PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

OF THE

CORPS OF ROYAL ENGINEERS.

R. E.

VOL. II.

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INTRODUCTION.

THE delay that has occurred in the publication of the second volume of Professional Memoranda, has been principally caused by the number and character of the papers contributed; and the same cause has operated to enlarge the bulk of the volume, not only beyond that published last year, but also beyond what the number of subscribers and the moderate amount of the annual payment would altogether justify. The success, however, which has attended the publication of the first volume, and the prospect of an increasing number of subscribers as the work continues, and its enlarged professional character becomes more developed, has determined me not to postpone the publication of any of the papers which now form this volume, although the effect will be to oblige me to draw to some extent upon the subscription for the year 1838. The amount of this anticipation I trust, however, to cover by the increased sale of the work. Should this not be the case, and should the narrowness of the publication-fund oblige me to reduce the size of the next volume, the interesting nature of the various papers here given must plead my excuse.

To Officers of Engineers, the Memoir on the Fortifications of Western Germany is of paramount interest. It explains the modifications which have been introduced by the Prussians and Austrians in the general outline of their works, and gives much valuable information as to the details: and on this subject I feel that I cannot confer a greater service on my brother Officers, than by quoting the following remarks of Lieut.-Colonel Reid.

"If we sit down satisfied that the art of fortification, and the rule of construction in that art, as laid down by Vauban and Cormontaigne, are perfect and sufficient, we shall assuredly be left behind in the race of improvement by the other great nations who are at the present moment turning all their attention to the modifications in the art of defence, which alterations in the system of warfare, and the greater power of the various weapons employed, have rendered necessary.

"It is not a sufficient reason, that the principles of defensive fortification should remain unstudied in England, because we have no great internal fortresses, and because we rely on our maritime superiority. We have colonies to defend; we have our naval arsenals to protect; which, while an object of great importance, is rendered more difficult than ever from the extended application of steam power to shipping generally.

"As our fortifications are limited, and we have not, as other nations, specimens of the defensive art constantly before us, it is more especially necessary that the *principles* upon which they are constructed should be perfectly understood. We are too apt to follow servilely the rules dogmatically laid down in the published works on the art of fortification, while our business should be, to apply the general principles of the art to a species of fortification suited to the circumstances of our country.

"In the smaller description of forts required for the defence of harbours and colonies, all the true principles of defence must be kept in view; whilst at the same time it is necessary to adapt their size to small garrisons at all times, whether of peace or war, so that they may not be found cumbrous to the country.

"It is therefore not alone among the regular fortifications of the French, and in the school of Vauban, that we should study; in all parts of the world ingenious constructions are to be met with; instances of the most skilful adaptations of general principles to the ever-varying features of the ground. If officers then who travel would record what they see bearing on this subject, the facts thus collected would form an invaluable body of examples for our guidance.

"Few countries afford so many opportunities of studying the art of defence (particularly when applied to irregular ground) as Spain, owing to the many and long protracted wars of which it has been in all ages the theatre: descriptions of the varied forts of that country would therefore be of great value to us.

"Among the works executing by the French, Lyons is of the greatest importance: it is considered as the great strategical point for the defence of the South of France; and they are there forming what they term a 'permanent entrenched camp,' consisting of reveted detached works, each defensible by itself. The details of every one of these works seem to have received the utmost consideration, and there appears something original in each. We advocate examination into these and similar new constructions, not in the spirit of *spying*, but with the higher view of cultivating and extending the knowledge of the art of defence, which it is the true interest of every nation to improve. As England throws open her fortresses to the inspection of foreigners, we have no doubt but that, on proper application through our Ministers at foreign Courts, facility would be given to Engineers and other officers of witnessing the improvements adopted by other nations.

" The Austrians are preparing a great fortress of support at Verona, for the defence of their Italian territories: there it is said the bastion system, with long lines of defence applicable to the range of cannon, is combined with towers placed at short intervals from each other, suitable to the short range of musketry. These towers serve the important purpose of keeps, and remedy one of the greatest defects of modern fortification. It would be highly desirable therefore to gain some information regarding the new works at Verona.

