd strand in a hedge, perhaps a short length of two or three strands well bedded into growing stakes. The extraction of this wire is a matter of some considerable difficulty, and when it has been got out, it is the very devil to use. Anybody who has had to use second-hand barbed wire of this nature shies at it as badly as did the Boers when it was offered them for almost nothing for fencing their farms. Again local stores are no good. It was ascertained that the whole of the stocks in an ordinary country town amounted to less than 1 ton or 20 rolls, and enquiries during the manœuvres of 1913 proved that the total stocks of one of our large cities amounted to only 20 miles or 100 rolls.

It is therefore clear that we must try to get barbed wire out of our minds and look for something else if we want to make obstacles.

The resources of the country are therefore reduced to the material of the fences such as quick-thorn hedges, hop poles and hop-pole wire, perhaps some sheep hurdles, and nut bushes. Abattis made of quick-thorn hedge or nut bushes can be made an effective obstacle if it is of sufficient depth to prevent an armed man from clearing it in one jump, and strongly picketed down to prevent any chance of removal. This must be insisted upon. The depth should be from 12 ft. to 15 ft. and all pickets used should be really strong, about 2 ft. 6 in. long and 3 in. thick, and be driven till the fork at the head takes the ground. The usual run of picket provided by a military working party is a wretched affair, too weak to be driven, too short to hold, and too small in the forked head. Hop poles will make a *chevaux de frise*, or pointed stakes driven in the ground at close intervals will offer sufficient resistance to make a check in a rush; this is a revival of the tactics of the days of the English archers. Sheep hurdles and jubilee fences placed in rows at 5-ft. interval will, if firmly picketed down also form an efficient check to a rush. Brushwood hurdles cannot be used except in very favourable circumstances owing to the cover they give. All the above can be made very much more efficient if barbed wire taken in short lengths from the hedges is intelligently introduced. Hop-pole wire though plain is most valuable in making the abattis, etc., difficult to move.

With reference to concealing the obstacles of a hasty defence scheme:—There is no doubt that something in this line can be done by judicious siting from the attacker's point of view. Taking advantage of folds in the ground, placing them behind a line of fence, but I very much doubt whether the expedient of sinking them in the ground as outlined in the *Manual of Field Engineering* could ever be carried out except in very deliberate work. The destruction done by artillery fire to obstacles is not very serious. The Bulgarian shells at Adrianople were found to improve the wire obstacle.

The use of obstacles to deny dead ground which I mentioned has been applied in the manner shown in *Fig.* 1. *Fig.* 2 shows how the interval between New Pound and Highlands could have been defended on this principle.

Let us now consider the obstacles from the point of view of the attack.

We will assume that the field of fire is only 150 yards, which in a close country like this is not too pessimistic—and that at this distance orders are given for the assault. The officers and men see the obstacles in front of them. Will the G.O.C. order the destruction of the obstacles prior to the assault?

FIG. 1.

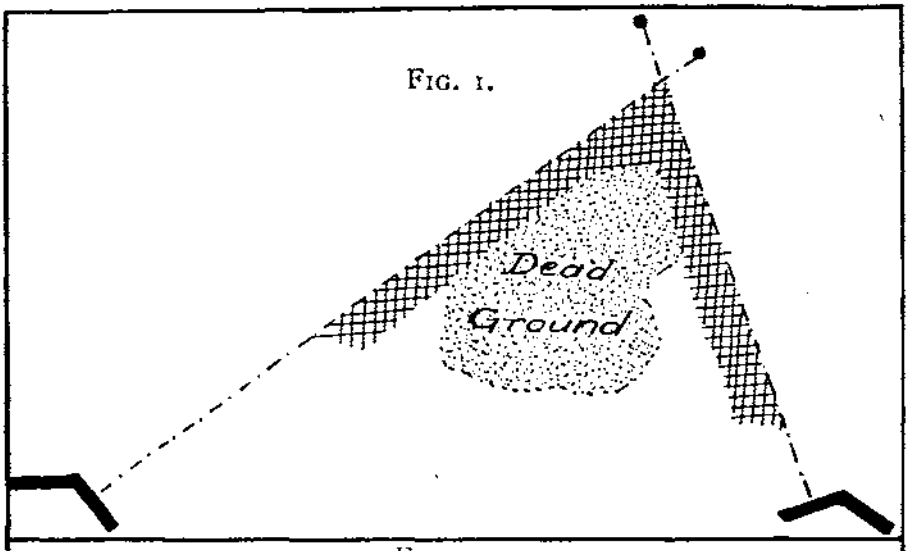
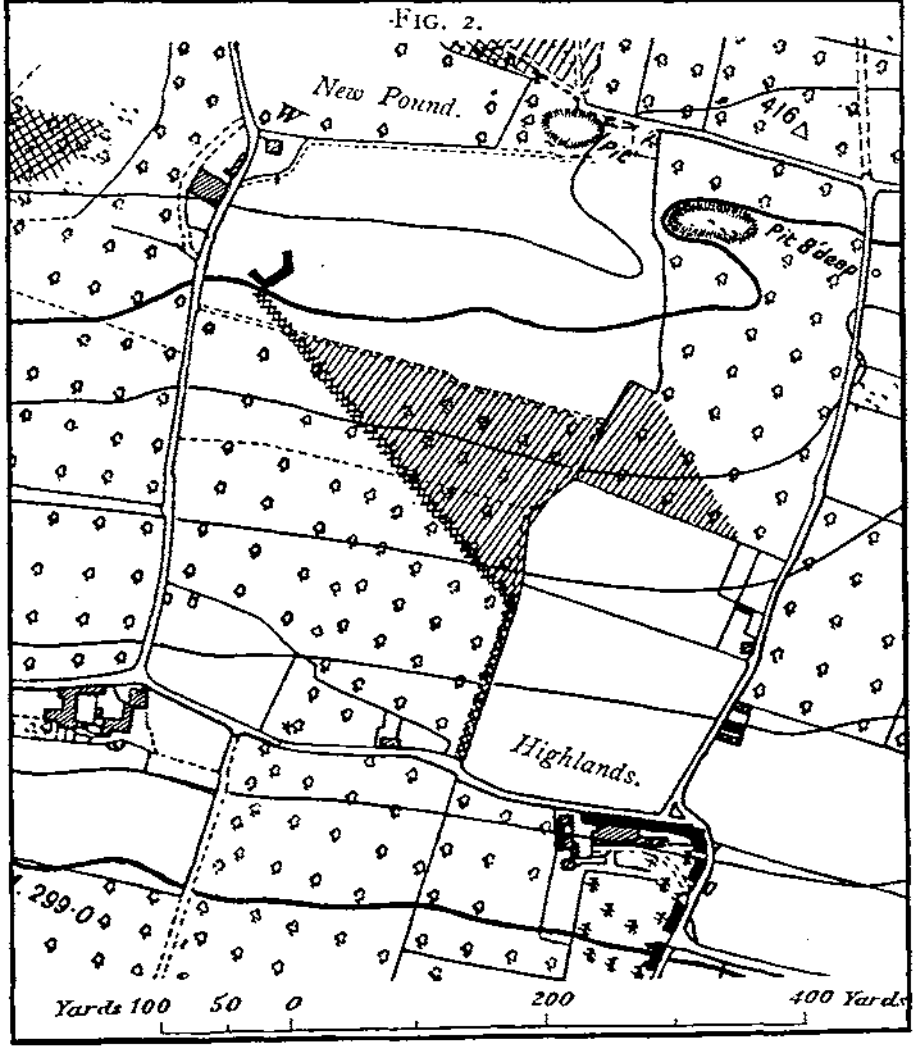

Dead
Ground

FIG. 2.


New Pound.
W
Pit
416△
Pit 8 deep
Highlands.
299·0
Yards 100 50 0 200 400 Yards

It is stated in the *F.S. Regulations* that the R.E. should be pushed forward to clear obstacles, but will the appearance of a field obstacle such as I have described above be sufficient excuse either for the almost certain decimation of the R.E. with the advanced troops, or the delay thus imposed on the assault, while the R.E. perform their task?

Will not a G.O.C. think twice about risking his skilled workmen when he may want them for far more important work later on in the campaign? Besides the feelings of the infantry have to be considered. The view of these field obstacles is by no means discouraging to them. They have also made these things in peace time and think they know their worth.

Let us now try to picture what part our field obstacle will play in the assault. First of all there will be a tendency of the men to edge off towards the intervals which will become more or less crowded. The troops who have to cross the obstacle probably rush and jump. Some individuals may clear the lot and continue their rush, but those who cannot jump well or do not get a clear run at it, land in it, and once in it the sting is taken out of their charge. Men who are wounded fall and struggle to rise, upset their comrades, and thus increase the efficiency of the obstacle which becomes slippery with blood, and thus generally speaking our obstacle is doing its job of delaying and holding the enemy under the close fire of the defender.

The delay caused at the obstacle prevents that perfect cohesion of the attack which gives success, for the troops at the intervals will not wait for those entangled in the obstacles at such short ranges; these again being probably rather crowded and affording a good target will have been subjected to the attentions of the machine guns of the defence. It seems therefore fair to assume that our obstacle has tended to break up and divert the attack, and the local reserve is close at hand to throw it back whence it came. In such circumstances there is no doubt that the existence of an obstacle has been justified.

Take the case when the assault has a clear run at the defence works. 150 yards should be covered in 30 seconds, and with no check intervening can the defence stop a determined assault within this limit?

I do not intend to dwell on the construction of obstacles for siege works—their purposes are the same, but with time and resources they can be made practically impregnable, or at least strong enough to induce such delay to the attack that sufficient time is given for the defence to develop any further resources it may possess.

The deep ditch is still the most formidable of permanent obstacles, but the ditch must be provided with flanking fire. This was most forcibly impressed on military engineers by the experiences of the Russo-Japanese War.

Other forms of permanent obstacles are the palisade, optimistically described as unclimbable. This can be seen in various forms round W.D. property. It varies from 5 ft. 6 in. to 9 ft. in height, and barbed-wire entanglements take their place even in permanent work. I have heard that the entanglements round some German fortresses are 100 yards wide, those at Adrianople were 30 ft. wide.

As regards the crossing or destruction of these permanent obstacles, the lesson of the Russo-Japanese War is that the ditch can only be crossed by the systematic attack by sap and mine conducted first against the counterscarp, then across the ditch to the escarp, and when this is destroyed then the attack has some chance of entry. Palisades can be cut by explosives.

You have already seen some ideas as to how the barbed-wire obstacle can be crossed or destroyed. You have seen that there are three ways of dealing with the problem, over, under or through. I cannot believe that any passage over the obstacle can be effected except when the enemy is thoroughly demoralized, or when the obstacle has been so badly placed that it is not under close fire from the infantry parapet. The passage through may sometimes be effected by judicious use of explosives, but too much trust should not be placed on the effect of the artillery shells—the effect of 6-in. shells at Adrianople was rather to improve the obstacle.

The Siege of Adrianople does not throw any fresh light on this subject of crossing wire. I have been informed from a second-hand source that the 10th Regiment of the Bulgarian Army which captured the dominating point (Fort Ayi Yolu) in the section of the defences the Bulgarians attacked, were fortunate enough to strike a place in the wire entanglement which had been meant to allow egress for a sortie, and this was closed by a barricade which was not under fire. The removal of the barricade enabled the whole of the regiment to pass through the obstacle. It is stated that other regiments who were not so fortunate were held by the barbed wire, and only crossed it when the Turks' line was rolled up.

There remains the way under, by which the entanglements may be destroyed by mining. This, I think, will be the way of the future, for it is difficult to imagine any troops again facing the carnage wrought at Port Arthur.

SOME NOTES ON THE ORGANIZATION AND EQUIPMENT OF THE ENGINEERS OF FOREIGN ARMIES AS COMPARED WITH OUR OWN.

By LIEUT. K. J. MARTIN, R.E.

THE terms organization and equipment suggest long tabular statements and many figures. In the preparation of this article it has been difficult to avoid making it a recitation of a string of figures and hard uninteresting facts, giving the numbers of men, horses, and tools which each nation think it fit to include in the engineers of its army.

An attempt has been made, therefore, so to digest the matter of data collected, in such a manner as to convey some idea of the position of the engineers in foreign armies as compared with our own Corps. Further, it is proposed to investigate what each country expects of its sappers in the light of their organization, and how far they are likely to attain their object as indicated by their equipment.

Before comparing any foreign army with our own, it is necessary to remind ourselves of the vast difference in the conditions of service between them. We must remember that every foreign army, except that of the United States, is raised by some form of conscription. As a result, we have to deal with very much larger numbers than we are accustomed to at home, and for this reason the war and peace strengths of the principal European Powers which most directly interest us are shown in Table I. The war strengths shown in each case are the total numbers available. It must not be thought that these are the numbers which would be put in the field on mobilization at the outset of a campaign. They represent the total number of trained or partly trained men available for war. That is, they include contingents for filling up the gaps in the first line army caused by the wastage of war, and men for the second and successive lines of defence.

The terms of service in France are three years with the colours, and obligation to serve in the various branches of the Reserve and Territorial Army for 25 years till a man's 50th year. In Germany service with the colours is for two years and liability to service continues till the 45th year of the man's age. In Russia the engineer has to serve four years with colours, as compared with three years in the case of the infantry.

TABLE I.

STRENGTH OF ARMIES.

Austria.—War	———————	2,265,000
Peace	—	425,365
Belgium.—War	—	200,000
Peace	-	50,000
France.—War	———————	3,878,000
Peace	——	608,000
Germany.—War	———————	4,186,000
Peace	——	693,000
Holland.—War	—	176,500
Peace	-	33,000
Italy.—War	———	1,214,000
Peace	—	242,375
Russia.—War	———————	5,529,700
Peace	———	1,209,600
Gt. Britain.—War	——	800,000
Peace	—	250,000

In Table II. is shown the percentage of engineers in an army corps of each of the principal foreign armies. From it we can gauge the importance attached to the sapper by each nation. It is noteworthy that the proportion of sappers to other arms in the organization of the German and British Armies is almost identical.

So much for the general survey of conditions.

TABLE II.

PROPORTION OF ENGINEERS IN AN ARMY CORPS.

Austria	60,000	1,226	2·02%
France	36,500	1,913	5·24%

The engineers of foreign armies usually comprise the following branches :—

(*a*). Field Pioneer Battalions.
(*b*). Bridging Trains.
(*c*). Field Engineer Parks.
(*d*). Telegraph units } Communication Troops.
(*e*). Railway units }
(*f*). Siege and fortress units.
(*g*). Submarine-mining units.
(*h*). Aeronautical formations.
(*i*). Pigeon post.

Time does not permit us to go fully into every branch of the Engineer Services, so I propose to consider, only, those units which are normally attached to an army corps in war, whose position is similar to our own in a division of the Expeditionary Force, and consequently whose *rôle* we are more likely to appreciate. Further, we cannot obviously go into the conditions prevailing in every foreign army, and we will, therefore, confine ourselves to the three largest armies, viz. France, Germany, and Russia, about which I have been able to obtain most information.

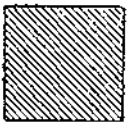
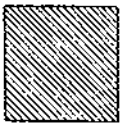
Tables III. to VI. illustrate the engineer formations normally allotted to a division or army corps of the field army.

TABLE III.

GREAT BRITAIN.

ENGINEERS IN A DIVISION.

C.R.E.'s Staff :—	4 Officers.	10 Other Rank.
2 *Field Coys.* :—	6 Officers.	211 Other Rank.

25 yds. Bridge (each).

1 *Signal Coy.* :—	6 Officers.	157 Other Rank.

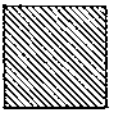


TABLE IV.

FRANCE.

ENGINEERS IN AN ARMY CORPS.

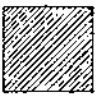
1 *Battn. Sappers* :—	Battn. Staff.	15 O.'s.	32 O.R.


258

A.C.H.Q.'s.


247

Divl.


247

Divl

3 Coys. :

Pontoon Coy. :—	5 O.'s.	46 Sappers. 190 Drivers.

140 yds. Bridge.

Engineer Park :— 3 O.'s. 21 Sappers. 68 Drivers

Detachment of Engineer Cyclists :—

Varying in Strength.

Bicycles Fitted to Carry Light Tools.

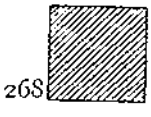
Telegraph Coys. :—
Railway Coys. :— } Attached as Required.

TABLE V.

GERMANY.

ENGINEERS IN AN ARMY CORPS.

1 *Battn. Pioneers :—* Battn. Staff. 2 O.'s. 5 O.R.



A.C.H.Q.'s.

Divl.

Divl.

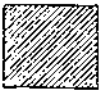
Divl. Bridge Trains :— Attached to Divl. Field Coys., O.'s. & Men from Train.

37·5 yds. each.

Corps Bridge Train :—

136 yds. Bridge.  **6 O.'s. 138 O.R.**
2 O.'s. 64 O.R.

Corps Telegraph Detachment :— 8 O.'s. 161 O.R. (**37**).



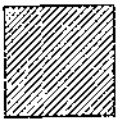
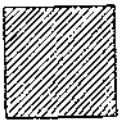
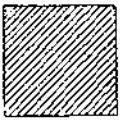
Telephone Detachment :— 1 O. 35 O.R.

TABLE VI.

RUSSIA.

ENGINEERS IN AN ARMY CORPS.

1 *Battn. Pioneers :—* Battn. Staff 7 O.'s. ? O.R.

4 O.'s. 237 O.R.

3 Field Coys.

23 yds. Bridge (each).

Engineer Park :— 1 O. 45 O.R.

Telegraph Coy. :— 7 O.'s. 209 O.R.

FRANCE.

Field Company (War).

	Officers.	Men.	Vehicles. 1-horse.	Vehicles. 2-horse.	Vehicles. 6-horse.	Tools.
Captain	1		1 explosives (1,000 lbs.)	2 baggage and supply.	2 tools.	114 shovels.
Subalterns	3					50 pickaxes.
"Adjutant" ..	—	1				12 picks.
Colour-Sergeant ..	—	1				44 axes.
Sergeants	—	18	1 pack mule.			30 billhooks.
Corporals	—	17				30 saws.
Master-Workmen ..	—	16				10 wire-cutters.
Hospital Orderlies ..	—	5				700 135-gramme petards.
Cyclist	—	1				
Tailor and Shoemaker	—	2				290 100-gramme cartridges.
Buglers	—	2				
Sappers	—	180				
	4	243	1	2	2	

The Army Corps Field Company has in addition 1 captain, 1 corporal, 9 drivers.

From the above table it is evident that the French field company cannot be split up into independent sections as is possible with our own. The limited transport prevents this being the case.

It is noteworthy that all the explosive carried by the company is carried in one cart. One lucky shot into this cart would apparently mean a serious loss to the company.

Further 1 cyclist per company, as compared with the 33 we have, must considerably diminish the range of action and mobility of the French unit. This is, presumably, made up for by the cyclist detachment which would be under the orders of the C.R.E.

FRANCE.

Pontoon Company (War).

	Officers.	Men.	Vehicles. 2-horse.	Vehicles. 6-horse.	Tools.
Captain ..	1			Divisions (2).	45 shovels.
Subalterns ..	2			20 pontoon wagons.	23 pickaxes.
V.O. ..	1			14 G.S. (bridging stores).	34 picks.
Administrative Officer ..	1			2 tool forges.	14 billhooks.
Rank and File		46		Reserve.	4 saws.
Drivers ..		190		1 pontoon wagon.	
				1 G.S. (bridging stores).	
			Train.		
			6 baggage and supply.	1 field forge.	
				1 G.S.	
				1 forage.	
Total ..	5	236	6	41	

Each company is divided into 2 divisions, a reserve and the train transport. Each division is divided into 7 sections, viz., 1 abutment wagon, 1 trestle wagon, 4 pontoon wagons each carrying 2 pontoons, 1 forge wagon; and can build a bridge 70 yards long.