" Bayonne is intended to be made one of the greatest fortresses in Europe, and to give protection to an army of 60,000 men. This was a project ordered by Napoleon, and the plans were approved of during his reign: they are now being carried into execution by small portions annually. In these new works, it is understood far greater facilities are afforded to the troops occupying them to act offensively than in Vauban's systems, where they are too often compelled to defile from narrow sally-ports close to their enemies, without the possibility of taking the proper order of battle to meet them.

" The defence of the mouths of our harbours is a point of paramount importance; and it is incumbent on us, as Officers of Engineers, to devote particular attention to the subject. Here also we should endeavour to learn what precautions other nations are adopting to meet the changes taking place in the system of war. We may instance Newport, in the State of Rhode Island, a great naval station of the Americans, as an important position now being fortified.

" The question of the best construction of booms, and other impediments to prevent steam vessels from forcing the mouths of harbours, requires study and consideration; for there cannot be a doubt but that at the outbreak of another war, fire-ships, moved by steam, will be extensively used."

It is not, however, only on the subject of the construction of the different systems of fortification that information is desirable; the interior arrangements for the accommodation of the garrisons, hospitals for the sick, magazines for provisions and military stores, have a very great influence on the duration of a siege. A paper, showing the requisite amount and description of bomb proof accommodation in a fortress of a given size, first under the supposition that it contains only its ordinary garrison, and secondly, that it is made a place of depôt for different description of stores (either naval or military, according to position), would be a valuable contribution.

The attention of officers should be drawn to the various details of military equipment. Colonel Reid has touched upon this matter in the first paper in this volume; and I have reprinted a note from Colonel Jones's 'Sieges in the Peninsula' upon the same subject. The construction of the various tools, the proportion they should bear to each other according to the nature of the service, the best mode of packing according to the character of the conveyance; all these require attention. The labours of Colonel Pasley, Colonel Blanshard, and Sir James Colleton, have placed our pontoon equipment in a satisfactory state; and I trust, in the next volume, to be able to give an account of the different forms of pontoon proposed by these officers, and of their application to the construction of military bridges.

The paper on the subject of Hurricanes, by Colonel Reid, will be read with great interest, and I trust will induce many to turn their attention to atmospheric phenomena generally. The observations of greatest interest at present are those for the purpose of determining the phenomena of terrestrial magnetism. The Royal Society have obtained from the government a sum of money for the purchase of the necessary instruments; and they have expressed their willingness to confide these instruments, with full instructions for their use and application, to the Officers of Engineers at the different stations where it is desirable that experiments should be made. To this confidence I feel certain we shall respond; and I hope shortly to be able to procure from the Society both the instruments and instructions necessary to enable us to commence our observations.

Since the publication of the first volume, an 'Aide Mémoire à l'Usage des Officiers du Génie,' has been published at Paris, by Captain Laisné, of the French Engineers. The arrangement of this work is very good, and may serve in some measure as a model for us when we commence a work of the kind. Portions of this will admit of translation, with the mere change of weights and dimensions from the French to the English standard; and any officer who has time and opportunity will be usefully employed in selecting and translating such passages.

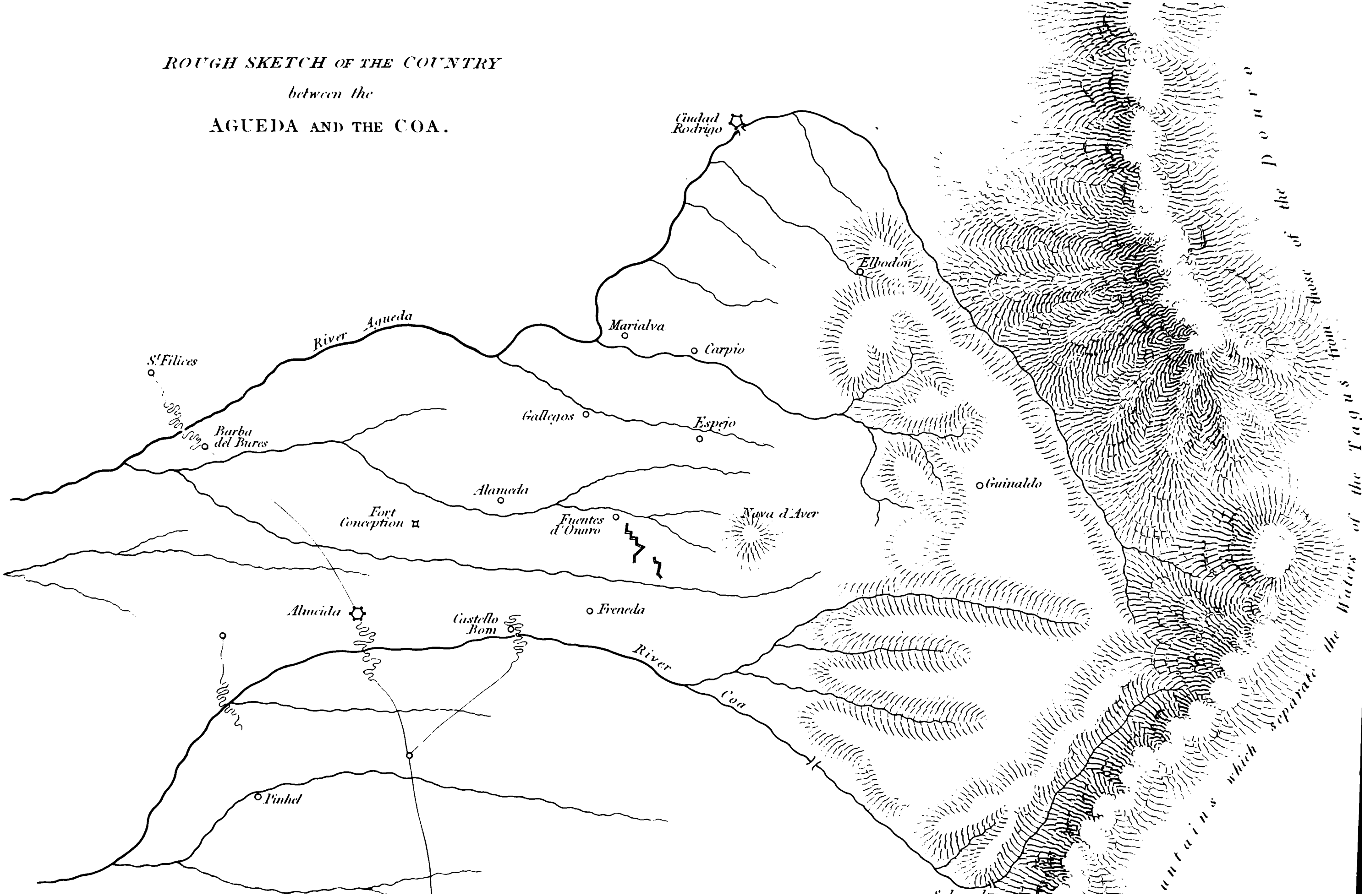
The following is the Statement of Receipts and Expenditure laid before the General Meeting on the 1st of February, 1838.

EXPENDITURE.	£.	s.	d.	RECEIPTS.	£.	s.	d.
For Printing................	68	2	0	Subscriptions from Officers of Engineers for 1836 and 1837	215	0	0
Wood-cuts and Engraving....	80	11	6	Ditto from Officers of Artillery..	77	0	0
Binding...................	49	16	0	By sale of sundry copies of work....................	89	0	0
Miscellaneous Expenses......	6	1	9				
Balance.............	176	8	9				
	381	0	0		381	0	0

Since February several of the remaining copies of the first volume have been sold, and various officers have attached their names to the list of subscribers. I have received assurance of the intention of the Officers of the E. I. C. Engineers to afford us their assistance and support; and from the nature of the duties upon which they are employed, we may expect to receive from them some valuable communications. I trust, therefore, that the list of subscribers hereto annexed will be largely increased; and that next year I shall be able to present as satisfactory a statement to my brother Officers as I was able to do at the last meeting.