Note.—In the French cavalry there is no brigade or divisional bridging equipment; each cavalry regiment carries in one wagon two metal boats.

FRANCE.

Army Corps Engineer Park (War).

			Vehicles.				Tools.
			1-horse.	2-horse.	4-horse.	6-horse.	
Captain ..	1		1 telegraph.	2 baggage and supply.	1 field forge 1 G.S. (spare).	9 tools. 2 spare tools. 1 ropes & bridging stores. 1 explosive	45 sledge-hammers. 106 saws. 640 spades. 20 hand spades. 20 small picks. 1,575 round shovels. 259 square shovels. 995 pickaxes. 144 picks. 424 axes. 495 billhooks. 94 wire-cutters. 1,600 135-gramme petards. 1,728 100-gramme cartridges.
Subaltern ..	1						
Admin. Officer	1						
Rank and File		21					
Engineer Train :—							
" Adjutant "		1					
Sergeants ..		2					
Corporals ..		5					
Bugler ..		1					
Farrier ..		1					
Saddler ..		1					
Drivers ..		57					
	3	89					

Remarks :—

(1). The above constitutes a reserve in the field unknown in the British Army; either to replace lost tools and expended explosives or to provide additional material for any large works that have to be undertaken.

(2). Note the spare vehicles.

France.

Telegraph Company (War).

Attached as required.

	Officers.	Men.	Vehicles. 1-horse.	Vehicles. 2-horse.	Vehicles. 4-horse.	
Staff.						
Captains	2		6 cable drum.	6 post.	1 field forge.	Each company has about 460 k.m. (287 m.) of cable, 1,214 telegraph poles and 24 helios.
Subalterns	2			12 telegraph.	1 rack.	
Colour-Sergeant ..		1		12 G.S.	10 cable.	
Q.M.S.		1		2 baggage and supply.	3 telegraph poles.	
Hospital Orderly ..		1				
Cyclists		4				
Detachment of Engineer Train.						
Subaltern	1					
Sergeant		1				
Corporal		1				
Farriers		2				
Drivers		14				
			6	32	15	
Sections (6)						
Subalterns	6					
"Adjutants"		6				
Sergeants		18				
Corporals		24				
Cyclists		24				
Buglers		6				
Sappers		192				
Engineer Train :—						
Sergeants		6				
Corporals		12				
Drivers		48				
Material Section.						
Sergeants		2				
Corporals		5				
Cyclists		2				
Sappers		11				
Engineer Train :—						
Sergeants		2				
Corporals		5				
Farrier		1				
Drivers		26				

Totals :—Officers, 11 ; men, 415.

Notes on the French Signal Service.

Visual signalling is very little practised. Semaphore signalling is taught ; but it is found that though the men pick it up quickly, they forget it still more rapidly.

Each infantry battalion is equipped with lamp and helio signalling apparatus ; but the rate of working is very slow.

The employment of telegraphs and telephones is limited to connecting divisions and higher units. Each brigade has a telephone detachment for communication with the divisional commander, but little reliance is placed upon it, partly because of the idea that in war the wires are liable to be cut or otherwise interrupted, but

chiefly owing to the French system of *agents de liason* giving such excellent results.

The French consider that cyclists and motor-cyclists are too easily captured to form a reliable means of communication.

The *agents de liason* are orderlies and officers sent by each unit to the unit above it to maintain communication with it.

GERMANY.

Pioneer Field Company (War).

Officers, 6. Horses, 20.
Other ranks, 262. Vehicles, 7.

Vehicles :—3 2-horsed } pioneers' stores.
1 4-horsed }
1 baggage wagon }
1 supply wagon } 2-horsed.
1 field kitchen. }
1 pack horse.

Organized in three "self-contained" sections.

Horses and vehicles are all supplied by the train. There is no mounted branch in a German field company.

No bridging material is carried; the whole of this being concentrated in the divisional and corps bridge trains.

Armament :—1898 Mauser rifle with pointed bullet. Sword-bayonet with special pattern saw-back.

The men carry a kit of 60 lbs. including a tool and 150 rounds.

Principal tools :—

	Portable.	In Wagons.	
Picks ..	.. 57 ..	.. 4	Besides carpenters' and smiths' tools, etc.
Shovels ..	.. 99 ..	.. 8	
Axes ..	.. 57 ..	.. 20	
Hatchets	.. 21 ..	.. 4	
Wire-cutters	.. 6 ..	.. 30	

Explosives (trinitrotolnol) :—Has the same effect as picric acid, but insoluble in water and safer to handle.

Remarks :—

(1). The number of cyclists per company is not given.

(2). The marching order is the same as for infantry. Its great weight must impede mobility, and limit the working power.

(3). The small number of horses must restrict mobility. Also very few horses are available for carting materials for field defences. Compare the British field company with 77 horses.

(4). The so-called "self-contained" sections hardly agree with the British ideas on the subject.

GERMANY.

Searchlight Section (Organization ?).

No. 1 Light :—1 Officer, 1 N.C.O. and 4 men, 1 projector carriage with limber containing motor and dynamo, drawn by 6 horses.

No. 2 Light :—Same as above.

Projectors :—60-c.m. Schuckert with parabolic reflector of silvered glass, mounted on telescopic steel mast, range of elevation 9 ft. to 22 ft. Concentrated beam.

Lamp :—Automatic Schuckert (horizontal); with small arc deflector. Size and nature of carbons not stated; 60 volts with 60 amps.

Limber :—Contains 2 cylinder 6-H.P. benzin motor, with automatic carburettor and magneto ignition, driving a small dynamo at 6,000 revs (?) per min., 2 insulated copper cables 100 m. long connecting limber to projector carriage. These cables are wound on drums on either side of mast.

Weight behind team about 35 cwt.

Time required for changing reflectors 20—30 mins., which shows that spare backs ready fitted with reflectors are not carried.

The lamps are really automatic, burn steadily, and the carbons have rarely to be adjusted.

Note.—These searchlights were used in 1910 Pioneer Manœuvres. According to 1913 establishments one section is to be included in each pioneer field company.

Portable searchlights are carried on a store wagon. They are on the Kamm system with 30-c.m. projectors.

Tradesmen in a German pioneer battalion in peace :—

Among 508 N.C.O.'s and men :—

160 boatmen and boat builders,
164 carpenters,
16 miners,
70 men of the iron trades,
30 masons,

the remainder being made up of telegraphists, saddlers, and men of no particular calling.

The men do not have to reach any standard of trade qualification and many of them have but a smattering of knowledge of their so-called trade.

GERMANY.

Divisional Bridge Train.

Officers, 2 } from Train. Horses, 98.
Men, 59 } Vehicles, 21.

It is attached to the pioneer field company of the division, and is under the command of the officer commanding that company. On the march this latter officer details one pioneer for every vehicle of the bridge train to look after the bridging material.

Vehicles :—

1 shore transom wagon.
2 trestle wagons.
12 pontoon wagons.
1 tool wagon.
1 store wagon.
2 forage wagons.
1 baggage wagon.
1 supply wagon.

Pontoons are of galvanized steel and are bipartite. Bow pieces differ from stern pieces in that they have raised bows to give extra safety in rough water. A single pontoon will ferry 18 men; 2-pontoon raft 60 men, or 7 men and 7 horses, or field gun with 4 horses and 8 men.

Remarks :—

(1). Bridge can be constructed with the men who can be transported on the wagons (seats for four on each), though there would be slight delay as the number of men is insufficient to unload simultaneously with construction.

(2). The *personnel* of the divisional field company is sufficient for the rapid construction of the bridge, but does not allow of a reserve.

(3). Trestles are of Weldon pattern.

(4). Pontoons are carried bottom upwards which prevents men sitting in them on the wagons. They are very visible at long ranges owing to plate steel not being painted.

Bridging capacity :—

A normal bridge is designed to take all weights up to 3·14 tons. For 21-c.m. mortars, long 15-c.m. guns and all vehicles weighing between 3·14 and 4·92 tons, normal bridge is strengthened by doubling the baulks under the wheel tracks. For the army mechanical transport trains (greatest weight on each back wheel of tractor, $3\frac{1}{4}$ tons) the bridge must be constructed with twice the number of pontoons required for normal bridge, the number of baulks is increased from 5 to 9 and the chesses are doubled.

This type of heavy bridge may be used by fully loaded mechanical transport trains across rivers with a velocity not exceeding 5·1 miles per hour.

Nature of Train.	Bridge.			Time of Construction.	No. of Pioneer Companies required.
	Light.	Normal.	Heavy.		
	yds.	yds.	yds.	hrs.	
1 Divisional bridge train ...	44·8	37·5	12	½—1	½—1
1 Corps bridge train ...	169·5	136	82	3	1—2
1 Corps bridge train and 2 divisional bridge trains...	257	214·5	121·3	5	2

GERMANY.

Corps Bridge Train (*War*).

Officers { 2 / 6* } Horses, 239.

Men { 64 / 138* } Vehicles, 39.

It is composed of a pioneer detachment and a train detachment, and is under the command of the captain of the train detachment.

Vehicles :— 2 trestle wagons } 6-horse.
26 pontoon wagons }
2 store wagons } 4-horse.
2 tools wagons
1 demolition (explosives) wagon
4 forage wagons
1 baggage wagon } 2-horse.
1 supply wagon }

Pontoons are galvanized steel whole pontoons, 26¼ ft. × 4 ft. 11 in. × 2 ft. 9½ in. and weighing about 1,102 lbs. Their buoyancy is practically the same as that of the bipartite, viz. 7¾ tons with a free board of 3½ in. Each pontoon or trestle wagon carries a complete bay of superstructure.

Note.—It is curious from British point of view that a Bridge Train, which is a pioneer unit, should be commanded by a train officer.

GERMANY.

Corps Telegraph Detachment (*War*).

Officers, 6. Horses, 73.

Other ranks, 161 (37 belong to the train).

Vehicles :—16 2-horse material and store wagons.
4 2-horse station wagons.
1 2-horse baggage wagon.
2 motor cars.
16 cycles.

Organized in four sections of equal strength and identical equipment. It provides communication between A.H.Q. and Army Corps and Divisional H.Q. (when this latter has not been effected by the telephone detachments).

Each section carries 3 field telegraph apparatus, and 9 telephones ; also 13½ miles of insulated cable, 12½ miles of insulated wire, and ¾ mile of bare wire. It can lay 11 miles of line at a speed of 1,100 yards in 30 mins. ; and can establish 2 to 3 stations for simultaneous Morse and telephone traffic, and 3 telephones in addition.

All the men of the detachment can find room on the material wagons for rapid transport when necessary. Sections can move at a trot.

* Train.

Notes on Signalling in the German Army.

Visual signalling has not hitherto been treated seriously in the German Army. There is no School of Signalling, and what instruction is given, is carried out under regimental arrangements when opportunity offers.

New Flag Signalling Regulations appeared in 1904 pointing to the fact that increased attention is being paid to this method of communication.

In each company of infantry there must be 1 officer and 2 N.C.O.'s capable of acting as instructors. The following men must be trained as signallers :—All bandsmen ; trumpeters of the field artillery.

In the infantry, cavalry, field artillery and pioneers—6 men per company, including those trained in telephone duties.

In the communication troops 12 men per company.

A rate of signalling of 2 words a minute is aspired to with both lamp and heliograph. These are only carried by the cavalry.

Orderlies are much used.

GERMANY.

Telephone Detachment (War).

Officers, 1. Horses, 17.
Other ranks, 35. Vehicles :—3 2-horsed material wagons.
1 2-horsed store wagon.

Organized in 3 squads, each consisting of 1 mounted telegraph N.C.O. and 5 or 6 men ; the whole detachment being under the command of a lieutenant.

Each squad carries 5 miles of telephone cable and 4 telephones with batteries ; these stores are carried on a material wagon on which the men of the squad are transported. Each squad can lay 4 miles of line in about 2⅓ hours, and can establish 4 telephone stations.

Telephone detachments will probably be allotted to the H.Q.'s of army corps and divisions.

RUSSIA.

Field Company (War).

Officers, 4.
N.C.O.'s, 20.
Sappers, 217, 17 of which are non-combatants.

First line transport :—

3 store wagons containing :—
40 shovels.
18 picks.
40 axes.
2 saws.
100 sandbags.
Wire and special tools.

The men carry on the person the following tools :—

100 shovels.
30 picks.
70 axes.
8 saws.
4 augers.
8 carpenters' chisels.

The divisional field companies carry the following bridging equipment :—6 3-horse wagons carrying 2 trestles and 4 half-pontoons and superstructure, giving 23 yards of normal bridge.

Russia.

Engineer Field Park (*War*).

Constitutes a mobile reserve :—

(1). To supplement the tools carried by the infantry and field companies when especially large works have to be undertaken.

(2). To replace lost and expended stores.

Establishment :—1 subaltern.
45 men.

Principal tools carried :—

2,700 shovels.
582 axes.
212 picks.
350 sandbags.

Note.—(1). No mention is made of demolition stores such as explosives ; presumably a reserve of these is also carried to make up for expended materials.

(2). Tools carried by an infantry company :—

On the men—140 small shovels, 30 picks, 30 handaxes.

Company reserve—16 large engineer shovels, 6 picks, 8 axes.

Russia.

Telegraph Company (*War*).

Officers, 7.
N.C.O.'s, 54.
Sappers, 155.

Organized in 3 sections :—

2 airline, with 16·9 miles of line each.
1 cable, with 23·1 miles of cable.

The company has sufficient men and material for 12 telegraph stations, as well as for 6 stations for visual signalling.

It is stated that the cable is specially used when communication has rapidly to be established or in the immediate neighbourhood of the enemy, or when the ground is too hard for the poles of the air line to be driven in.

Notes on Communication.

(1). Russia has 13 mounted orderlies per regiment.

(2). Not much importance is attached to visual signalling, except in mountain warfare and for the passing of conventional signs between skirmishing lines.

(3). They possess excellent telephones and make much use of them. Each infantry regiment has a telephone detachment of 12 men. The telephones are carried in carts; and the line is laid by dismounted men.

SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

(*Continued*).

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

THE SECOND SIEGE OF BHURTPORE, 1825.

Towards the close of the year 1824, trouble again arose in the Native state of Bhurtpore, not far from Agra, through the usurpation of the "gaddi" by one Doorjan Lal, who imprisoned the rightful heir, recognized by the British on the death of the Rajah, Runjert Singh of Bhurtpore.

Sir David Ochterlony, well knowing the temper and intrigue of which this city was the centre, collected a force at once, and moved against Doorjan Lal. Lord Amherst, however, ignored the danger, and refused to ratify Sir David's action, and ordered him to withdraw and break up the army. This gave Doorjan his opportunity, which he made the most of, in collecting arms, powder, artillery, and sending round messages to the Central Indian States to support him. He soon made his position exceedingly strong; and relying on the prestige of the invulnerability of his fortress (gained 20 years before when it withstood four assaults by Lord Lake's Army which lost 3,000 men in futile efforts), he now defied the British openly. This constrained the Government to take vigorous action, before he was actually joined by the other states, who were ready to move, but who were then merely looking on. In December, 1825, therefore, a force of some 27,000 men, with a large siege train, moved against Bhurtpore, under Lord Combermere, then Commander-in-Chief; and by the 11th of that month the city was invested by a cordon 15½ miles long. On the 18th of December, three companies of Goorkhas (Sirmoor Rifles) reached Muttra, which was held by some of our cavalry, and next day joined the camp of the main army before Bhurtpore. The same high mud walls which had baffled Lord Lake still surrounded the city, and the Motee Jheel still supplied water to the moat. Guns innumerable crowned the walls, and 25,000 Jats, Pathans and Rajputs defended the city, with its immense store of treasure.

The first act in this siege was a fortunate one, for a rapid move of a portion of Lord Combermere's left wing surprised the enemy in the act of cutting the dam which admitted the waters of the Motee

Jheel into the moat, and thus prevented it from becoming a terrible obstacle.

Nine days were spent in survey and reconnaissance which resulted in the Commander-in-Chief's decision to attack from the east, while making a feint of coming from the south-west as Lord Lake had done.

Under cover of this feint the cordon was drawn still closer, two important positions were taken up, and parallels were opened some 600 yards from the walls.

The duty of reconnoitring and seizing the "Kaddam Kandi," a temple situated in a wood within 400 yards of the so-called "Long-Necked Bastion," was carried out by a column consisting of the Grenadiers of the 59th Foot, five companies of the 21st Native Infantry, 100 of the Sirmoor Battalion, two troops of cavalry, and two howitzers. On reaching the wood, the Goorkhas were sent forward to clear it and hold the further edge, while a passage was dug through some banks for the guns.

The enemy retreated at once, and a heavy but ineffective fire was opened from the walls. The Goorkhas were then sent forward to reconnoitre the ditch, while the 59th replied to the fire from the temple walls and banks. The reconnaissance completed, the Goorkhas were withdrawn to hold the "Kaddam Kandi" Temple with the 59th. At the same time 100 men of the Sirmoor Battalion, under Lieut. Kirke, attached as skirmishers to General Reynell's Column of the 14th Native Infantry and 23rd Native Infantry, operating to the right of the first-named column, were successful in obtaining possession of a walled garden and in repulsing a vigorous sortie from the Soorajpur Gate with slight loss. These two positions now formed our advanced posts, and were held by the Goorkhas almost throughout the operations.

The first parallel was commenced on the 23rd December, and the following day all women and children, other than those of the Royal Family, were allowed to pass out; at the same time a force of cavalry from the city succeeded in cutting their way out through our lines.

The regular siege now opened, the Goorkhas acting as covering parties and holding the advanced posts.

On the 26th it appeared as if the enemy's guns were more or less silenced, and the second parallel was opened within 250 yards of the ditch, while on the 28th December the approaches were almost within 20 yards of the moat. But the enormously strong earth walls defied our hammering. On the left of General Nicholls' column 14 heavy guns had battered one of the curtains for nearly a week without making any impression, and the same thing had happened at the other points we hoped to breach, in spite of the large number of heavy guns brought to bear on the place—every siege gun in Upper India having been collected for the purpose.

So on the 6th January, 1826, resort was found necessary to mining. The bombardment, however, continued till the 17th January to distract attention from this new work. Parties of the Sirmoor Battalion were continually used to guard those in the mines, and more than once our miners met those of the enemy countermining, when severe hand-to-hand fighting occurred; on one occasion a party of sixty of the enemy were surprised under the counterscarp by sixteen of the Goorkhas who killed a number of Jats. The naick of this party was promoted on the spot by Lord Combermere.

On the night of the 15th a mine was sprung to the left of the Long-Necked Bastion opposite which General Nicholls' column lay in their trenches. This was rumoured to have made a practicable breach, and Capt. Carmichael, the General's A.D.C., taking with him an Engineer officer, six of the 59th Grenadiers, and five of the Sirmoor Battalion, actually did manage to scramble to the top to reconnoitre and report on what they could see inside in the way of obstacles. This was done at noon when the enemy apparently were not very vigilant; the party gained the top, threw in some 50 hand grenades, fired three rounds, took a deliberate look well into the interior, before the astonished enemy recovered their surprise, and returned with the loss of only one grenadier. Later a similar piece of work was done at another reported breach by Havildar Mawanchand and 12 Goorkhas of the battalion, the former being promoted at once for the success of the undertaking.

The long-looked-for time for the assault was now close at hand. Another mine had successfully been sprung under a curtain in the Long-Necked Bastion, bringing down a mass of wall with some guns on top, and a huge mine of 10,000 lbs. of powder under the North-East, or Pathan Bastion, opposite General Reynell's point of attack, was completed on the 17th January. It was arranged that the firing of this mine was to be the signal for the final assault, which was to be in three main columns—General Nicholls against the breach in the Long-Necked Bastion, with two small columns, detached, one to attack the extreme left breach, the other, under Colonel Wilson, was to escalade at a point midway between the two great bastions; another, under General Reynell, was to assault the North-East Bastion; while on the extreme right a column under Colonel Delamain, with which was a detachment of the Nassera battalion, was to assault the Jugeenah Gate, which was partially breached. Lieut. Spottiswoode with 100 Goorkhas was to cover the advance of the Reserve Column under General Adams, who was to enter by the Muttra Gate immediately after the storm. Lieut. Kirke with the remainder of the Goorkhas was to cover General Reynell's stormers.

Before dawn on the 18th January, 1826, all the stormers were in their places in the advanced trenches, awaiting the springing of the

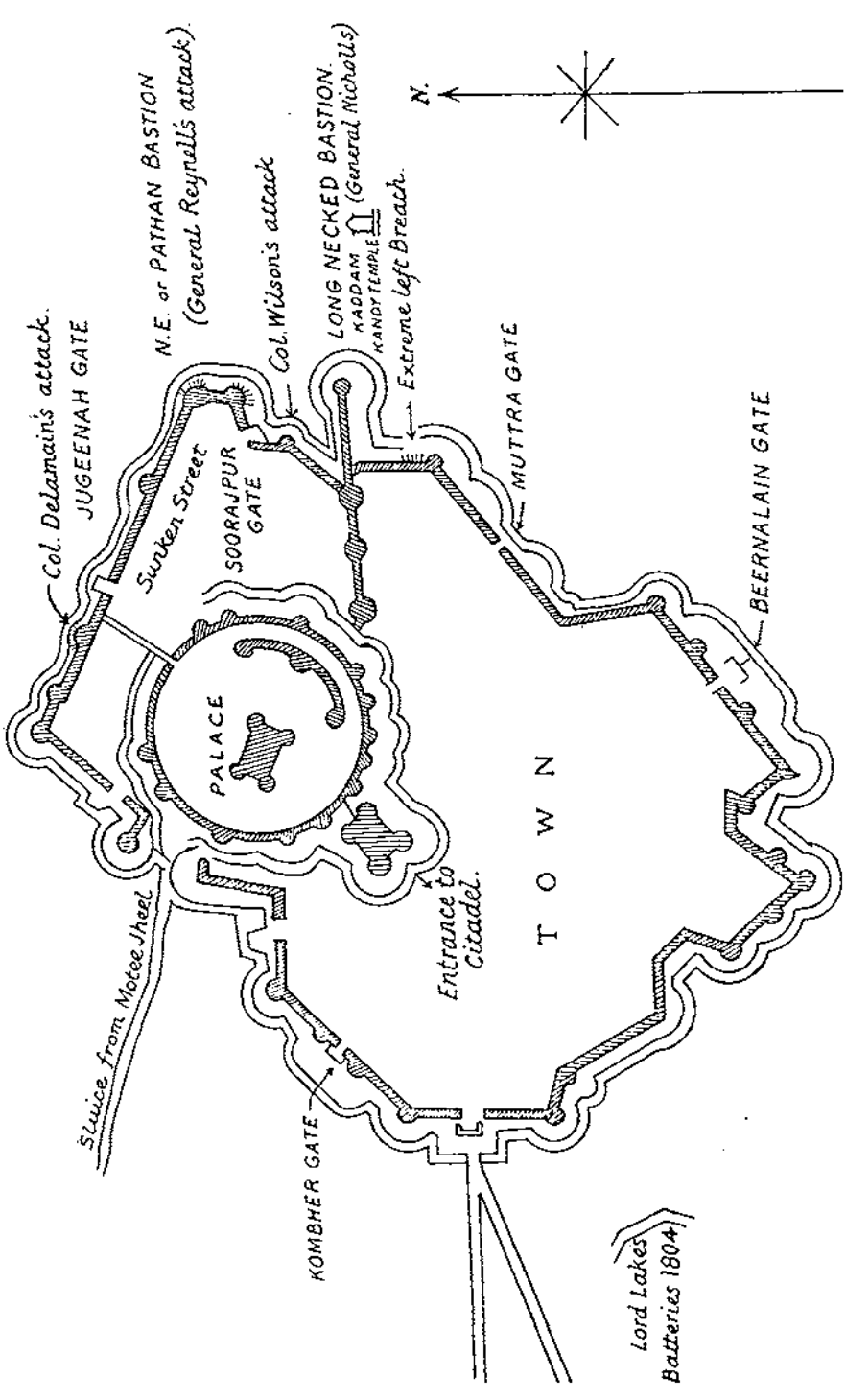
mines, while the defenders, with an intimation of what was going forward, opened a heavy fire at daybreak. Word went down our line that all was ready. A mine at the Jugeenah Gate was sprung first, and then that in the counterscarp of the North-East Bastion, and all were awaiting the firing of the train for the demolition of that work. These explosions brought the garrison crowding to the walls, some 800 Pathans rushing to the parapets of the huge North-East Bastion, which it was their particular duty to defend. Immediately the mine under this with its 10,000 lbs. of explosives was fired; the ground heaved and rocked, and with a dull heavy roar half the bastion lurched and rose slowly in the air, followed by clouds of thick pungent smoke, carrying up guns, gabions, Pathans, banners, swords and matchlocks, to be strewn in their descent a mass of mangled flesh and broken metal. Three hundred of the defenders had been blown to pieces, and those in our advanced trenches also suffered somewhat, a number being hopelessly buried by the descending débris.

As soon as the smoke cleared away, with loud cheers Reynell's and Nicholls' stormers rose and dashed at their respective breaches, at the top of which the defenders fought desperately. They were, however, beaten back, and the entire line of hitherto impregnable walls was in our hands. Brigadier Edwardes, who led the assault at the Long-Necked Bastion had been killed, and the brigade suffered such losses that they could not penetrate beyond the bastion which they had won, till Fagan's Brigade arrived to reinforce them; then the whole swept forward into the city, and the place was soon in British hands.

Doorjan Lal managed to cut his way out through a cordon of the 14th Foot but was overtaken and captured by our British cavalry. The casualty list on the part of the enemy was reported as upwards of 13,000 of whom 4,000 perished in the assault alone; while the total British loss was 1,000.

In the Divisional Orders by General Nicholls, of the 19th January, 1826, he says: "The handsome and gallant advance of the 59th Foot was followed—indeed emulated—by the 31st Native Infantry, the Light Infantry of the 37th Native Infantry, the Grenadiers of the 30th Native Infantry, and the detachment Sirmoor Battalion. The service which fell to the troops was essential, and it was gallantly and effectively performed. Capt. Orchard, 37th, and Herring and Mercer, 35th, and Fisher's Sirmoor Battalion are requested to receive the Major-General's very best thanks for the exertions so cheerfully made by their respective battalions."

The army dispersed towards the end of January and a General Order later directed that the word "Bhurtpore" should be borne on the standards and colours of all the corps which were employed at the capture of that fortress.



SKETCH OF BHURTPORE.—SECOND SIEGE.

DEFENCE OF KHELAT-I-GHILZAI, 1841-42.

Khelat-i-Ghilzai is a small fort built on a high flat-topped hill, rising abruptly from the plain, about 150 ft. above its level—situated 87 miles from Kandahar, 134 from Ghazni, and 229 from Kabul. From the centre of this table-land rises, to about a height of 100 ft., a small conical hill which formed the citadel.

The garrison consisted of 600 of the 3rd Regiment of Infantry, in the service of Shah Shujah; three companies of the 43rd Bengal N.I., under Capt. Webster and Lieut. Trotter; 40 European artillery, 23 Native Sappers & Miners; Major Leech, Bombay Engineers, Political Agent; Dr. Campbell Mackinnon; Lieut. H. Milne attached to Shah Shujah's force as Commissariat Officer and Lieut. T. Studdert, Bengal Engineers, Executive Engineers; Lieut. David Gaussen and Lieut. Robert McKean, about 950 in all—under Capt. John Halkett Craigie.

This noble little garrison maintained their position during the whole winter, from November, 1841, until relieved by Colonel Geo. Peter Wymer on the 26th May, 1842, although exposed to cold and privation unequalled by any of the victorious troops in Afghanistan.

On the 21st May, 1842, they repulsed in a most gallant and determined manner a fierce assault that was made on their position by a large body of Ghilzais, variously estimated by themselves from 5,500 to 7,000 men. Capt. Craigie in his despatch dated 21st May, 1842, says "that Khelat-i-Ghilzai was attacked at a quarter before four o'clock this morning in two places, viz. at the long neck to the north-east, and at an outwork constructed last winter by the Sepoys, to give a raking fire in rear of the barracks. The enemy advanced to the assault in the most determined manner, each column consisting of upwards of 2,000 men, provided with 30 scaling ladders, but after an hour's fighting were repulsed and driven down the hill, losing five standards (one of which was planted three times in one of the embrasures) and the whole of which are now in our possession.

* * * * *

"The greatest gallantry and coolness were displayed by every commissioned, non-commissioned officer, and private (both European and Native) engaged in meeting the attack of the enemy, several of whom were bayoneted on the top of the sandbags forming our parapets. On our side I am happy to say only six Sepoys were wounded, viz. two of the detachment 43rd N.I. and four of the 3rd Infantry.

"A body of about three hundred of the enemy were driven back, took shelter under the rocks below the outwork, but were immediately dislodged by a company of the 3rd Infantry, which I detached for that purpose."

They left 104 dead bodies at the foot of the defences, and within a few days after the assault the Political Agent ascertained that the number of killed, and of wounded men who died immediately after the action, considerably exceeded four hundred.

Siege and Capture of Ghazni, 1839.

Ghazni is a walled town with a deep ditch, situated in a plain surrounded by high mountains, by a spur of one of which it is commanded. In the centre of the town is a hill about 300 ft. high, on which is the citadel. A small stream runs near and round the town, and there are numerous walled gardens occupied by the Afghans.

At the time of the first Afghan war in 1839, the fort was garrisoned by from 3,000 to 4,000 men under Hyder Khan, the son of Dost Mahomed, and the Ameer of Afghanistan had therefore calculated rightly upon the British force being delayed for some time before it. He and his emissaries had had no difficulty in deceiving MacNaghten as to its strength and the nature of the resistance likely to be offered, and so completely was the latter deceived by the information supplied, that the day before Ghazni was reached he declared the place to be empty. Acting on this information the Commander-in-Chief and his staff rode on ahead to enter the deserted fort and they were only undeceived when fired on and compelled to return. Two forces under the Ghazni chiefs, Abdul Ruhman and Gul Mahomed Khan, had meanwhile marched parallel to the British all the way from Khelat-i-Ghilzai, one on each flank, at a distance of from 12 to 15 miles, with the object, not of immediate attack, but of taking advantage of the anticipated check to our troops at Ghazni, and of any confusion that might result therefrom. It cannot be denied therefore that when our troops reached Ghazni and found it strongly guarded, their position was critical in the extreme. Not only was the food supply short, but the breaching guns also had been left behind and there was only one battery of 24-pounder howitzers with the force, and these were useless for battering purposes. In their dilemma, the Envoy and the Commander-in-Chief (Sir John Keane) called upon the Chief Engineer (Capt. G. Thomson, of the Bengal Engineers) to reconnoitre and report.

He did so, and placed two alternatives before Sir John Keane, viz. either to blow open a gate and immediately assault, an operation the success of which may be doubtful and generally attended with heavy loss, or to mask the fort by a small corps, and with the rest of the army advance and attack Dost Mahomed. The latter alternative was abandoned, as the army was without the necessary supplies, and the proposal to assault was approved. A party of engineers was told off to the desperate duty of blowing in the gate in connection with

which the following extracts from the diary of Lieut. James Broadfoot are of interest :—" A bag of 300 lbs. of powder was to be laid at the Kabul Gate, protected by the fire of the batteries and by the Goorkhas. The gate was to be blown open, and a storming party, composed of four European regiments was to advance immediately. I volunteered to carry the bag, as did Pigou ; but the latter was refused. Later in the day William* came, very excited, and told me he was not to go, the corps having been stopped on the pretence that the Shah was not sufficiently protected. He nearly threw up his commission in the Shah's service, but at last went away to try to join his old corps as a volunteer. Batteries and embrasures were made and the guns put in position, and then daylight was awaited. At last Peat and the powder party appeared, when the eastern horizon was just strong enough to show the hills in strong relief. The garrison opened fire on them ; the covering party extended on the edge of the ditch replied ; a few minutes afterwards a large volume of smoke above the walls and a rushing sound showed that the explosion had taken place. The head of the storming party now appeared with Brigadier Sale, doubtful whether to proceed or not. In this emergency I offered to go on to see if the explosion had been effectual. Being allowed I ran on towards the gate ; my anxiety to get on, and the constant whirring of balls past my head, made every step appear a mile. A little farther on I got into the range of the camel battery, and had to creep along to avoid our own balls. At last I met Durand† and shouted " Has it failed ? " He called out, " No, no." I then ran back so fast that my breath was entirely taken away. Peat and Macleod were stretched under a little tomb half-way, the former groaning heavily. He had been rolled over and over by the explosion, and was much shattered.

My report having been made the advance was ordered. I then ran on to the head of the column and entered with it, exposing myself to a severe reprimand. From the advance of the powder party not a quarter of an hour had elapsed, yet it seemed an age. On our way to the gate a shower of matchlock balls was kept up from the fort, with an occasional round shot, while our own artillery was thundering in our rear. Once within the darkness of the archway the fire stopped, the men gathered close, and sent up a magnificent cheer, in which we all joined and thus was our first step gained. A rush was made at the gate—the vicinity of which was nearly deserted—and it was carried with small opposition.

The colours were then planted on the four corners of the palace. The firing in the town was as constant as ever, few people asking quarter, and

* Lieut. William Broadfoot, of the 1st European L.I., now the Roya Munster Fusiliers he was then attached to Shah Shujah's force.

† Afterwards Major-General Sir Henry Durand, K.C.S.I., C.B., Lieutenant-Governor of the Punjab.

no one giving it." Lieut. Broadfoot describes how he saw men jumping from walls 30 ft. high, or sliding down ropes, or hunted through the streets by soldiers with their bayonets close to their backs. Outside, the cavalry killed about 100 or 200 men, and 1,700 prisoners were made.

The result of the capture was decisive; it was worth many lakhs of rupees paid by political officers to secure immunity from attack, or to induce treason in the enemy's camp. The Afghans learnt for the first time that the English could strike a heavy blow, and respected them accordingly. Dost Mahomed behaved under the circumstances with his accustomed bravery. He had brought his troops from Kabul to oppose the advancing force, and finding that his men were shaken by the news from Ghazni, he rode amongst them, Koran in hand, begging them to support him so that at least he might die with honour, after which they might if they pleased join Shah Shujah. It was in vain; his men deserted him, and with his family and a small remnant of his force he fled to Bamian.

Our army found the Amir's guns at Arghandeh, and, advancing by regular stages, occupied Kabul on August 7th, 1839, and seated Shah Shujah on his throne, without opposition on the one hand, but on the other, without the slightest popular enthusiasm.

It should be mentioned in connection with the capture of Ghazni that whilst serving as an Engineer officer through the first Afghan war it fell to the lot of Lieut. Durand to undertake the duty of blowing in the gate of the fortress, an operation rendered necessary by the absence of any siege train. In reference to this brilliant episode it may be remarked that in the obituary article which appeared in *The Times* newspaper on the occasion of Sir Henry Durand's tragic death, more importance was laid on his share in the work than it appears he really deserved. This called forth a remonstrance from Lord Keane, who wrote: "The credit of blowing in the gate was entirely due to Capt. Thomson,* the Chief Engineer. Lieut. Durand performed his part of firing the train with great coolness and self-possession, being fully exposed to the enemy's fire from the ramparts while he applied the match to the fuze, which he had some difficulty in lighting."

Lieut. James Broadfoot, in his notes on the siege, writes thus: "Whilst to Capt. Thomson is due the credit for planning the demolition of the gate of Ghazni and the immediate assault of the fortress, to Lieut. H. M. Durand must be assigned that of successfully carrying out the instructions. He exhibited there the greatest coolness and gallantry in the most dangerous situation. After the powder was laid and all ready, the port fire did not light as it should have done,

* The late Lieut.-Colonel George Thomson, Bengal Engineers.

and he had to blow the slow match and port fire until at last it ignited. He then watched it burning for some time before returning to cover." The other engineer officers engaged in this arduous duty were, Capt. Peat, Bombay Engineers, and Lieut. (afterwards Lieut.-General) Macleod, Bengal Engineers. At Ghazni, indeed, it may be said that the army was indebted for its safety to its engineer officer, Capt. G. Thomson.

Sir John Keane—afterwards Lord Keane of Ghazni—did not fail to do justice to Thomson. He wrote: "To Capt. Thomson, of the Bengal Engineers, much of the success of this brilliant *coup de main* is due. A place of the same strength, and by such simple means as this highly talented and scientific officer recommended to be tried, has, perhaps never before been taken, and I feel I cannot do justice to Capt. Thomson's merits throughout."

Again in his General Orders, Sir John said: "The scientific and successful manner in which the Kabul Gate—of great strength—was blown up by Capt. Thomson, in which he reports having been most ably assisted by Capt. Peat, Bombay Engineers, and Lieuts. Durand and Macleod, of the Bengal Engineers, in the daring and dangerous enterprise of laying down powder in the face of the enemy, and the strong fire kept up on them, reflects the highest credit on their skill and cool courage, and His Excellency begs Capt. Thomson and officers named will accept his cordial thanks."

SIEGE OF MOOLTAN, 1848.

In April, 1848, two well-known, able, and popular officers—Mr. Vans Agnew, of the Civil Service and Lieut. Anderson of the 1st Bombay Fusiliers, had been sent with a large escort by the Lahore Government, to support an incoming Sikh Governor, Sirdar Khan Singh, and this at the request of the retiring Governor, Mulraj.

On the morning of the 18th April, the two officers were riding unarmed out of the fort when they were attacked by the soldiers of Mulraj, and both were severely wounded. They were carried to a strong Mahomedan building called the Eedgurh—a short distance from the city walls—in which they were lodged. Mulraj, who was present, rode away without offering any assistance. Next day the escort proved faithless and Mr. Vans Agnew and Lieut. Anderson were attacked by a furious and excited mob and brutally murdered.

Sir Henry Lawrence, who was the British Resident at the head of the "Lahore Durbar," was in England on sick leave at the time, and the absence of his determined leadership made itself felt disastrously.

The movable column at Lahore was not launched against Mooltan immediately, and instead of this, four columns of disaffected Sikhs, led not by men like Sir Henry Lawrence, but by Sirdars of doubtful

loyalty—amongst whom Sher Singh was pre-eminent—were sent against a Sikh chief with whose cause the rank and file of the force were in ardent sympathy.

These Sikh columns, moreover, did not reach Mooltan till some eleven weeks after the murder of the two Englishmen, at which date the rebellion at Mooltan was beginning to take on the character of a religious and national war.

At this time Lieut. Herbert Edwardes was the Political Agent in charge of the Derajat. No sooner did this young officer—a disciple and friend of Sir Henry Lawrence—receive Vans Agnew's letter asking for help, than, without asking for orders from Lahore, he swept across the Indus at the head of wild Pathan levies, and with the aid of Colonel Van Cortlandt and the Nawab of Bahawalpur succeeded in driving Mulraj into Mooltan, which he thought he might succeed in capturing if speedily reinforced by "Napier* and some guns"; for both of which he begged in vain.