W. DENISON,

Lieutenant, Royal Engineers.


ROUGH SKETCH OF THE COUNTRY
between the
AGUEDA AND THE COA.
Ciudad Rodrigo
Elbodon
Marialva
Carpio
River Agueda
St. Filices
Barba del Bures
Gallegos
Espejo
Guinaldo
Alameda
Fort Conception
Fuentes d'Onoro
Nava d'Aver
Almeida
Castello Bom
Freneda
River Coa
Pinhel
untains which separate the Waters of the Tagus from those of the Douro

PROFESSIONAL PAPERS.

I.—*On Intrenchments as Supports in Battle, and on the Necessity of Completing the Military Organisation of the Royal Engineers. By Lieutenant-Colonel* REID, *Royal Engineers.*

THE annexed plan of the battle of Fuentes d'Onoro, was made very soon after that action was fought in 1811. The intrenchments thrown up on the field, whilst the two armies were still in presence of each other, were drawn upon the spot, and inserted on the plan at the time with great care. The troops were marked upon it, with the assistance of an officer who commanded a brigade in the action; and after an attentive perusal of the dispatches of both generals commanding the armies.

It might have been sufficient simply to print the plan itself, which, from having been carefully made, is alone of some value; but the object of the present article, is mainly to press the importance of Field Intrenchments to the army; and the advantage of possessing such a field equipment as to enable us in war, to avail ourselves of the great support given by intrenchments. The very slight works thrown up at Fuentes d'Onoro had a great influence, if we may judge by the French general's despatch; and therefore, slight as they were, they deserve notice.

An animated account of the battle will be found in Napier's History. The following concise description of the affair, and of the ground where it was fought, will be sufficient for this place. It was risked to prevent the French from revictualling the fortress of Almeida on the frontiers of Portugal, when they retreated out of that kingdom in 1810.

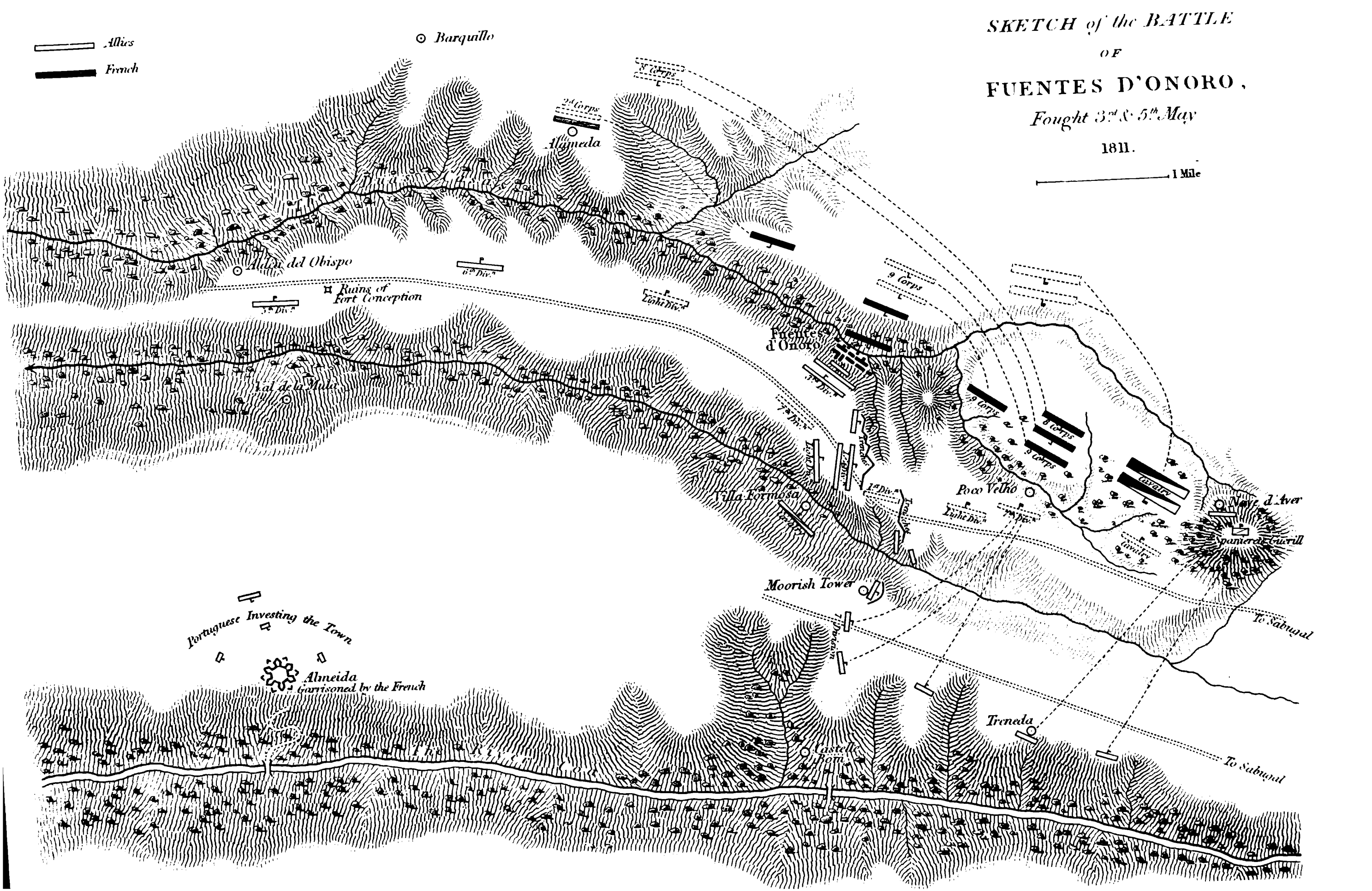
Almeida lies between the Águeda and the Coa, two rapid rivers, both of which are branches of the Douro. As they approach their confluence with it, their banks become very precipitous; and it is difficult to scramble across their rocky beds, even when the water is so low that they might be otherwise fordable. A small map of the country between these two rivers is annexed.