Forced into action by the energy of their subordinate, and by the danger of their position, the British authorities at last despatched a column under General Whish to co-operate with him and the Sirdars in attacking Mooltan. The force arrived at Mooltan after the middle of August.

The strong fortress of Mooltan could only be taken by breaching its walls and to do this large guns and heavy ammunition were needed. Carriage, however, was exceedingly difficult to obtain, while the boats and boatmen of the Ravi and the Sutlej were quite unfit to be entrusted with so precious a convoy. Major Robert Napier*—the Chief Engineer of the Force—remembered the pontoon boats at Ferozepore, and thought that they might be used for this purpose if put into suitable hands, although unwieldy and not designed to carry freight through difficult waters.

He sent for Lieut. Alexander Taylor,† and asked him if he would undertake to carry the heavy artillery and engineering stores more than 200 miles down the Sutlej in his bridge boats. The young engineer replied in a delighted affirmative.

On the 30th July the heavily-laden flotilla started for its long row from Ferozepore to Adamwahan, 40 miles from Mooltan. The Chief Engineer and Alex Taylor travelled with it. Neither Taylor nor the boatmen knew the river; the boats were cumbersome, and there were many difficulties and obstacles during the journey, owing to rapids, shallows, rocks, sand banks, storms, and floods.

The flotilla, however, safely reached its destination—Adamwahan, opposite Bahavalpore—in little more than a fortnight, arriving on the 15th August; its contents were disembarked by the Sappers &

* Afterwards Field Marshal Lord Napier of Magdala, G.C.B., G.C.S.I., R.E. (late Bengal).

† Afterwards General Sir Alexander Taylor, G.C.B., R.E. (late Bengal).

Miners, who had marched thither from Loodianah at 48 hours' notice. Steep and firm banks were found, beside which the water was sufficiently deep to allow the boats to come alongside; and the precious cargo, of which nothing had been lost *en route*, was gradually unladen and heaped in gigantic piles on what seemed to be *terra firma*.

Without siege materials it would have been impossible to inaugurate a siege, and it was only owing to Taylor's energy in moving the stores further inland, that these were saved, as the whole area on which the ammunition had been heaped, owing to the water undermining its base, shortly after collapsed into the rushing stream.

Day by day more siege material arrived but so great was the amount required that it was not till the 4th September that the engineer and artillery parks received their full equipment.

Immediately after the arrival of the complete siege train, General Whish issued a proclamation inviting the inhabitants and garrison to surrender unconditionally, within 24 hours of the firing at sunrise on the 5th of a Royal salute in honour of Her Most Gracious Majesty the Queen of Great Britain, and her ally, His Highness the Maharajah Dhuleep Singh.

"On the morning of the 5th, accordingly," writes Taylor, "the force turned out, and the artillery fired a Royal salute from 24-pounders. Before the sixth round, we received Mulraj's reply—a 14-pound ball, said to contain Whish's proclamation! The direction was good, but it fell short and hurt no one. Mulraj had spoken; and preparations for the siege were at once commenced."

On the 6th September a Council of War was held, during which the general plan of the siege operations was fixed. The plan adopted after much discussion—two other projects having been negatived—was that a trench should be run from the north-easterly angle of Herbert Edwardes' camp to a point called Ram Terut, a mile further to the north-east, and that this trench should be used as a base from which to advance on the city.

The town of Mooltan lies in the midst of a desert. Its climate in summer is exceedingly hot. Though rain rarely falls, the city and its environments, which are exceedingly wealthy, are richly provided with artificial canals of running water.

Between the walled gardens, enclosing country houses, lie dirty villages, temples, tombs, mosques, brick kilns, ravines, and fragments of mere jungle; ground, easy to defend and most difficult to clear.

The suggested trench was a "first parallel"; it was destined to afford cover from which the troops might advance over the difficult ground lying between it and some position from which the town wall could be distinctly seen and breached.

The first step in the realization of this plan was made next day (7th September). At dawn, working parties, numbering in all 2,800

men, left their camps and set themselves to trench work. The composition of General Whish's Army now gave rise to complications. It contained 20,000 men of all arms ; 13,000 of these were Irregulars, largely Herbert Edwardes' Pathans, men who would dig trenches for themselves, fight anywhere and against any odds, but would not put a spade into the ground for the defence of others ; against this their pride rebelled, it was contrary to "custom." The burden of the digging was therefore thrown on the Native Regulars and the British regiments. It was found, however, that the latter could not face the sun, it simply struck them down. These difficulties were met by two expedients ; the British troops were permitted to work at night, and the Pathans were allowed to carry out a separate set of parallels of their own ; "this separate attack was conducted by Lieut. Lake, assisted by Lieuts. Charles Pollard* and Frederick Maunsell†, two young Engineers, "whose cool bravery and indefatigable zeal won the admiration of us all." writes Herbert Edwardes ; who adds : "The same remark would, however, apply to the whole Engineer staff at Mooltan—a finer body of men was never collected in any Indian Army."‡

The rebels set themselves to work at the same time to entrench themselves in the vicinity of the city. "So," writes Herbert Edwardes, "there were two armies throwing up works within a few hundred yards ; the rebels with little science, but unbounded zeal, rearing stockades, piling up felled trees and the woodwork of wells and houses, for the defensive warfare in which the soldiers of the Punjab excel ; the British approaching with laborious discipline to the attack which, at the proper moment, would burst from the trenches like a flood, and sweep all obstacles away."

Presently the process of dislodging the enemy from the aforesaid defences, houses, gardens, etc., began. The house-to-house and hand-to-hand fighting that ensued was of a most desperate and determined character.

We read of the cool courage with which the officers of the engineers placed scaling ladders and laid explosive bags close under the fire of the enemy's muskets ; of the rush of the soldiers surging over garden walls, or leaping from these walls on to trees, from the boughs of which they dropped into the midst of the enemy ; of confused attacks on unknown ground ; of hundreds of Mulraj's soldiers being heaped beneath the mango trees in walled enclosures ; and of our own many heroic dead. Ever to the fore in the midst of these brave assailants was Robert Napier, chivalrous, cool, and fertile in resource.

Sometimes driven back, often brought to a temporary standstill.

* The late General Charles Pollard, R.E. (late Bengal).

† General Sir Frederick Maunsell, R.E., K.C.B. (late Bengal).

‡ *A Year on the Punjab Frontier*, by Major Herbert B. Edwardes, C.B. 2 vols. Richard Bentley, London, 1851. 2nd edition, ii., p. 513.

the invading tide of British soldiers nevertheless pressed steadily on, taking point after point of vantage, until on the 13th of September, the engineers stood on the destined breaching ground—the summit of a cone in one of the suburbs, which rose within 600 yards of the Bloody Bastion, and from which the masonry of that tower could be seen for at least two-thirds of its height. Without loss of time, and protected by seven batteries already erected in its rear, the Sappers & Miners set to work on the great Breaching Battery.

All was going well. The day of the assault seemed to be within measurable distance, when on the morning of the 14th September came the news that Sher Singh—the chief of our allies, the Lahore Sirdars—had gone over to the enemy during the previous night taking the column of 4,300 Sikhs with him.

The transference of so great a weight from one arm of the scales to the other so altered the relative strength of the two armies that General Whish was obliged to suspend operations. The projected attack was abandoned for the time being; our hardly-won positions within breaching distance of the walls; the streets, houses, and fortified posts, just taken; our own batteries and trenches—all were deserted; and the British Army fell back in the direction of Bahawalpore, whence it drew its supplies, there to await reinforcements which were immediately ordered from Bombay.

There is no doubt that this step was necessary. Major Napier, who was among the wounded, gave it as his professional opinion that the force at General Whish's disposal after the desertion of Sher Singh was insufficient for the successful execution of his plans, and in this opinion he was supported by the most experienced officers in the camp.

The first act in this retrograde movement was the withdrawal of the guns, ammunition, etc., from the Great Breaching Battery and its neighbourhood. This was done at nightfall on the 14th, under cover of the falling darkness, and without molestation from the enemy. By some oversight no orders had been issued to the engineers for the removal of their large depôt of tools and engineering materials.

The loss of these stores would seriously affect the park equipment, and Taylor resolved to recover them if possible. Taking a sufficient number of camels and workmen, and a few of the Park Guard, he sallied out into the darkness, and made his way towards the city. On arriving at a reasonable distance from the Breaching Battery, he halted his escort and rode on alone. On reaching its neighbourhood he was pleased to find that it was still the target for the enemy's fire, for this showed that the British withdrawal had been unobserved, and that it was still believed to be in our possession. He went up to it, and found it unoccupied. He signalled to his men to advance to the Engineer depôt, and the tools were soon in the hands of their lawful guardians. The camels were

quickly laden and their heads turned homewards, and the party eventually reached the engineers' camp safely, not without adventures, but without serious molestation. The rescue was accomplished only just in time; next morning the whole of the area abandoned was in the hands of the Sikhs.

To prevent Mulraj's rebellion from growing into a Sikh war, by entrusting the Sikh Durbar with the task of quelling it, had been the political object of the Siege of Mooltan. This object was defeated by the defection of the Sikh Sirdar, Sher Singh, after whose desertion it was clear that a second Sikh struggle for national independence was inevitable. It was further clear, that the struggle would not take place at Mooltan, but in the home proper of the Sikhs, the country north of the Munjha, lying between the Chenab and the Jhelum, where fighting on an imposing scale might be expected.

These circumstances made the Siege of Mooltan, *per se*, a matter of secondary importance; it was all-important, however, that the heavy artillery collected there should be set free soon, for it would be urgently needed in the north. It was because all the available troops in Northern India would be wanted by the Commander-in-Chief to meet the new emergency, that the reinforcements necessary to the renewal of the siege were ordered from the south, *i.e.*, from Bombay.

In the meantime General Whish's Army temporarily abandoned its position. On the 15th September the forces of the Nawab of Bahawalpur, those of Van Cortlandt, and the Irregulars commanded by Herbert Edwardes, fell back to their new camp in and near the village of Suraj Kund, some 5 miles south of Mooltan. A few days later the British troops took up a position on their left. "Our camp," says Alex Taylor, writing from it on the 14th November, "was pitched in the midst of high jungle or underwood, some 8 ft. in height, but by dint of hard labour the ground to our front had been cleared to a distance of about 600 yards, and we are now in a tolerably good fighting position."

The removal from one camp to another of the great quantity of siege material collected was a large undertaking. Innumerable country-carts, gathered together for the purpose, plied backwards and forwards between the two camps, under the protection of 2,000 Irregular Horse and six guns, commanded by Lieut. Richard Pollock,* who defended the convoy from the flanking attacks of Sher Singh's Sikh horsemen. In spite of all efforts, however, sufficient carriage to move so much heavy ammunition was not forthcoming. Edwardes' Irregulars saved the situation. Each of his 1,500 horsemen took a cannon-ball—a 16-pounder—into his keeping,

* The late Major-General Sir Richard Pollock, K.C.S.I.

and either holding it in his hand, or slinging it across his saddle, carried it to the new depôt.

The siege was raised on the 14th September, and not renewed till the 21st December. This long period of inaction—more than three months—was one of great anxiety. Opposite General Whish's small heterogeneous army rose the battlements of the city of Mooltan, which was overlooked by one of the strongest citadels in Northern India, manned by 15,000 men who fought with halters round their necks; while for some time Sher Singh, who never came to terms with Mulraj, or was allowed by him to enter the city, lay with his fanatical soldiery to the north-east. It was with feelings of intense relief that the British Army saw this storm cloud move northward, for, had those traitors, Mulraj and Sher Singh, been loyal to each other, and had they attacked the British camp simultaneously, things must have gone hardly with it. It was known at the time that Mulraj was intriguing with Dost Mohamed and others of our Trans-Indus foes, to whom he promised Peshawur and the lands west of the Indus, if they would invade the Derajat, and thus force the British Army to move away from Mooltan.

During this interval the engineers under Major Napier prepared busily for the future resumption of siege operations. A store of gabions and fascines on an immense scale was made; in December the Engineer Park of which Taylor had charge possessed the enormous number of 15,000 gabions and 12,000 fascines, as well as a number of ingenious mechanical contrivances for facilitating the siege operations, and invented by the Director.

On the 30th November Colonel Cheape,* the Chief Engineer of the Punjab Army, arrived, and took over the general direction of the siege operations. Detachments of the troops from Bombay were now beginning to arrive at Mooltan, and by the 21st December, the numbers of the besieging army were complete.

On the 27th, the British Army, moving *en masse*, retook the suburbs they had abandoned at the end of the first siege, and entrenched their position north-eastward as far as Mulraj's garden palace, Am Khas, 500 yards from the north-eastern angle of the fort. The rebels were driven in at the Delhi Gate, and positions seized on heights suitable for battering the south-eastern walls and the Bloody Bastion; the breaching battery destined to deal with the latter being only 120 yards from it. As these batteries were completed they began to pour their shot and shell against the walls which they were designed to breach.

On the 30th the Grand Mosque within the citadel—the rebels' chief powder magazine, and hitherto believed to be *bombproof*—was

* Afterwards General Sir John Cheape, G.C.B., Colonel Commandant, R.E. (Bengal).

pierced by a shell and blown up. The explosion was terrific; an immense volume of smoke and débris rose in the air, and overspread the sky. "At a vast height," writes Herbert Edwardes,* "the heavy cloud stood still, like some great tree, and its shadow fell at night over the camp below. All action was suspended, every eye was turned up in awe, and watched the strange vision sink and disappear."

Finally, on 2nd January, 1849, the breaches having been declared practicable, a successful assault was delivered, and the city fell into British hands. Not the citadel, however, into which Mulraj withdrew with 4,000 picked men, leaving the rest of his army outside to die or escape as fate might decree.

Two breaches had been made in the south-easterly portion of the battered city wall:—one in the Bloody Bastion, and the other near the Delhi Gateway. The column destined to assault the latter was led by Robert Napier; while the perilous honour of guiding the Bombay Column up to the breach in the Bloody Bastion and through it fell, at the Chief's request, to Alexander Taylor.

The latter breach was carried by the 1st Bombay Fusiliers, Lieut. Anderson's regiment, to whom the place of honour in the avenging column was given as a right. Sergt. John Bennet, of the same regiment, planted the regimental colour on the crest of the breach, and stood beside it until it was torn and tattered by bullets. The place was found to contain another trench inside, but this was also taken after a bloody struggle.

"Then, from every crowded height and battery whence the excited struggle had been watched, rose the shouts of applauding comrades, and through the deafening roar of the musketry which pealed along the ramparts and marked the hard-earned progress of the victorious columns through the streets, both friend and foe might distinctly hear that sound, never to be forgotten—the 'Hurrah' of a British army after battle"; so writes one who was present. By nightfall the army was in entire possession of the city.

The following additional account of the Siege of Mooltan, with some details of the construction of the trenches and batteries, is taken from the Biographical Notice of General Sir John Cheape, G.C.B., who was the Chief Engineer of the Army:—

"The city of Mooltan is situated 4 miles from the present left bank of the Chenab, enclosed on three sides by a wall from 10 to 20 ft. in height, but open towards the south, where the dry bed of the old Ravee intervenes between the town and the citadel.

The original town consisted of two islands which are now crowned by the citadel and city, at an elevation of about 50 ft. above the surrounding country. The fortifications were dismantled in 1854,

* Major-General Sir Herbert Edwardes, K.C.S.I.

but the fort still remains a place of considerable strength, occupied by a European garrison. Within the city proper, narrow and tortuous streets, often ending in *culs de sac*, fill almost the whole space; but one broad bazár—constructed by the British immediately after the annexation—runs from end to end. Mooltan is a place of great antiquity. The principal buildings include the shrines of the Mohammedan saints Baha-oo-din, Ruku-ul-alam, lineal descendants of the Prophet, which stand in the citadel. Close by are the remains of an ancient Hindu temple called Paládpuri, blown down by the explosion of the powder magazine during the siege of 1849.

On Christmas Day General Whish had occupied his old position, and the Bombay force under the command of Brigadier the Hon. H. Dundas next day formed on his left.

On the 27th the enemy in the suburbs were attacked by four columns. Brigadier Dundas commanding the left, moved round the left of the first original parallel, and drove the enemy successfully from the Maya Temple, and the mound called the Sidi Lal ke Bed, and the Baghi Bagh. Brigadier Casson advanced against Ram Tirat and compelled the enemy to evacuate the Mandi Awa and drove them out of the suburbs into the city.

The right column occupied without any loss the suburbs and buildings east and north-east of the citadel, and the brick kilns with their entrenchments.

General Whish had decided on attacking the north-east angle of the citadel in regular form, but Brigadier Cheape advocated an attack upon the suburbs and town. This was considered too great a risk, but a diversion on the south-east side was resolved upon. There was therefore a right and a left attack; the first fell to the Bengal gunners, the latter was shared with the Bombay artillerymen. The numbering of the batteries was that of the engineers, which included both Bengal and Bombay batteries.

December 28th. Right Attack.—A ravine to the right of Shams-i-Tabiz occupied the day before was converted into a battery, No. XI., for six 8-in. mortars, which moved out of park that evening and opened this morning at 700 yards from the outer wall of the fort. The infantry posts were loopholed. At dusk No. X. for two 24-pounders to destroy the upper defences of the north-east face of the citadel, and No. XII. for two 8 and three 10-in. howitzers to enfilade the face commanding the town, were marked out.

Left Attack.—No. I., three 10 and four 5½-in. mortars (Bengal) were established during the night on the Mandi Awa. No. II. for six 18-pounders to breach the curtain near the Khuni Burj at about 120 yards, was traced out, but not completed, material having to be conveyed from a distance. In the morning a heavy matchlock fire prevented more than the revetting of the finished portion. No. I. opened in the evening and continued during the night.

December 29th. Right Attack.—Nos. X. and XII. commenced and completed during the night as also connecting trenches with Shams-i-Tabiz. They were armed and opened during the day and trenches widened.

Left Attack.—On the previous day Edwardes and Lake had relieved the Bombay troops of the posts about Sidi Lal ke Bed, and the latter closing to the right had their left posts in the suburbs about the Khuni Bhurj. No. II. was completed by midnight, but the first gun was not brought in until daybreak, and a company of the 9th Bombay Native Infantry was unable, after several attempts, to bring in a second. Several gunners were wounded.

December 30th. Right Attack.—Magazine for No. XII. was commenced and completed.

Left Attack.—No. II., completed during the night and opened at daybreak. No. V., for two 6-pounders, was commenced and armed by daybreak among the houses near the Delhi Gate, to destroy the town wall defences at about 200 yards. Two Bombay 18-pounders and two 8-in. howitzers were placed behind a mud wall opposite the Delhi Gate, and opened with effect upon the gateway. The mud wall coming down, a sandbag battery was put up.

At 10 a.m., this day a shell from a mortar laid by Lieut. Newall in No. XI. Battery fell upon the principal magazine near the southern face of the fort, a mosque which had been appropriated for that purpose, and which blew up, opening an extensive crater in the ground through the inner wall. General Whish in his report compares it to the explosion at the Siege of Hattras, March 1st, 1817. When the smoke and dust had cleared away the enemy resolutely resumed their fire.

January 1st, 1849.—On this day the Commanding Engineer at noon reported the Khuni Bhurj as looking well, though not likely to be a good breach, and recommended the assault, if it were to be made here, to be done at once.

Right Attack.—No. IX. completed. Repairs to batteries during the day.

Left Attack.—The fire of the four right* guns of No. II. was turned from the curtain on to the Bhurj itself. No. VIII. Battery armed and opened fire. Capt. Siddons examined the breach in the early morning, and reported it practicable though steep. That at the Delhi Gate was said to be sufficiently practicable for an attempt.

The troops told off for the assault left camp after noon in two columns; the right under Brigadier Markham, to attack the Delhi Gate; the left under Brigadier Stalker, to attack the Khuni Bhurj.

The Bombay column was completely successful, the leading party

* This was done by Lieut. (afterwards Lieut.-General) Pollard, Bengal Engineers, without interfering with the direct fire of the left pieces.

crowning the breach found the communication with the Bhurj interrupted, but with the aid of two ladders procured by Lieut. Oliphant* and his sappers, they got over a low house into it, driving out the enemy.

The other parties forced their way through the town, taking possession of the Pak, Haram, and Bohar Gates, which were held during the night. Major Scott was wounded. That under Markham, on getting to the Delhi Gate, found the lower part of the wall, previously concealed from view too high for escalade. Capt. Smyth, with great decision withdrew the leading companies under cover. This column had to find its way in through the other breach, whence it followed the eastern face of the town to the Delhi Gate. The Daulat Gate was taken next morning. Major Napier (afterwards Lord Napier of Magdala) commanded the engineers here. Capt. Garforth was dangerously, Lieuts. A. Taylor and J. A. Fuller severely, wounded; the latter by an explosion of a magazine near the Bohar Gate."

Thus fell the town and citadel of Mooltan, after a resolute defence and severe fighting. The Mulraj was put on his trial for the murder of an official, and being found guilty was sentenced to death; but this penalty was afterwards commuted for that of transportation. The district at once passed under British rule.

* Afterwards Major-General Oliphant, R.E.; died in 1898.

(To be continued).

MEMOIR.

LIEUT.-GENERAL H. A. BROWNLOW, ROYAL ENGINEERS.

IT is not always easy to write a memorial of a very dear friend. One does not wish to write extravagantly on the one hand, nor to omit points of importance on the other. I think then that I had better state at once that in all my long life I never knew a better man than Henry Brownlow.

He was born on the 1st March, 1831, and came of good Ulster blood. He used to spend his holidays in the North of Ireland. His father belonged to the Bengal Civil Service, and in due time his son obtained what used to be called "a cadetship" in the East India Company's service, and went through the Military College at Addiscombe. On the 11th December, 1849, he obtained his commission in the Bengal Engineers, and after some time spent at Chatham he went to India, and was posted to the Irrigation Department in the N.W. Provinces.

At that time the department was on a very small scale, its officers being nearly all Bengal Engineers. They had however as their chief a man of real genius, Sir Proby Cautley, an Artillery officer, absolutely without any engineer training, but a born engineer. Under this officer young Brownlow began his career. There is no great work that bears his name, but of strong common sense, high courage and untiring energy he made his mark wherever he went. He was an excellent rider even after he had partially lost the use of his leg.

In 1856 Brownlow was Executive Engineer of the Eastern Jumna Canal, a small but a very important work, watering an area of some 500,000 acres, extending from the foot of the hills to opposite Delhi, a distance of about 130 miles. He might have spent all the rest of his service on those irrigation canals, when to him, as to so many others, came the great Indian Mutiny. From Benares to near Umballa the whole country was in a blaze of excitement and revolt, and the few scattered English residents flocked into the nearest garrisons.

The headquarters of the Eastern Jumna Canal was at Saharunpur, a native town of some importance about a hundred miles up the canal from Delhi. The white population consisted of a judge, a magistrate, two assistant magistrates, and two or three irrigation officers; but these last from the nature of their duties were constantly moving about amongst the villages. There was besides a detach-

ment of Sepoys on guard over the treasury where there was some revenue at the time. Brownlow was the only sportsman among them, and he had two fowling pieces. There were not more than two other guns among them all. Besides this small garrison there were two warrant officers with their wives and families, encamped on the canal, two or three marches from Delhi.

The chief source of danger lay in the detachment of Sepoys. Regiments were breaking out into mutiny all over India. Would anyone vouch for the fidelity of the company at Saharunpur. Whenever the news of the general outbreak reached Saharunpur, the judge called a meeting to decide what should be done. The ladies and children could easily be taken to a hill station not very far off. But how about the families of the warrant officers? They were in hiding during the days, and going from village to village during the nights. How could they be brought in?

The council of war at Saharunpur resolved that with their small numbers they could not spare a man to bring the families in. Brownlow said "Then I will go out alone." Then said his comrades "You must also take the Sepoys with you. We are unarmed, and must be protected from our protectors." The matter was thus compromised.

Brownlow had borrowed an elephant and two or three carriages. He started down the Delhi road. His Sepoys all went in front. He brought up the rear on his elephant with two loaded guns across his knees, and never taking his eyes off his Sepoys. About 15 miles from Saharunpur he met the two families he had gone out to rescue. The doubtful Sepoys dispersed of their own accord.

The Army was then on its march from Amballa to Kurnal and Delhi, along the Grand Trunk Road, which was blocked with endless carts and wagons, elephants, horses, camels, guns and camp followers, all the stores necessary for the prosecution of a great siege. Brownlow was called on to bring in stores from the left bank of the Jumna. The road was unmetalled. The Jumna was unbridged. It was the hottest season of the year. Brownlow had always been a delicate man, very subject to fever. The distance was about 90 miles. In spite of all these drawbacks he brought his convoy safely to Delhi. For the remainder of the siege he had charge of the Engineer Park.

Colonel Baird Smith who commanded the Engineers has thus reported :—" With what assiduous care and untiring energy Brownlow supervised these operations is known to all who served at the siege. Thousands of fascines, gabions, and other siege materials were collected, and the troops were also instructed by Brownlow in their uses and the method of packing them on camels. The arrival of the siege train having placed the Artillery in an equally satisfactory condition, ground was broken on the night of the 7th September."

I have no intention of entering into the details of this famous siege. It has been described in many books, of which I would only mention two, both of them by ladies. Mrs. Flora Steel's *On the Face of the Waters*, and Miss Taylor's admirable biography of her noble father, General Sir A. Taylor, to whom more than to any other person was due the success of the enterprise.

On the night of the assault, while bringing up stores to the Kashmir Gate, Brownlow was dangerously wounded, and there was an end of campaigning for him. He was carried up to the hill station of Mussooree, and it was only after some months that he was able to return to duty at Saharunpur. It was during his stay at Mussooree that he made the acquaintance of Miss Ellen Eliza Brind, the daughter of General Sir James Brind, who shortly after became his wife. She has survived her husband.

In his tent one day the news reached him of a terrible gunpowder explosion at Lucknow. More than twenty lost their lives, and among them Brownlow's younger brother Elliot. They were both Sappers, and when Elliot lost his life he was on the eve of returning to the survey of Kashmir, Lucknow having been taken. When I first arrived in India in June, 1858, everyone was full of the praises of Elliot Brownlow, and he was thought quite equal to his brother Henry. They were heroes both. When Henry received the news of his brother's death he shut himself up in his tent for three days. When he came out he had changed. He had the old pluck and high courage, the same cheery good spirits; the same kindly ways which endeared him to all with whom he came in contact. But besides all this he was now the devoted servant of Jesus Christ. When he was fit for duty Brownlow returned to his work on the Eastern Jumna Canal.

One day he was out shooting accompanied by his assistant, the late Oliver St. John, and another young officer, when some villagers came and asked him to drive away a tiger which had got between them and their drinking water. They had only shot guns, and no bullets. But a mould soon enabled them to cast bullets, and they started on foot through the jungle. They fired, the tiger charged and knocked Brownlow over. I remember his telling me afterwards how fetid was the brute's breath as it lay on the top of him. Fortunately a bullet had gone through the tiger's jaw or it would certainly have killed him. As it was it crunched his left leg and his right hand. St. John killed the tiger, and for many weeks Brownlow was in a critical state, and was sent home on furlough as soon as he was fit for the journey. He used to say jokingly how much he owed to that tiger. But for it he would not have been sent home, and would inevitably have died of fever among the Saharunpur swamps.

During his absence on furlough things did not go very well with

the Irrigation Department of the N.W. Provinces. There was no one in charge of the great Ganges Canal who had really had experience of such a work. The banks and bed of the canal had become greatly eroded, with a mean velocity exceeding 3½ ft. per second. Great holes were scoured out in the bed and there was a fear that the bridges would become unsafe.

A committee of engineers was assembled at Roorkee, and they reported that unless the scour of the bed could be stopped the canal was in a very perilous state. It should therefore be widened, that weirs should be interpolated between the existing ones, and that a fourth arch of 50 ft. span should be added to each of the bridges To carry out all this remodelling would require at least two years, during which the canal must be closed. A doctor who begins his cure by killing his patient is not likely to rise in his profession. Had the Ganges Canal been closed for two years the irrigation would necessarily have ceased, and thousands of peasants would have been ruined. Things looked very bad.

In 1868 Brownlow returned to India and inspired irrigation officers with fresh hopes. He showed them what a splendid work the Ganges Canal really was—that there was no need of a long closure if ordinary precautions were taken. He put the whole canal on to a sound footing, and so it has remained ever since. I have no idea of how many lakhs of rupees Brownlow at that time saved to the Indian Government, nor what is now the annual revenue of the Ganges Canal.

Brownlow was twice mentioned in despatches, and received a Brevet Majority for his services in the Mutiny. He eventually became Inspector-General of Irrigation, and Deputy Secretary to the Government of India. He also received a good service pension on his retirement in 1886. Some of us who had served under him were vexed that he did not receive any higher reward for his distinguished services. I am sure that in his great modesty he himself felt no disappointment on the subject.

After his retirement Brownlow settled with his wife and family first at Norwood and afterwards at Wimbledon. Henceforth all his energies were devoted to active charitable and religious work. He was on the committee of the Church Missionary Society, and gave many addresses which were said to be always clear, carefully worked out and inspiring. His addresses were specially appreciated by young men. He was a speaker of very high order.

For the last ten years of his life he was a great invalid, and was obliged to give up much active work. This must have been galling to a nature so vigorous as his; but he bore it all with cheerful patience, and used to say to his friends he was just waiting. He passed away early on the morning of the 19th April, surrounded by those he loved best.

COLIN C. SCOTT-MONCRIEFF.

TRANSCRIPTS.

THE SIEGE OF ADRIANOPLE.

From an article by V. N. Polvanski in the September, 1913, and subsequent numbers of *Injenerni Jurnal.*

(Concluded).

CHAPTER V.

Conclusion.

The following points stand out prominently in the fighting which resulted in the capture of Adrianople :—(i.) That against prominent objects, like the permanent works of the East Front, modern artillery can not only support an infantry attack but also practically effect the capture of the enemy's position, by demolishing the works and driving away any who may survive of the defenders ; (ii.) that against unseen targets, like the majority of the batteries on the South Sector, and against " invulnerable " trenches, like those on Pamuk-Sirti or in the intervals on the East Front, the fire even of heavy artillery can do little harm, provided that these works are protected by shrapnel-proof head cover ; (iii.) that the rifle and machine-gun fire of very small numbers is sufficient to stop a powerful infantry attack, and (iv.) that the most modern weapons, like the artillery of the defence, are ineffective in the hands of untrained men and without skilful direction.

The weakness of the defences of Adrianople lay in the fact that the lines of trenches, wherein in this case rested the whole power of the defence, were not supported by serviceable strong points. In the *main defensive lines* the old, out-of-date, forts, and even the incomplete new lunettes, were not only useless for this purpose—as they could not even defend themselves, and much less the intervals between them—but positively harmful, as they occupied the more important tactical localities, and were consequently points of weakness most dangerously situated. In the *advanced positions*, the Turks, under the guidance of their German instructors, had rightly discarded old-fashioned redoubts, but had put nothing in their place, and the absence of strong points was a serious source of weakness to these lines, which were otherwise strong, owing to the correct siting and construction of the trenches, many of which were without parapets.

It is interesting to note that psychological reasons account to some extent for the obstinacy with which the advanced positions on the south and west were defended in comparison with those on the East Front. In the two former cases these positions were practically the main lines of defence, for in the south the artillery was posted in front

of the fort line, and on the west there was no fort line. On the East Front the loss of the advanced positions would not have been necessarily fatal to the defence, and this may to some extent account for the feeble resistance which they offered to the assault.

In considering the form which the pivots or strong points of permanent fortifications should take in the future, it must be recognized that however skilfully the defence works are constructed with a view to concealment, the fact that the strong point must occupy some locality of special tactical importance will effectually disclose its position, and the concealment of its works, though it may usefully add difficulty to the ranging of the hostile artillery, cannot effect more than this. The strong point must expect to draw upon itself the extraordinarily accurate fire of modern howitzers, even of very large calibres, and what this may be was shown by the two-days' firing of the Servian howitzers on the South Front.

The tendency to replace forts by groups of two or three mutually supporting forts is very marked in modern permanent fortification. But even in this case the forts will not escape the accurate fire of the howitzers of the attack, and the fighting advantages of these fort groups can hardly be said to correspond with their great costliness.

The contest between solidity of construction and the penetration of modern shells cannot go on indefinitely, as there is a limit to the thickness of roofs, and no better material than concrete or ferro-concrete is to be found. To some extent the solidity of structures can be varied in accordance with their siting, and with their chances of being hit. But even if casemates were capable of resisting the blows of modern high-explosive shells, the condition of the works during a bombardment, the noxious gases, the flying splinters and the vibrations due to the explosions would probably render firing lines within them untenable.

It is evident that the all-important fire positions for the distant fighting cannot be in the strong points, and there are equally good reasons why they should be in the intervals between strong points, where their chances of escaping injury are far greater. They will consist of invisible and "invulnerable" fire trenches in combination with secure concrete shelters. The guns were the first to leave the strong points, and now the firing lines must follow suit.

We now come to the arrangements for flanking the intervals and the approaches to the strong points. There has been some inclination of late to underestimate the importance of these, in view of the power of the frontal fire of modern rifles and machine guns. But this is counteracted by the increasing use of the shovel in attack. Once the troops of the attack are entrenched in close proximity to the position they can be driven out only by enfilade or high-angle fire, or by a counter-attack. High-angle fire is difficult to make accurate at near distances, and in local counter-attacks against an entrenched enemy the advantages of the defence have passed over to the side of the attackers; enfilade fire upon the intervals and the approaches to the strong points must be organized as a means of opposing the "entrenching of the attack."

The means of obtaining this have hitherto been the "flanks" or flanking galleries, and the "interval caponiers" containing the guns

allotted for this purpose, all of which have been included in the strong point. The "flanks" must still remain in the pivot, and if it is one of group character they may possibly take the form of "invulnerable" trenches located somewhere between the forts. But as such trenches cannot be considered as permanent works, the "interval caponiers" become all the more important; and as the danger to them of fire within the strong point has become greater than the risk of capture outside, they also must be moved outside into the intervals. The guns must be mounted in disappearing turrets, and, to reduce as far as possible the danger of their fire to their own troops, they should be distributed to the number of three or four along each interval, the guns acting "for opposing assaults" in the sections in which they stand and "for opposing entrenching" in the adjoining sections.

What then remains of the strong point? It remains a tactically important locality prepared for purely passive defence, its most important work being its obstacle, the ditch, with the frontal or flank defences in connection with it. All the means of active defence are moved out to places where they can the better fulfil their objects, and from whence they can bring fire upon the approaches to the strong point, and the most important fire of the strong point itself is that used in defence of its obstacle in the close fighting.

The strong point from its position will still be the lightning conductor which will attract upon itself the forces of the attack. It must be a permanent work, as no group of field character will suffice to defend its obstacle and the defences connected with it against the artillery and the operations of a regular siege.

For the artillery of the defence the experience of both Port Arthur and Adrianople shows that, if the guns are placed in concealed positions, permanent batteries, built of concrete, etc., are unnecessary for them. The batteries may be of purely field type, provided that shrapnel-proof head cover is provided for the gun crews. The covered-in batteries adopted by the Allies at Adrianople are suitable for this purpose. If the guns cannot be placed in concealed positions, armoured mountings appear to be expedient.

APPENDIX.

Details of the Fortification Works of the Servians in the North-West Sector of the Investment Line.

(From an article by V. Kotelnikov in the May, 1914, number of *Injenerni Jurnal*).

The following information regarding the work of the Servian Timok Division in fortifying their portion of the N.W. Sector of the line of investment was obtained from Lieut.-Colonel Stanoilovich, who commanded the Engineers of that division.

The works were begun on 8th December in compliance with an order issued the day before by the commander of the division, who was also in command of the N.W. Sector of the attack. A map of the works of the attack and the defence in this sector is attached (see *Plate* I).

The following is an extract from the order :—

I. RIGHT FLANK SECTION (from the Maritza to the Kara-Bunar-Yekmekchi-Keui Farm Road).

(*a*). 1 Company 20th Regiment and ½ section Pioneers.	Redoubt No. 1 for one company with obstacles in front of the front faces. Tools :—160 shovels, 40 picks, 20 axes ; the pioneers to bring their own tools.
(*b*). 2 Companies 20th Regiment and 1 section Pioneers.	Group No. 2 of two redoubts, for one company each, and trench for one company ; obstacles on front and flanks. Tools :—320 shovels, 30 picks, 40 axes.
(*c*). 1 Company 20th Regiment and ½ Section Pioneers.	Group No. 3 of two redoubts, for one section each, and trench for two sections ; obstacles in front of the group. Tools :—160 shovels, 40 picks, 20 axes.
(*d*). 2 Companies 15th Regiment and 1 section Pioneers.	To make the group of Redoubts Nos. 4 and 5 with the trench connecting them ; (redoubts and trench for one company each). Tools :—320 shovels, 80 picks, 40 axes.

II. CENTRE SECTION (to Sarai-Ak-Bunar).

(*a*). 1 Company 15th Regiment and ½ Section Pioneers.	Redoubt No. 6 for one company. Obstacles. Tools :—160 shovels, 40 picks, 20 axes.
(*b*). 1 Battalion 13th Regiment and 1 section Pioneers.	The Tuashan-Kulaya group of works (consisting of Redoubts Nos. 7 and 8, for one company each, Lunettes Nos. 9 and 10, for one half-company each), and trench for two companies, in front of Sarai-Ak-Bunar. Tools :—640 shovels, 160 picks, 80 axes.

III. LEFT FLANK SECTION (from Sarai-Ak-Bunar to the Tunja).

. . . . . .

(This section was occupied by the 55th Bulgarian Infantry Regiment).

IV. REAR POSITIONS (consisting of Kemal Village and Redoubts Nos. 13, 14 and 15).

(*a*). 1 Company Infantry and 1 section Pioneers.	To put *Kemal in a state of defence.*
(*b*). 3 Companies 53rd Infantry Regiment* and 1 section Pioneers (Bulgarian troops).	To make Redoubts Nos. 13, 14 and 15 for one company each.

Profiles, where possible, to be the height of a man ; shelters to give protection from shrapnel ; overhead cover to loopholes to be provided, and also blindages ; obstacles to be wire entanglements and abattis ; cover for reserves to be sited approximately as shown in maps, well applied to the ground ; communication trenches also necessary.

The work of fortifying the position, including subsidiary works (loopholes, overhead cover, blindages, shelters, dug-outs, etc.) was pushed on energetically during almost the whole of the first period of the blockade. The conclusion of the armistice, which lasted from 3rd December, 1912, to 2nd February, 1913, enabled the Servians to entrench a second position closer to the Turkish lines, practically as if on manœuvres, without any interference from the enemy.