The two little brooks, Duas Casas and Turon, running nearly parallel to the Coa, form vallies on a small scale much resembling those of the Coa and Agueda. Near their sources, infantry may pass in all directions, but cavalry are impeded by deep holes in the rocky beds of the brooks, excepting just at the spot where they take their source. Lower down the streams the vallies become broad and deep, and the slopes of their sides are covered with many massive isolated rocks. The ridge between these vallies was without inclosures. Slight ravines descend from it on both sides, some rocky like the vallies themselves, but others scarcely marked enough to afford shelter for troops against an enemy's cannon.

The village of Fuentes d'Onoro is situated at that part of the valley of the Duas Casas where a marked change first takes places in the features of the ground; for thereabouts, those isolated rocks begin, which form a military obstacle. The village lies on the Portuguese side of the valley, and is so situated as to be much exposed to the fire of an enemy's cannon from the other side. The houses lie scattered, and are not substantially built; but there are many small gardens, surrounded by thick dry stone walls, affording ample materials for barricading. The greater part of the village lies in the bottom of the valley, but a portion of it extends up to the plateau, on which the British and Portuguese took post.

The cavalry being in advance, supported by the light division of infantry, observed the enemy coming out of Ciudad Rodrigo, and passing its bridge on the 2nd of May, 1811. The French directed their march towards Almeida, and the light division fell back on Fuentes d'Onoro. The plan shows, in a general way, the position of the armies when they came in presence of each other on the 3rd of May, 1811, the corps moved during the action, having first occupied the dotted position. The chief force of the English and Portuguse was behind Fuentes d'Onoro; but divisions in observation were extended as far as the ruins of Fort Conception, about four or five miles from the main body at Fuentes d'Onoro.