The most typical strong points are shown in *Plate* II. Redoubt No. 1 was in plan an ordinary closed work for one company, with wing trenches ; on the front and flank faces there were small traverses at intervals of from 15 to 20 paces, and in the gorge two blindages, for 10 men each, but which could, on emergency, and for a short period, hold a section ; the roofs of these blindages were calculated to be proof against direct hits of field artillery. The profile differs from the normal Russian type

* In reserve at Vizgach.

in the complete absence of an outside ditch, which the Bulgarian engineers look upon as only a means of supplying earth for the parapet, if the latter is large enough to require it, as in Group No. 3; the obstacle to assault was some form of artificial obstacle, generally a wire entanglement, or more rarely abattis, placed 50 to 80 paces in front of the work.

From want of material the obstacles were placed before the front and flank faces only, and were at first only 14 ft. in width. This was done in the case of nearly all of the defences of the Allies before Adrianople. It infringed one of the essential rules of strong points, that which requires a "closed obstacle," but in this case no harm came of it, as the Turks directed their weak sorties against the intervals between strong points and against the artillery placed in rear of them, in the endeavour to do the greatest possible damage to the active forces of the attack.

In the profile of No. 1 Redoubt the low command of the parapet (1¾ ft.) and its glacis-shaped formation should be noticed, both features being important for concealment. Even with overhead cover to the loopholes the total height did not exceed 3½ ft. The low command of the firing line was possible owing to the smooth surface of the ground and the absence of vegetation in the winter months.

Group No. 2, consisting of two redoubts and a trench, each for one company, was designed for a battalion, the fourth company forming the local reserve. In rear of its centre, at 300 paces back, was a field battery of four guns, in a semi-concealed position. In rear of the flanks were shelters for the reserve, and a refuge casemate for the garrison.

Strong point No. 3 was another group, but in this case for one company only, with one section in each of the closed works on the flanks and the remaining two sections in the trench between them. The front faces of the redoubts had outside ditches of triangular section and these faces were also equipped with overhead cover, but of a worse design than that of No. 1 Redoubt.

In both No. 2 and No. 3 Groups the idea of the subdivision of units for defence is to be noticed; the case of No. 3 is especially interesting, where even the company was split up, and the two flank sections, at any rate, were taken completely out of the control of the company commander.

Of the remaining works those which showed the most original forms of construction were No. 6 *bis* (which was pushed somewhat forward from the line of investment) and that named "Kodgrobla" ("Tombs"), near tumulus + 90 m., on the position of closer investment (see *Plate* III.).

In both of these there was hardly any interior terreplein. The Servian Engineers had already shown a tendency towards this form of work, and under the Turkish shrapnel fire they became convinced that the depth of redoubts should be reduced to a minimum. In the works carried out during the armistice the results of this conviction are seen.

No. 6 *bis* had two small terrepleins on the flanks, but between them the front and gorge faces consisted, for the greater part of their extent, of a single combined trench. As this trench followed a crest line, equally good fields of fire were obtained from it to front and rear.

In the "Tombs" redoubt the trenches of the front and gorge faces were separated by a mass of earth of varying thickness, and the defenders of both faces were better protected from being shot in the back. *Plate* III. gives a copy of the design for this work. The large number of small traverses is noteworthy, but their siting is faulty, as they are drawn back in rear of the firing line and consequently give protection neither to the men lining the banquette nor to those on the step behind it. Each of the four blindages in this work could accommodate from 10 to 15 men. Their roof covering consisted of metal narrow-gauge sleepers, carrying 4·66 ft. of earth and two layers of stone rubble. Unfortunately there is no evidence to show whether this would have given protection against direct hits of fortress, or even of field, artillery, as no cases of such hits are reported.

Section II.—II. shows a form of overhead cover made of rails and sleepers of the narrow-gauge railway.

To recapitulate, the *strong points* on the line of investment were placed in the

same line as the trenches; at intervals of 1,000 to 2,000 yards apart, thus possessing good fire command of the approaches to the intervals between them, and to their own front; they were extended in length and compressed in depth; they were usually made for garrisons of one company each; had all-round fire; but obstacles only in front; were generously equipped with small traverses and shrapnel-proof head cover; blindages, proof against direct hits of shells up to 3-in. calibre, were provided in them for the guards only; for the rest of the garrisons refuges of light construction were placed outside the works, at some 150 to 200 paces back, on reverse slopes.

With regard to the reduction, and even extinction, of the interior terrepleins of closed works, the supporters of this form of construction claim that its chief advantage lies in the reduction to a minimum of the area exposed to the action of hostile artillery fire. But they overlook the fact that losses depend not upon the size of the exposed area but upon the density of its occupation. When the gorge face is drawn nearer to the front face, its defenders, and also the interior reserve, are brought, without any special necessity, closer to the front crest line, which is probably the most visible part of the work and that on which the hostile artillery will direct their fire. The disadvantage of this will be seen when it is stated that even at 35 paces back the percentage of probable hits is only one-half that to be expected in the trench lying immediately in rear of the crest line.

Furthermore in a work like No. 6 *bis* there is only one line of communication between the flanks, while in one of normal design there are trenches of the front and gorge faces besides other interior lines. The "Tombs" work is but little better in this respect, as the distance apart of its two lines is less than the diameter of the crater formed by a field howitzer shell.

As regards the defenders of these faces, it is suggested that in works like No. 6 *bis* the defence from front and rear can be entrusted to the same men. But there is no reason why there should not be simultaneous attacks from front and rear, or at any rate demonstrations in combination with real attacks. Each face should have its own garrison, and where two such garrisons occupy the same trench it must lead to a certain amount of confusion.

This author calls particular attention to the abnormal conditions due to the two-months' armistice, of which one of the clauses sanctioned the continuance of the provision of cover for the outposts during its operation. This enabled the besiegers with impunity to advance their investment lines and to carry forward the transference of artillery and military stores at distances of less than 2,000 yards from the Turkish positions. The moral effect upon the defenders of the passage of the Bulgarian trains through the fortress, and of the intercommunication between besiegers and defenders, has been already mentioned.

The advantage to the defence of the *advanced positions* may be summarized as follows:—(i.) They kept the siege batteries at a distance; (ii.) they retained important observation points in the lands of the defence; (iii.) they, perhaps unintentionally, gave greater freedom of action to the defenders, by enabling them to get outside their line of obstacles; and (iv.) they increased the perimeter of defence to dimensions more in keeping with the numbers of the garrison.

As regards this last the Editor of the *Injenerni Jurnal* notes that with such an enormous garrison (58 battalions of infantry, with a fort line of 23 miles) advanced positions were not only useful but necessary, in order to make use of the superfluous numbers. But how would it be with advanced positions if the garrison was accurately estimated and only just sufficient for the occupation of the main positions?

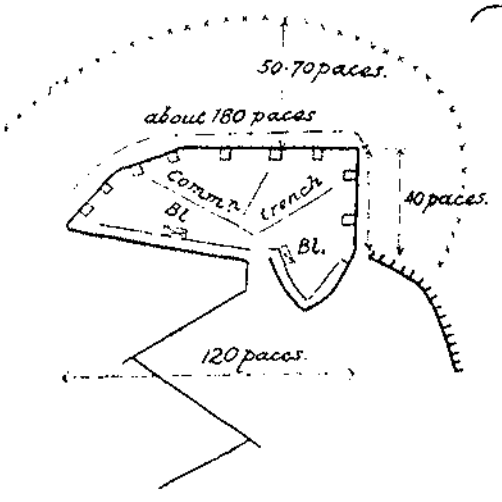
F. E. G. SKEY.

STRONG POINTS OF THE LINE OF INVESTMENT.

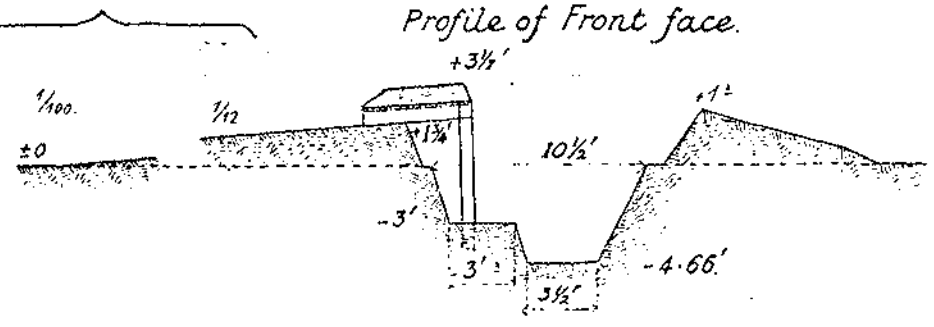
The Section of the Servian Timok Division.

Redoubt Nº 1 (Right flank) for 1 Company.

Plan.

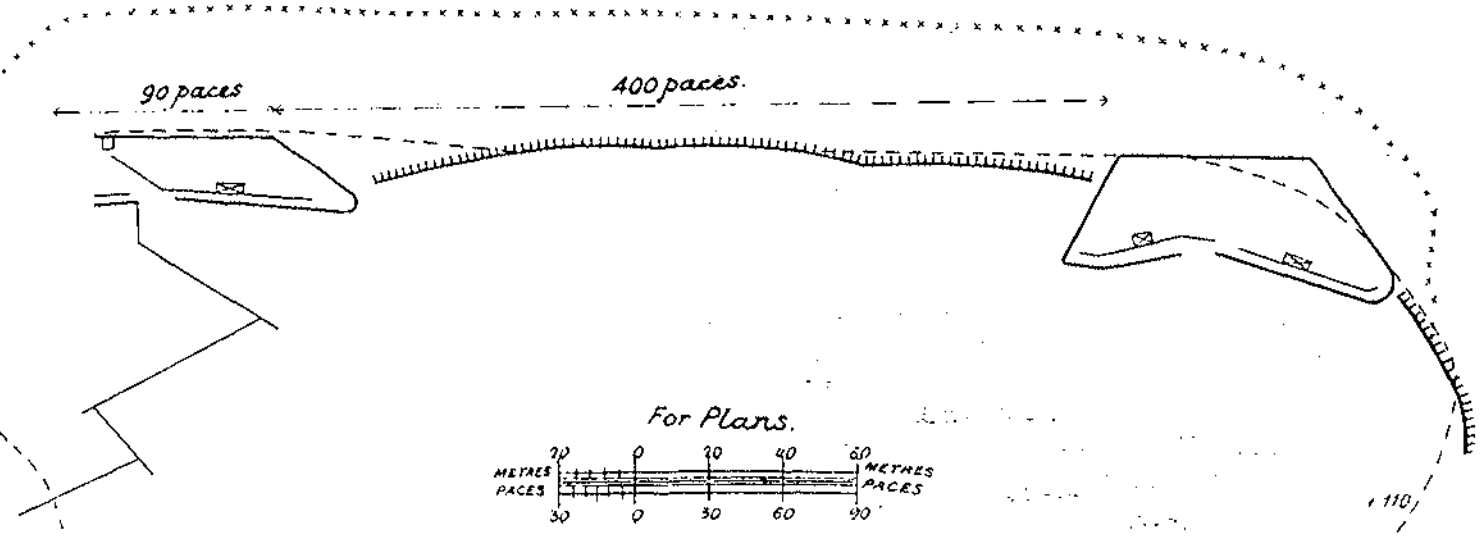


Profile of Front face.

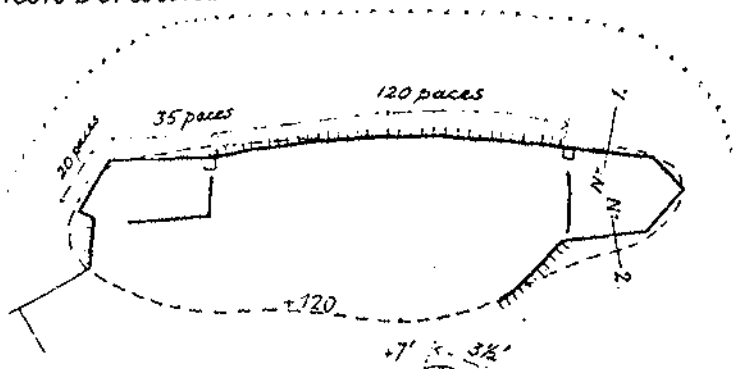


Group Nº 2.

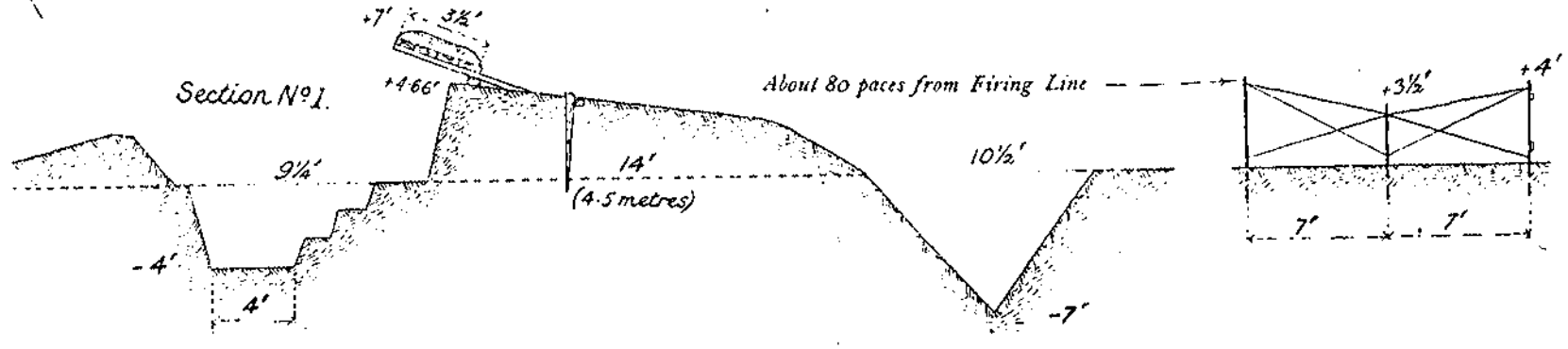
2 Redoubts with adjacent trenches (for 1 Company each) and rifle trench (for 1 Company) between them.



2 Works for 1 section each and rifle trench for 2 sections between them.



Section Nº 1.



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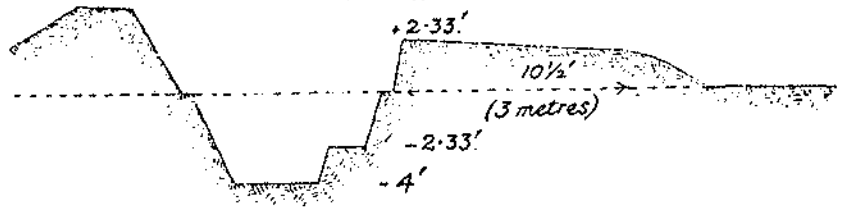

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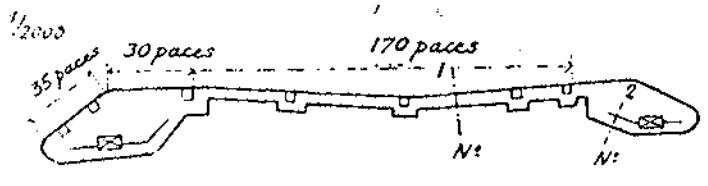

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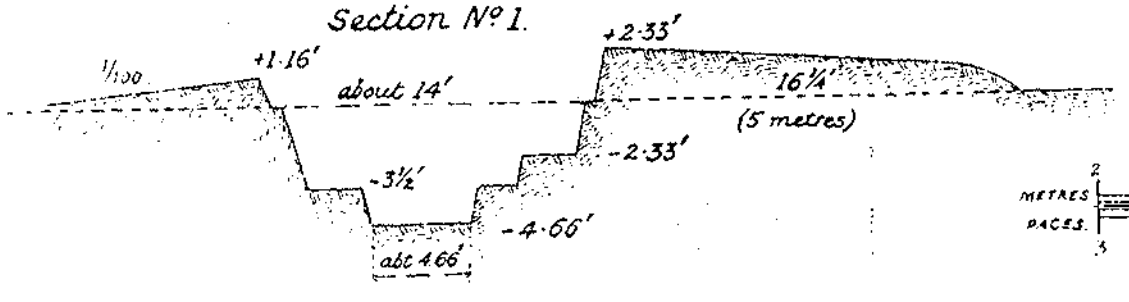

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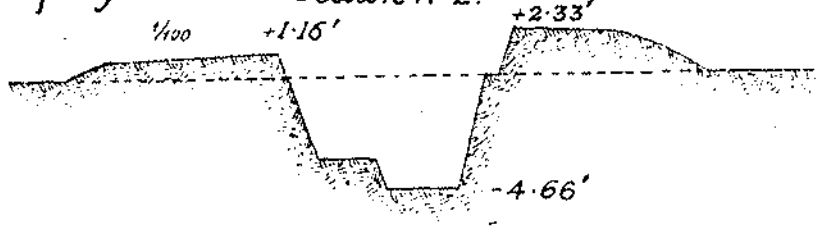

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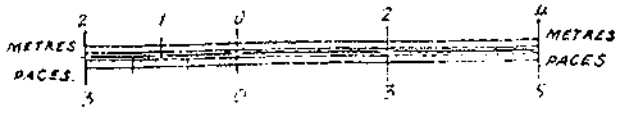


HISTORY OF UNDERGROUND WARFARE.

Being a Review of the book by A. Genez, Captain of Engineers, French Army.—(Librarie Militaire Berger Levrault, Paris, Rue Des Beaux-Arts 5-7, 1914. Price 5 francs).

(Continued).

Third Period.

The Siege of Candia demonstrated the importance of subterranean defence outside the fortress, and from 1670 all new fortresses had systems of countermines under the glacis, with listening galleries in masonry. Numerous systems were devised, but so far there was no rule for determining the weight of the charge with reference to the direction of its explosion, and to the weight and nature of the material to be moved. With Vauban a scientific spirit was introduced, and under his directions Mesgrigny undertook various experiments at the Siege of Tournai.

From these experiments it was wrongly deduced that however much the charge was increased the radius of rupture was always the same as that of a common mine, the only difference being that the materials were expelled with greater force. This error prevailed for half a century, when Belidor demonstrated the properties of overcharged mines; possibly the effects produced by large mines at Luxembourg and Turin suggested to him the need for further experiments.

At Luxembourg (1684) Vauban directed the siege works, assisted by several Engineers. The principal attack was directed against the Barlemont Bastion, which was itself protected by a counterguard, the escarp wall of which was 13 ft. thick at the base. Behind it was a masonry gallery 10 ft. high and 10 ft. wide. The whole was demolished by 22 charges of 440 lbs. each placed 4 ft. from the exterior face of the wall, and 15 charges of 385 lbs. each placed in the earth behind the inner wall of the gallery, which was 4 ft. thick. These charges must have been 12 ft. to 16 ft. below the top of the parapet, and 25 ft. to 30 ft. apart. The width of the breach opened was about 500 ft., the largest hitherto made by mines.

In 1706, during the Wars of the Spanish Succession, the French besieged Turin, which was held for the Duke of Savoy. The garrison was strong, the inhabitants were devoted to Savoy, and the fortifications had been improved by Vauban, to whom the King wished to entrust the conduct of the siege, but Mme. de Maintenon secured it for her son-in-law, the Duke de la Feuillade. Vauban would first have taken the Capucin Heights, on the east, or right bank, of the Po. They commanded the city, which was situated on the left bank. His scheme was sent to la Feuillade, but the latter preferred his own, which was to capture the Citadel on the West Front. He had attempted to do so once before, and the Duke of Savoy, forewarned, had recently constructed lunettes in front of the citadel with a countermined glacis in front, had divided the citadel into two parts by a retrenchment, and protected the bastions by counterguards.

The French sent a fine army, with a numerous artillery, eight brigades of Engineers commanded by Tardif, and four strong companies of miners. From right to left the front attacked comprised the Amédée and St. Maurice Bastions of the citadel, with the demilune de Secours opposite the curtain between them covering the Secours Gate, then the Royal Bastion, the demilune of the Susine Gate, and a hornwork protected by a flèche, the last three being a part of the defences of the town itself. The countermines of the defence in front of the citadel were of masonry in two tiers, the upper tier being on a level with and entered from the ditch. There was also an improvised system, constructed since the siege had been threatened, in front of the other works mentioned. Every precaution was taken to organize a system of listeners, arrangements for firing mines, and materials for repairing damages.

On the twenty-fourth night of the siege the French commenced a gallery 50 yards from the Amédée Bastion. Progress was only 4 yards a day owing to the sandy ground and to damage caused by shells, and on 5th July a mine was fired, which did no damage to the countermines but formed a crater which was crowned. On 21st July another mine was fired 10 yards from the salient of the flèche in front of the bastion, the flèche was carried, and the powder hose leading to the defenders' countermines was cut. Next day the defenders fired a mine, which they had prepared low down in the flèche, and drove off their assailants who, however, recovered the flèche by a counter-attack.

Here the 4th parallel was opened, and shafts sunk to 38 ft., the level of the defenders' lower tier of countermine galleries, which were broken into on 4th August, and the powder hose severed. The defenders erected a barricade which was blown down on the 8th, and the further progress of the besiegers was only prevented by throwing earth and bombs down a ventilator and so blocking the gallery. On the 16th and 27th August the defenders blew up batteries placed to fire on the demilune de Secours, but, compelled gradually to retreat, they prepared countermines under the position of the expected breach, and fougasses in the ditch.

By the advice of Vallières, Commandant of the Miners, the French had commenced two galleries with the intention of blowing in the flèche of the demilune de Secours, but these were discovered, and on the 14th July the Piedmontese fired a countermine which broke up both galleries and buried miners and grenadiers. The air in the galleries was so bad for some days afterwards that they could not be entered again until fresh air had been pumped in by forge bellows connected to tin tubes.

On the 21st July the French blew up a palisade and captured the flèche, and next day discovered a ventilator which appeared to lead to the defenders' lower countermine gallery. Careful investigation showed the possibility of excavating a channel and bringing water about 1,200 yards to flood this gallery. This work was finished on the 3rd August, and the water turned on. On the 9th the lower gallery was opened, and it was found that the inundation had prevented the firing of several mines. However, the defenders had blocked the gallery and not much progress was made.

On the 13th July, before capturing the flèche of the demilune de Secours,

the French had managed to find and break into the defenders' upper countermine gallery. They were on a higher level, and lowered three men one after the other, who were shot at once. A man with a shield then went down and managed to place some sandbags to cover the descent of others, and a hot fire was carried on until the smoke made the gallery uninhabitable.

The French had now reached the gorge of the flèche and, after a few mines had been fired by the defenders with little effect, were lulled to a false sense of security in the hope that their inundation of the lower gallery had produced the desired effect. They forgot the upper tier of galleries to which the Piedmontese still had access from the counterscarp gallery of the demilune de Secours. A battery of 16 guns and some mortars was established on the flèche, whereupon the defenders drove four branches under it, on the level of the ditch, from the counterscarp gallery. On the morning of the 24th the French were firing their first salvos, and looking for the early fall of the walls, when the four mines were fired, and destroyed all but three of the guns. The attackers fled, many falling under the fire from the walls. Some of the damage was repaired that night, and on 25th four guns opened fire, two of which were destroyed by a fresh mine. On the night of the 26th an assault was made on the demilune and the two bastions, the counterscarp was blown down, but the escarp had hardly been touched, and the attack failed.

It has been said that the upper countermine gallery was entered from the ditch. A ladder led to the lower gallery. On 29th August four French miners with shields descended into the ditch, and managed to reach the entrance to the gallery. They were killed by the guard, and three more met the same fate. A dozen more followed, and overcoming the guard, obtained possession of the entrance. A mine had been prepared in case of need, and as the guard retired by the lower gallery, the last of them, Pierre Mica, set fire to the hose. The explosion killed him, but also killed all the assailants. A monument was afterwards raised to his memory in the arsenal.

On the 31st August a second general assault was attempted and again failed. During the action the defenders fired a mine under the re-entering place of arms, between the Amédée Bastion and the demilune de Secours, destroying two guns of a 4-gun battery, and almost annihilating two companies of grenadiers, the survivors of whom fled. The remaining two guns were destroyed by the Piedmontese, and one gun which had been blown into the ditch was recovered and mounted in front of the Governor's residence. One of the defenders' mines under the place of arms had failed to explode. This was rectified, and the mine was fired on the 5th September, when two guns which had recently been brought into action were destroyed.

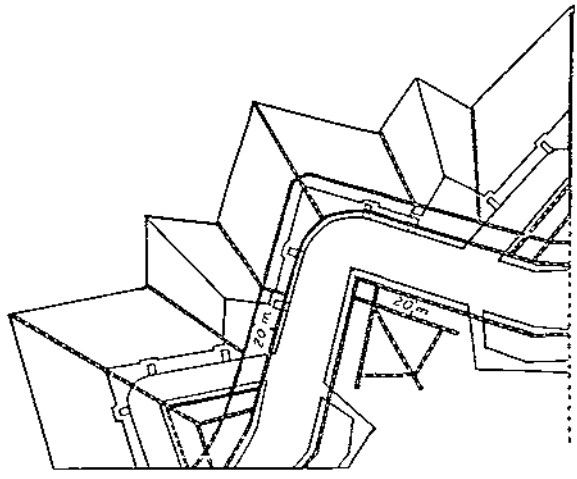
The subterranean battle in front of the Amédée Bastion proceeded all through the siege, but presents no interesting features. It was less vigorous in front of the Susine Gate and the hornwork. Some mines of the defenders had delayed the attackers' works there, and they concentrated all their efforts against the citadel, which was the key of the position.

At the end of August a French field army, under the Duke of Orleans

and Marsin, took refuge in the besiegers' lines, but la Feuillade would not attempt a general assault, and gave time to Prince Eugène and the Duke of Savoy to cross the Po, and attack the field army, which was defeated. la Feuillade tried to intervene, but in vain, and was forced to raise the siege, after destroying his magazines and abandoning his artillery.

It is undeniable that the system of countermines prepared beforehand saved Turin, and although the defenders were short of powder they used their resources to the best advantage. la Feuillade's plan had been anticipated and provided for, and though several engineers besought him to accept Vauban's scheme, he was too proud to do so. His engineers deserve all praise. They sacrificed themselves to secure the success of a plan in which they had no confidence. Vauban himself offered to serve under la Feuillade, but Louis XIV. would not permit him to do so.

Count de Mesgrigny, who had served as an engineer in numerous sieges, was appointed in 1668 King's Lieutenant of the Citadel of Tournai, which was then being constructed. He there carried out the system of countermines which bears his name. The town was defended by a simple enciente, with the addition of a citadel of five bastioned fronts, having demilunes between the bastions, and tenailles in front of the curtains.



System of Countermines of a front of the Citadel of Tournai.

de Mesgrigny employed two escarp galleries, one close behind the revetment wall from which to advance to meet the enemy and dispute the passage of the ditch. This gallery was prolonged under the tenailles to prevent the system from being turned. The second gallery was 25 yards in rear, and was intended to facilitate blowing up lodgments formed in the breaches. There were other galleries in the bastions for a step-by-step defence.

In the demilunes were two similar escarp galleries, and the mine defence

of the interior was secured by prolonging the main counterscarp galleries. One of these ran under the covered way and the gorges of the demilunes, the second was 25 yards in front of it, and there were listening galleries running out under the exterior and interior angles of the glacis. No bastion or demilune could be taken without being breached, and to effect that the covered way must first be crowned; the second, or outer gallery, was to prevent this crowning. When that gallery was destroyed, the gallery under the covered way would enable the batteries overhead to be blown up, delay the breaching operations, and prevent a descent into the ditch. The only defect worth mentioning was the want of a counterscarp gallery in front of the demilunes.

Tournai was invested at the end of June, 1709, by Prince Eugène and Marlborough. Favart directed the engineering operations. There was no reserve of provisions in the fortress, the garrison of 6,000 men existed on what they could extract from the inhabitants, which was only grain, and the necessity of using water for grinding it prevented the ditches being flooded. The Allies were 50,000 strong with numerous artillery. Trenches were opened on the night of the 7th of July, on the 29th the town capitulated. The citadel held out longer in order to keep a besieging army occupied, and prevent it from joining the field army.

de Mesgrigny was 80 years old, but insisted on directing the operations. He had only 52 miners; the besiegers, under Count de Lottun, had 200 of the Piedmontese who had all served at the defence of Turin. The attack was directed against one front, and half the two adjacent fronts. Early in August the defenders made a sortie, and remaining in the covered way enticed the besiegers over three mines in the glacis, which were fired, and shortly afterwards some of the besiegers' works were damaged by mines.

On the 8th another body of troops under General Schulembourg arrived and attacked the citadel on the opposite side. The countermine defence was so active that neither attack could make much headway. On 13th August de Lottun's troops carried the covered way and managed to enter one of the countermines, where they found, and destroyed or removed, 4 tons of powder, but, in spite of this, explosions of other mines compelled them to vacate the covered way. A similar attempt on the 15th met with the same result. On the 16th the Allies on the opposite front managed to penetrate a countermine gallery and establish themselves there, but were checked by a barricade. This was their first real advance, for not being able to secure the covered way, they were unable to breach the escarp, of which the edge only was visible from their batteries. Their mines had hitherto been of little effect.

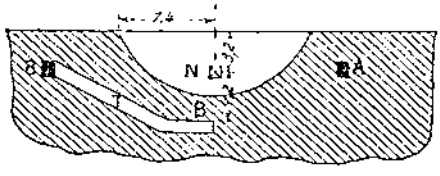
On the 19th two battalions were annihilated in their trenches by countermines, and on the 20th several soldiers and miners were crushed in the ditch by the blowing up of part of the wall of the town. On the 23rd the gallery which had been captured by the Allies was blown in, and several miners were suffocated in it. A battery of mortars erected by the assailants between the town and the citadel was next blown up, but a sortie following on this success was repulsed, and the besiegers were only prevented from entering the citadel by the explosion of another mine, which however also killed a number of Hanoverians.

On Schulembourg's side the besiegers now established a battery on the covered way, and as they had previously exploded a mine on the site of their lodgment, considered themselves secure. However on the 24th a portion of the guard in the trenches was blown up. On the 26th the bursting of a mine exposed several countermines, but the defenders blew up part of the ditch on the town side where 800 of the besiegers had assembled. Many of the besiegers' miners deserted, and were sheltered by the inhabitants in spite of the dire penalties which were threatened for such behaviour.

Failure of provisions led to the capitulation of the citadel, and the garrison on the 3rd of September was allowed to depart with the honours of war. The underground war had lasted 51 days, and this lengthy defence, in the face of famine, was entirely due to de Mesgrigny's countermines.

Amongst the engineers who have made the corps of miners famous, Belidor is the most celebrated by his efforts to uproot the "invariable crater" myth. He was professor of mathematics at the school of La Fère, and evolved the theory that increasing the charge of a mine increased almost indefinitely the radius of the crater. He called his mines "globes of compression" and in 1725 commenced experiments to prove his theory, which had been vehemently attacked by many engineers led by Vallières, Director-General of the Artillery College.

He dug four shafts, C, D, E, F, 10 ft., 11 ft., 12 ft., and 13 ft. deep respectively at the angles of a square of 24 metres side, and joined their bases by four sloping galleries each 1 m. wide by 1·44 m. high. These were lined with oak, and had been excavated in compact clay, except that the bottom of Shaft C was in a wide and deep bed of hard marl. A mine N, 10 ft. deep, was placed at the end of a cranked gallery. The centre of the charge was 8 m. from the gallery CD, 9·6 m. from DE, 11·2 m. from EF, and 13·5 m. from FC. A branch ramped gallery



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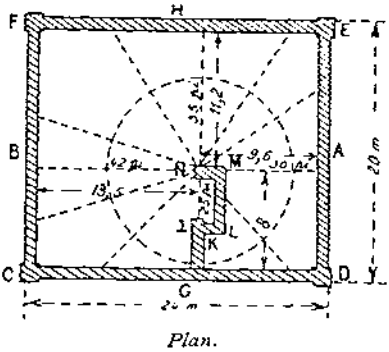


Plan.

T was excavated having its top 4·2 m. below the centre N. According to Belidor the charge for a common mine should be 100 lbs. of powder; he fired 13,200 lbs. The radius of the crater was 24½ ft., more than double the line of least resistance. All the galleries were staved in for lengths "almost in inverse proportion to their distances from the mine." The gallery beneath was broken in, also the two shafts D and E nearest to the explosion.

The success of this experiment did not convince his opponents, and in 1753 Louis XV. directed that official trials should be made at Bizy. These were carried out, in the presence of many distinguished officers, practically on the same lines as Belidor's, except that the galleries were lined with masonry. The mine was 13 ft. below ground, the crater was 17 ft. deep, and 66 ft. in diameter. The charge had been 3,000 lbs. The galleries were all shattered for nearly their whole length. Little impression was made in France by these experiments, and the celebrated engineer, Delorme, did not profit by them at the Siege of Berg-op-Zoom, but abroad, especially in Germany, the results were received with enthusiasm. Lefevre, who was in service with the Great Frederic, repeated them with like results at Potsdam, and applied them at the Siege of Schweidnitz.

In 1747 a French army under Count de Lowendhal laid siege to Berg-op-Zoom, which had been fortified by Cohorn, and was reputed impregnable. The attack was directed against the front from the Cohorn Bastion to the Pucelle Bastion. Opposite the curtain was a large demilune, flanked by two lunettes. There was a covered way 22 yards wide in front of all these works, which were revetted and had dry ditches. The countermine system consisted of a main counterscarp gallery from which led four listeners about 45 yards long. It was reached by gates opening on the ditch, and by two galleries from the demilune, passing under the ditch. Cut stone troughs had been provided for the powder hose.

The underground warfare presents few features of interest. It began on the night of 26th July (thirtieth of the siege) and by 16th September the counterscarp walls opposite the right flank of the Pucelle Bastion, the left flank of the Cohorn Bastion, and in front of the demilune, had been blown into the ditch, both lunettes had been captured, and there were two breaches in the escarp walls of each bastion, and one in the escarp on the right of the demilune. A general assault through the breaches, by escalading, and by the postern gate, was delivered on that day, and the place was captured.

Four-fifths of the total length of the siege was occupied in crossing the glacis, and as during all that time a violent fire of musketry, guns and mortars had been maintained, a large proportion of the fatalities of the besiegers may be attributed to the slowness of their works, due to the defenders' countermines. At the same time the sandy nature of the soil presented almost insuperable difficulties to the engineers of the attack, from a great deal of which the defenders were saved by their masonry galleries. The latter do not seem to have extended their galleries at all until after the commencement of the siege, but, knowing the treacherous nature of the soil, had collected large stores of oak

mining cases of a pattern which afterwards came into general use under the name of Dutch cases. It is worthy of note that at this siege the French did not repeat the error they committed at Turin, but took care to clear the enemy out of the ground beneath before they established their breaching batteries. Only the epaulment of one of their batteries was damaged by mines.

A rapid method of sinking shafts introduced by a Capt. Boule was made great use of for reaching the base of the counterscarp walls and blowing them down. A shaft of about 18-in. side is excavated by means of spades, or scoops, shaped like a hoe, with handles from 3 ft. to 18 ft. in length. The earth is dragged out by baskets attached to a rope. When at the required depth a box is lowered filled with 150 lbs. to 200 lbs. of powder, the hose is fixed to one side of the shaft, the earth is thrown back and rammed to tamp the charge, and the mine is ready to fire.

In 1762 a Prussian army under Frederic the Great arrived to recapture Schweidnitz, which had been taken by surprise by the Austrians the year before. Trenches were opened on 7th August. The attack was directed against three of the exterior forts, that against No. 2 being the principal. The forts were of star trace, with dry revetted ditches, and the intervals were organized for defence. A covered way, with a wall outside it, ran continuously along the front of forts and intervals.

Five countermine galleries ran from the three front salients of Fort 2, and from the two re-entrants between them, reaching to beyond the toe of the glacis. Each gallery from the salients branched into three, each of which ended in a tee, and the galleries from the re-entrants also ended in tees. By this means the whole front was embraced. The mine attack was limited to the ground round the central salient system of galleries only.

Under the direction of Lefevre mining began from the third parallel on the 22nd of August, and on the 28th had advanced about 85 ft. when the defenders made a sortie, discovered the entrance to the mine which they filled with bombs, stink balls, and barrels of powder, and blew up. The sortie then retired with several prisoners, from whom details of the mine scheme were obtained. It was calculated that the galleries would pass about 7½ ft. below the countermine galleries, and measures were taken accordingly. The besiegers repaired their damaged gallery, but on the 30th having advanced about 100 ft. had to stop for want of air. It was decided to charge a mine chamber with 5,500 lbs. of powder with L.L.R. of 17½ ft. Tamping was completed on the 1st of September, and the first "globe of compression" was fired. A crater 20 ft. deep with a radius of 42½ ft. was formed. No damage was done to the Austrians, but the crater was crowned, and next day a fresh gallery from it was put in hand. On the 4th of September a small countermine of 165 lbs. powder was fired, but had no effect except to make the Prussians more wary.

The happy idea now struck the Austrians of joining up the T-heads of their countermine galleries. This much improved the ventilation, and enabled them to work towards the flanks of the besiegers' mines without fear of their retreat being cut off. The Prussians now came

across water, and had to abandon their gallery from the first crater and begin a second. On the 9th the Austrians damaged this with 150 lbs. powder with L.L.R. of 20 ft. and 30 ft. of tamping.

Next day the Prussians repaired their gallery, and when they had advanced about 80 ft., came across a branch of the defenders, who, however, contrived to explode a small mine, and destroyed about 65 ft. of the attackers' gallery. Thus 10 days after their first explosion, the attackers had to begin a third gallery from their crater. On the 16th the air in this gallery was so bad that it was decided to charge a second globe of compression of 2,200 lbs. of powder. 40 ft. of tamping was given, the crater was 16 ft. deep, and had a radius of 33 ft., but only one of the defenders' branches was damaged.

From their second crater the Prussians now commenced a new gallery, which was broken up by two camouflets each of 50 lbs. of powder. It was repaired, and another gallery parallel to it was started. These were both destroyed by camouflets on the 18th. Two new galleries met the same fate on the 19th and 20th.

Lefevre now almost lost heart, but Frederic ordered him to proceed again, and drive a gallery under the countermines for a large globe of compression, and a higher gallery to attack the countermines by camouflets. The higher gallery was discovered and damaged by a camouflet of 150 lbs. powder on 22nd, but was recommenced to distract attention from the lower and more important gallery. The latter was only 23 ft. long when countermining was heard on both sides of it. In spite of the short length available for tamping Frederic ordered a return to be excavated and 4,000 lbs. powder to be placed in it. This was successfully accomplished, and on 24th September the third globe of compression was fired, producing a crater 20 ft. deep with a radius of 33 ft. Some of the defenders' branches were damaged, and two of their miners killed, but neither the palisade nor covered way were touched. A great deal of the effect took place backwards, owing to the short length available for tamping.