It was very desirable that the communication by Sabugal should be kept open as long as possible; being the natural connexion with the right of the army then operating south of the Tagus. For this reason, a guerilla corps of Spanish cavalry and infantry was posted on a remarkable woody height, about a mile and a half to the right of Fuentes d'Onoro; in which height the Duas Casas brook has its source, formed by several heads, near Nave d'Aver. The only passage of


SKETCH of the BATTLE
OF
FUENTES D'ONORO,
Fought 3rd & 5th May
1811.
1 Mile
Allies
French
Barquillo
Aldea del Obispo
Ruins of Fort Conception
Alameda
Fuentes d'Onoro
Villa Formosa
Poco Velho
Nave d'Aver
Moorish Tower
Treneda
Castello Bom
Almeida
Garrisoned by the French
Portuguese Investing the Town
To Sabugal
To Sabugal
Cavalry
9 Corps
8 Corps
6 Corps
2d Corps
8 Corps
Light Div.
6th Div.
5th Div.
3rd Div.
7th Div.
1st Div.
7th Division
Trenches

the Coa, immediately behind the position, was by the Bridge of Castello Bom, and by a very rocky bad road leading down to the bridge.

Eight light infantry battalions of British infantry were posted in the village of Fuentes d'Onoro; and the troops intended to support this point were somewhat retired on the plateau above the village. The nature of the ground indicated this point as an important one to hold firmly.

As the bridge of Castello Bom lies immediately behind Fuentes d'Onoro, the French general hoped, by carrying the village, and placing the main strength of his army on the plateau, to make a retreat by its bridge very dangerous, or impossible. The village was therefore resolutely attacked on the 3rd of May, and as valiantly defended. Taken and retaken, after a long and hard contest, the English remained in possession of the upper part, next their own position, whilst the French kept the houses in the bottom.

On the 4th of May, the armies were not engaged, or very partially so; for the French general spent the day looking how he could turn the British right; and in the night he began to carry his principal force to his left, in order to attack the right of the allied army.

The positions marked in the Plan, without dots, show sufficiently the dispositions made for this attack.

The 7th division had been sent on the evening of the 4th from near Fuentes d'Onoro, and took post behind the village of Poço Velho, in an open wood of the ilex oak, (which abounds there); and which movement was ordered with the view of covering the Sabugal communication if possible. When the French general's movements were seen next morning, the light division was marched to its right, to support the 7th; and this support soon became necessary; for the French army having 5000 cavalry against 1000, (besides being superior in infantry and artillery), the British right wing had to retire, and a new line was formed with the right thrown back, as indicated on the Plan; the 7th division and the Spaniards occupying the ground between the Turon and the Coa.

That the Plan might not be confused, the further movements of the French are not marked upon it. The direction of their march, in which they brought their left forward, outflanking the English right with their cavalry, cannot be mistaken. Instead, however, of continuing the attack, the French general paused, and the English during the following night made every exertion to strengthen their position, with such small means as they possessed.

It was understood that the trenches dug across the summit ridge were only intended to cover the infantry from the fire of the enemy's cannon, which took great effect on that level ground. These lines had no ditches; the earth being dug and thrown forward, as in a siege approach. It was the custom during the late war, for the British infantry, when they occupied a defensive position, to draw up just behind and under cover of the slope of a ridge, when there was one, from whence the lines were brought forward to charge at the proper moment. There being no such cover across this summit, these trenches were to supply its place; and to preserve the usual formation of the troops, they should have been dug in straight lines, just where the troops were required to deploy. Formed like parallels at a siege, deployed infantry may sit down under cover, and rise, "elbows touching," in the best order to charge in line.

One of the greatest defects of intrenchments as they are often constructed is, that in occupying them, from being laid out in indented and flanking lines, the infantry must necessarily deviate from their usual order of battle. *Defensive positions are best maintained by offensive actions;* and defences, when it is possible, should be so constructed as to admit of the defenders coming forward in line, to meet and to attack in turn, the assailants. Indented defences have not the same objection when they are advanced in front of the main position, or line of battle, as all in front of the main position may be fought in skirmishing order. The trenches at Fuentes d'Onoro were however in the last position, beyond which there could be no retreat.