Excavation was again put in hand, but by the 26th of September the defenders were threatening No. 3 Crater with five mines on the left, and one on the right. At midnight the firing of the latter gave the signal for a sortie, which was pressed with such vigour that the besiegers were driven back into No. 1 Crater, and to their third parallel. No. 2 Crater was crowned against them and all their works between that and the fort were destroyed. The defenders then retired from No. 2 Crater, and on 28th the besiegers began to drive a gallery from it under No. 3. A camouflet fired against this gallery left it unharmed, but a miner was suffocated by the fumes.

On the 8th of October when this gallery was 105 ft. long the Prussians observed a high column of smoke burst from the fort. A small magazine had been accidentally blown up. The only profit the Prussians drew from this mishap was time to charge their fourth globe of compression, which was 25 ft. deep, with 5,500 lbs. powder. The defenders then fired a small camouflet of 60 lbs. of powder which they had already prepared, but it was too high above the attackers' mine, and did no damage. A larger charge might have breached the palisade of the covered way.

The fourth globe of compression was tamped for 52 ft. (twice the L.L.R.) and made a crater 39 ft. in diameter, threw down the salient, and completely demolished the countermine system. The ditch was so filled with débris as to allow of an assault being delivered. Next day the place capitulated.

What especially characterizes this siege is the open and direct advance of the mine attack on one line. The first globe was evidently fired at too great a distance from the fort. It would probably have been better, if, instead of a series of successive discharges, several globes had been prepared at short lateral intervals. There would not then have been the same risk of failure. However this may be, Belidor's globe of compression did not emerge from this test absolutely triumphant, and the reputation of countermines augmented to such an extent that, if the attackers knew that countermine galleries existed on any front, they preferred to confine their efforts to another front, and replace subterranean war by bombardment or blockade.

Besides the systematic establishment of permanent countermine galleries a characteristic of the third period of subterranean warfare is the close tactical connection between the miner and the artillery. Breaching batteries were of short range, and to be of any use at all had to be established as close as possible to the ditch. The certainty of having command over the subsoil was therefore of paramount importance. Neglect of this principle led to various disasters at Turin, while at Berg-op-Zoom the activity of the attackers' miner allowed the breaching batteries to be established in safety. The miner was therefore at this stage an indispensable auxiliary to the siege artillery.

A.R.R.

(To be continued).

NOTICE OF MAGAZINE.

RIVISTA DI ARTIGLIERIA E GENIO.

May, 1914.

ARRANGEMENTS FOR RENDERING THE WHEELS OF CARRIAGES MORE ELASTIC.

Some years ago there appeared in the pages of the *Rivista* certain proposals for the improvement of heavy wagons, for accelerating their movements over sunken and bad roads and for crossing ground broken by furrows, drains, stones and roots, without injury to the preservation of the vehicle, and without compelling the drivers to dismount. The disadvantages noted above refer principally to artillery, and proposals were made for a system for diminishing the great rigidity of its heavy carriages.

The author of the article with the above heading is Giuseppe Taraglio, Technical Superintendent of Artillery and Engineers, and he has studied the problem as one of interest not only for artillery, but for all kinds of wheeled traffic. Towards the end of 1908 he arrived at a solution and carried out experiments which appeared to verify the conclusions that he had before arrived at theoretically. He bases the solution of the problem on the elasticity of the air enclosed in a metal cylinder attached to carriages at a convenient height above the ground, in which a piston can work, of an appropriate form and construction. The various parts of the mechanism, as much in the piston as in the other portions of the system, function in a manner that the elastic reactions produced in the cylinder result in complete proportions within certain restricted limits, and act in opposition to the effects of the shocks on the wheels which are caused by the inequality of the ground. The mechanism is very simple and can be applied to all kinds of carriages.

Description of the Mechanism.—Suppose (see *Figs.* 1 and 2) a wheel attached to an axle 17, connected with the extremity of the arm of a lever whose fulcrum attached to the axle-tree has its other arm fastened to a spiral spring 21, that has its head at the framework of the carriage. It is evident that such an arrangement would not of itself be sufficient to absorb the effects of shocks to the wheels (i.) because it is based on the action of the spring which would not serve for this purpose: (ii.) for great variations of shocks of various velocities the vehicle would sometimes have an accelerated motion and on the wheels encountering a surmountable obstacle, the spring would be completely extended, and the weight of the carriage would act on the fulcrum of the lever as if there were no elastic organ. But if to the above-mentioned arrangement we add a cylinder fixed to the framework of the carriage in which works a piston in connection with the arm 20, by the spring (*Fig.* 1), we interpose to the system an elastic resistance caused by the air contained in the cylinder, which will impede the complete distension of the spring on encountering shocks to the wheels owing to inequalities of the ground. By this means the spring will vary in length only sufficiently to allow to the piston the necessary compression of air to counter-

act the effect of the shock, and on this ceasing will tend to renew the primitive condition of the system. The spiral spring may also be placed in the interior of the cylinder as shown in *Figs.* 5, 6.

To regulate the work of the piston in a manner to obtain for each corresponding velocity a proportional pneumatic reaction for absorption of the effects of the shock and the desired smoothness of elasticity, the cylinder may vary in its length, and the piston can be furnished with a varying number of diaphragms and with holes of various sizes to admit of a greater or less passage of the air. As shown in *Fig.* 4, the cylinder is closed at the two extremities 3 and 4, the piston rod being first passed through perforated stuffing, 5. The piston rod is formed of a hollow cylinder that carries a head, 7, and some diaphragms, 9, 10, 11, varying in number according to the degree of elasticity required, which divide the head of the piston into spaces 12, 13, 14. The perforation 8 in the head and in the diaphragms permit the passage of the air between the portions 15 and 16 of the cylinder traversed by the piston. The number of diaphragms may vary according to the kind of vehicle, in some cases it may be sufficient for only the head to be perforated, and in others to leave a convenient space between the cylinder and the lateral surface of the piston. Also, the number and size of the small perforations may be varied. The piston with its movement within the cylinder causes compression and rarefaction of the air in the two spaces into which the cylinder is divided, thus tending to re-establish equilibrium.

The passage of the air through the perforations in the diaphragms renders the resistance to the movement of the piston more elastic. If the shock is slight the pressure developed in the interior of the cylinder is also small, and the air issues from the holes with moderate velocity; if however there is a strong shock, the pressure increases owing to the more rapid movement of the piston, and the air issues with greater velocity through the perforations. It is evident that the resistance of the spiral spring maintains the equilibrium and tends to replace the piston in its initial position. The lubricating oil interposed between the surface of contact of the cylinder and the piston prevents the escape of the air.

The wear and tear of the tyres of the wheels of vehicles, automobiles, bicycles, motor cycles, etc., will also be much lessened by this system. The method above described can be applied with advantage not only to carriages, which now have india-rubber tyres (bicycles, motor cars, etc.) but also to other vehicles and all kinds of military wagons. The arrangement shown in *Fig.* 5a serves for wagons and for the carriages of field artillery; in the latter the suspension can be rendered rigid by the use of a bolt, 26, which when introduced in an appropriate position prevents the friction on the frame of the carriage.

Fig. 7 shows the arrangement for bicycles, 3a for autocars and heavy wagons, 1a, 2a, and 6a for automobiles.

Experiments are being made which apply to bicycles with inflated tyres (*Fig.* 8) and with very satisfactory results. For volunteer cyclist detachments the bicycles furnished with the suspension arrangement above described offer great advantages. The experiments will also be continued with carriages of various kinds.

E. T. THACKERAY.

Fig. 1

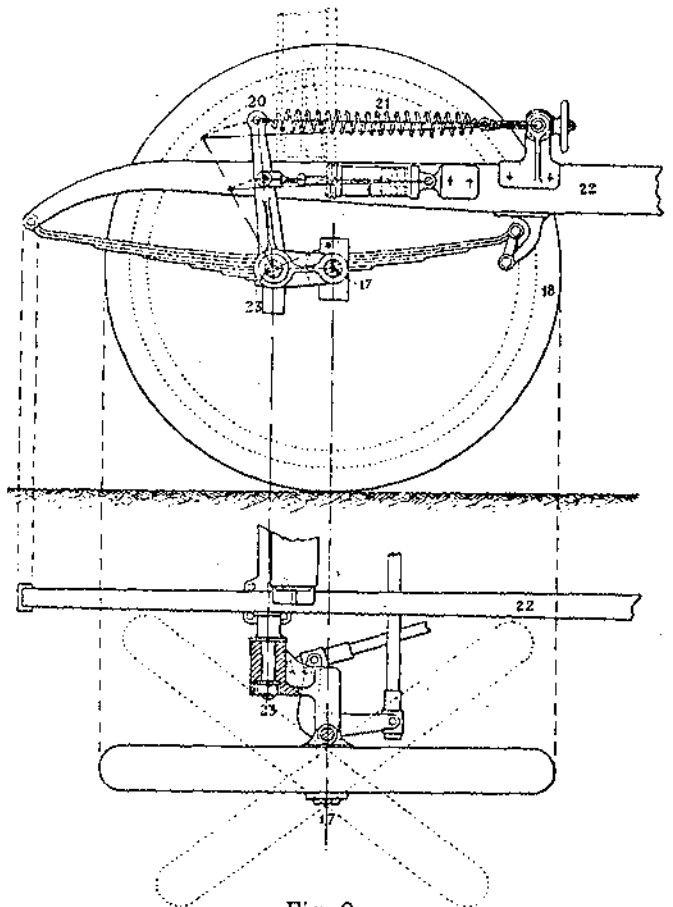


Fig. 2

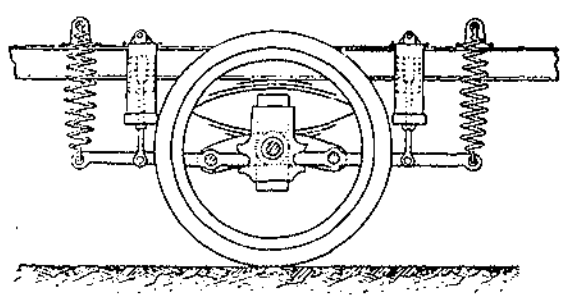


Fig. 3

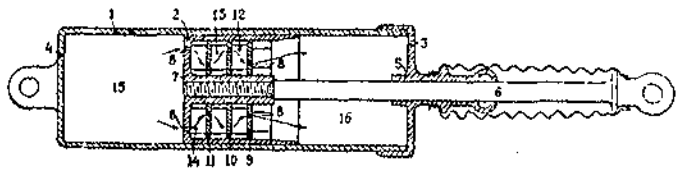


Fig. 4

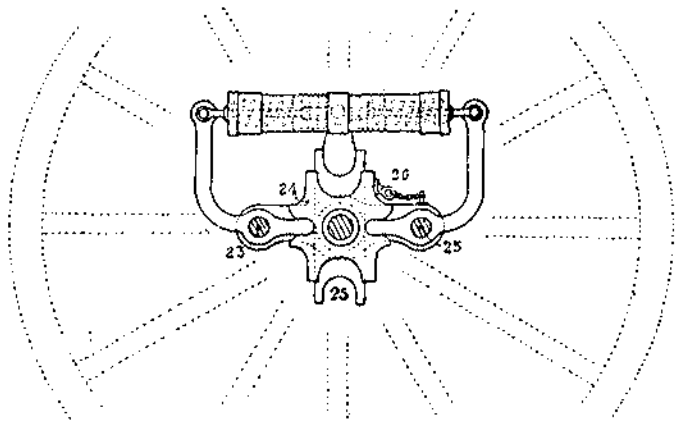


Fig. 5

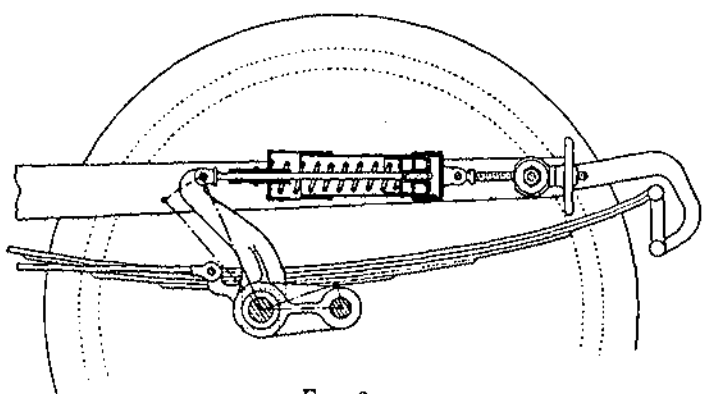


Fig. 6

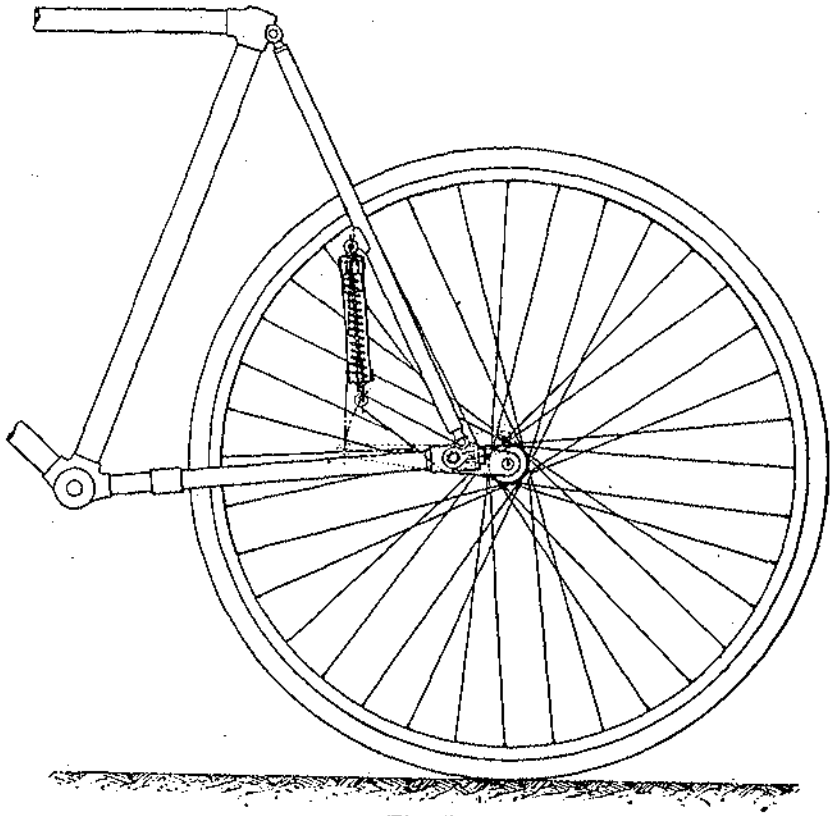


Fig. 7

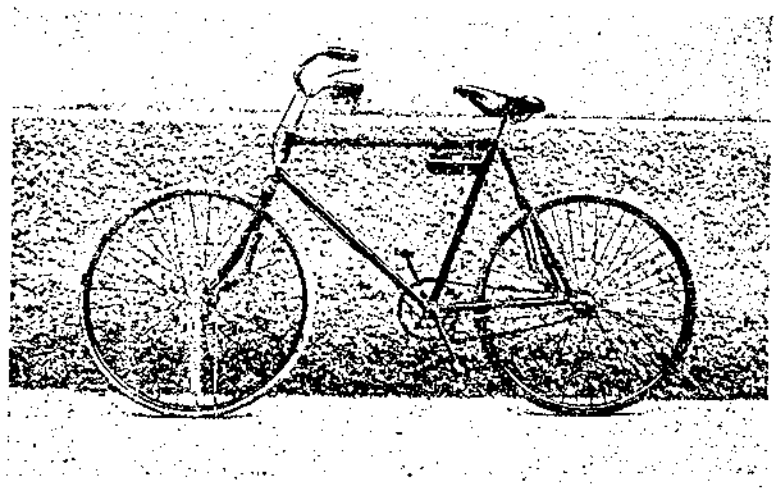
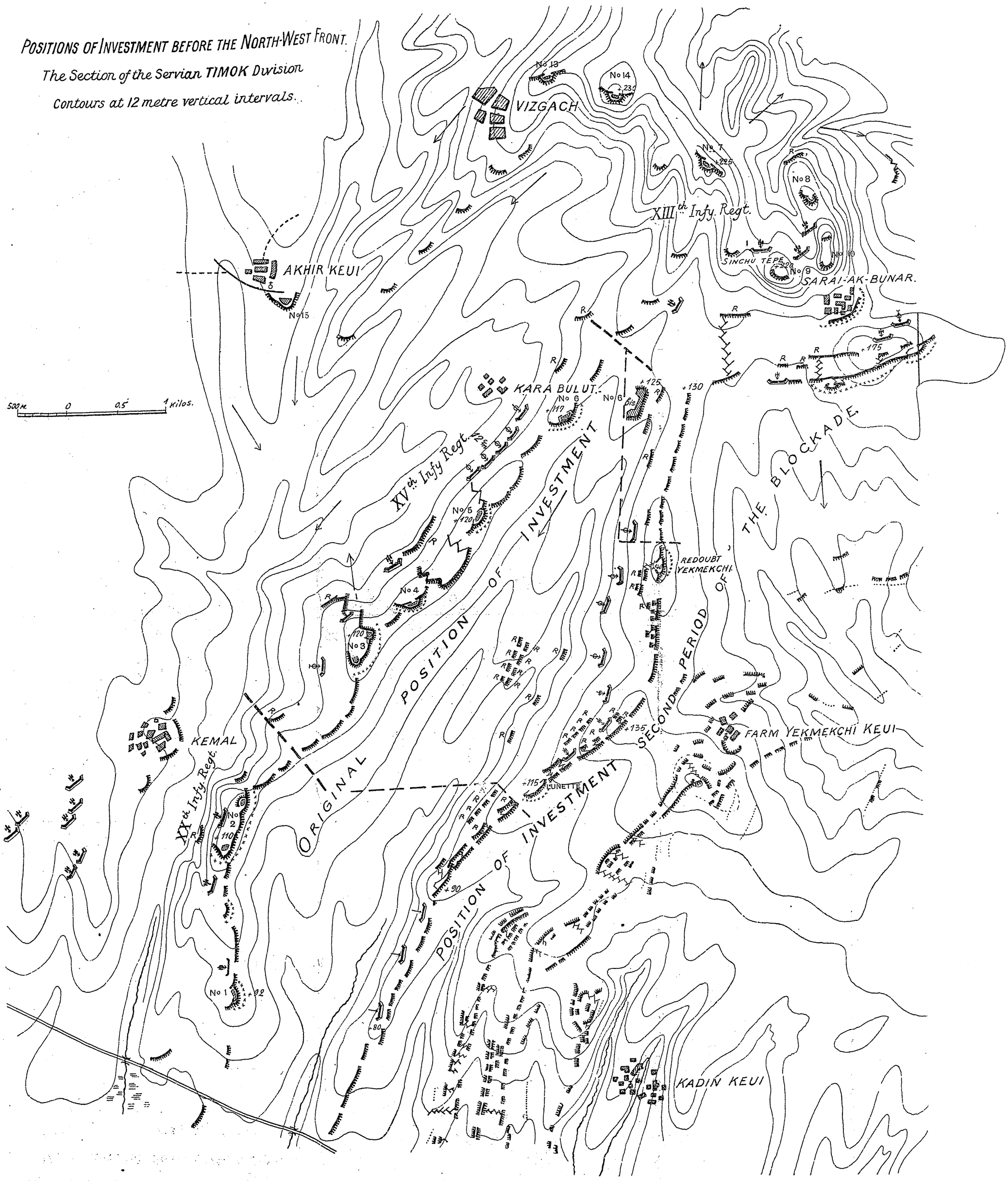


Fig. 8.

POSITIONS OF INVESTMENT BEFORE THE NORTH-WEST FRONT.

The Section of the Servian TIMOK Division

Contours at 12 metre vertical intervals.



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