In the manner here advocated, part of the ground, which was a level plain, was taken up to be fortified after the battle of Toulouse in 1814; *i. e.* that part where the Paris road leaves the city; but there was this material difference between the environs of Toulouse and the barren country between the Turon and Duas Casas, that around Toulouse there were many substantial country seats. Strong country houses were fortified at about every 600 or 800 yards from each other, and each house garrisoned by half a battalion, who were never to have quitted their posts if attacked. These posts were completed; and in rear of the intervals straight trenches were just about to have been commenced when the enemy's army retired. The trenches were to have been made with slopes both in the front and rear, so easy of ascent that even cavalry might have passed over them; and they were solely intended to cover infantry against cannon, and to secure them in the best attitude for defending their ground by *offensive operations.* The fortified house nearest to the Paris road was to have had a brigade of mountain guns in the upper rooms, which were to have been fired from the windows, and nearly in enfilade of the road.

A position particularly well suited for being strengthened by fortifications was held by the centre of the Duke of Wellington's army in the winter of 1813.

The enemy possessed the fortress of Bayonne, at the confluence of the Nive with the Adour. The allied army was separated into three portions by the nature of the country: the right was beyond the Nive; the left near the sea at Biaritz, and the centre across a ridge, which, beginning near Bayonne, runs between the heads of the streams, which flow on one side to the sea, and on the other to the Nive. Two of these streams flowing in marshy ground, covered the flanks of this position and greatly contracted it; whilst across the summit ridge were found three good points of support, on ground somewhat more elevated than the rest; on the very centre stood the church of Arcangues, having a church-yard wall, flanked by the parsonage house; 300 yards on the right was the chateau of the seigneur, with garden-walls and outhouses, and 300 yards on the left a large brick farm-house. These three points were immediately fortified. There are two very distinct kinds of fortifications on a field of battle, *viz.* such as are intended to check an enemy, but from which the defenders may retire if pushed; and such as never should be abandoned. The three points alluded to were of the last kind. The reserves were placed in the upper stories; and if the defenders had been forced below, the troops were to have retreated up stairs and to have fired through the floors.

This ground had not been long occupied before the enemy attacked the allies; and the first attempt appeared to have been designed against this central position. The French army advanced along the summit ridge from Bayonne, bringing up their masses of infantry very near, and opening a battery of cannon at about 500 yards only from the church.

It deserves here to be recorded, that the outposts of the 52nd regiment had been so well fortified by a captain* of that regiment, that the pickets had no occasion to retire until they had fired their sixty rounds of ammunition. This officer had taught himself how to strengthen posts by barricades and other temporary expedients; and he deserved the support he always received from the engineers, who supplied him with what he required from their small depôt of intrenching tools.

The pickets being thus enabled to hold their ground, without risk, for a considerable time, the troops for the defence of the main central position had full

* The late Captain George Barlow.

time to assemble (for it was in December, and they were scattered in houses) and to deploy in the position, the greater part somewhat retired behind the slope of the ground. There was nothing in the defences which impeded the usual formation, and every thing was prepared to maintain this ground *offensively*.

The enemy not choosing to attack here, moved in the afternoon to their right, when the hard fought action at Biaritz ensued: and two days later they made an equally determined but unsuccessful attack with their whole force against the extreme right beyond the Nive.

Although the enemy's cannon were brought forward, and fired for a considerable time, at 500 yards distance from the houses, their eight-pounder shot did not once penetrate the walls. The infantry in the church-yard directed a heavy fire of musketry against the gunners, firing with elevation; and from the marks afterwards observed on the trees near where the enemy's artillery stood, the musketry must have had great effect.

Massena, who commanded the French army, speaking of the allies at Fuentes d'Onoro, states:—*

"The enemy passed the night (of the 5th) after the battle in intrenching strongly the summit of the level. They placed also epaulements in the ravines and behind the rocks. In short they barricaded the summits of the villages of Fuentes d'Onoro and Villa Formosa; drawing to their assistance all the resources of fortification against an attack by main force."

This description is overdrawn. It is true, that very formidable barricades had been raised in the upper portion of the village of Fuentes d'Onoro, and dry stone parapets amongst the rocks which flank it; and the troops who defended the village, no doubt, were inspired to work by two very hard days of combat, and a sense of their danger. The first division likewise formed obstacles in front of their new position, consisting of some trenches, and trap-holes to check the enemy's superior cavalry; and the 7th division had begun some barricades round the Atalaya, or ancient watch tower, beyond the Turon. But however much every man in that army, at that moment, might have been desirous of availing himself of "all the resources of fortification against an attack by main force," such was not within his reach; for it is supposed that this portion of the army had no other intrenching tools than the few carried by the regiments for other purposes; and there was but one engineer officer† present.

* *Times* Newspaper, 29th May, 1811.

† Lieut. Trench, soon after this killed by an explosion of gunpowder.

In the later campaigns of the Peninsular war, the engineer department carried a depôt of intrenching tools with each division of the army; small at first, but increased by degrees, until every division had 25 mule loads. In the Waterloo campaign the quantity carried was further greatly increased; but they were then carried in Flanders waggons, instead of on mules' backs.

The civil duties in which the military engineer corps has been almost exclusively engaged since the peace, have prevented that improvement in the Engineer Department generally, as a component part of the military service, which the officers composing the corps were enabled to give to it from the experience gained in the war: and in proof of what is here stated, it is sufficient to say, that we possess no pattern of an engineer field equipment in our arsenals. The military bridge equipment has been greatly improved, and has become a pattern sought after by all the other countries of Europe. Had the same pains been taken regarding the other parts of the engineer field equipment, there are no reasons why they might not have become equally complete.

Note No. 50, at the end of "Jones's Journal of Sieges," sets forth in strong terms the necessity of forming an Intrenching Establishment with horses and drivers; and in some notes prefixed to Colonel Pasley's Fortification, the same subject is again urged; and the proposal of having a section of drivers as an integral part of a company of sappers and miners is advocated.

We here recommend that 1000 intrenching tools be packed as best suited for war, and that the mode of doing so, be an exercise at the school of field instruction: that a part should be carried on pack saddles and the remainder in wheel carriages; but the most essential thing to be done is to horse them occasionally and to move them. The subdivisions should be complete in themselves, so that when a battalion or a brigade is detached in war, it may be enabled to receive a complete proportion of implements for fortifying itself in any post it may be required to occupy.

In peace, an engineer intrenching equipment might be marched to such drill grounds as afford space for exercises in field fortifications, such as are thrown up in haste on the field of battle; or it might sometimes be sent to the Military College, along with troops, and there, on Bagshot-heath, carry on practice on a better scale than is now done by a small party of the Royal Sappers and Miners, for the practical instruction of the cadets. Neither are such exercises only applicable to positions of defence. During the progress of an attack, there frequently occur points which it becomes of the last importance to maintain when gained. Villages and groups of houses may become points of support for prosecuting an attack to a successful issue, if rapidly secured and barricaded; or they may save an attacking army from defeat: and sometimes it becomes of great consequence for troops who have taken a barricaded village, to know how to render the defences useless, or speedily to reverse them. This can only be done by old soldiers long accustomed to war, or else by young ones who have been properly instructed, and shown how it is to be done, before they are brought into action. It is not in the fortified posts of defensive positions only, that a corps trained as our Sappers and Miners now are, would be valuable, but also in supporting attacks and holding ground when gained.

Intrenchments on the field of battle would probably be much more used than they are, were it not for the system of modern armies, which leaves this part of war too exclusively to a single corps. The consequence is, that many officers rise to high commands without having considered the subject, and sometimes even believing the attainment of a knowledge in fortification to be difficult, and to require science beyond what they may possess.

That this wrong impression should be done away with is very important, both to the engineer corps and to the rest of the army: and it would be accomplished were the infantry of armies required to make intrenching, part of their military exercises; for the attention of the officers would be drawn to the subject in exercising their men; and they would soon learn that there is nothing mysterious or difficult to understand, in the field engineer's art.

It was proposed some years ago, and the proposal was approved and authorised, that all the infantry stationed at Chatham should take advantage, whilst quartered there, of the Engineer School of Field Instruction, so that every man might, once in his life at least, form a yard of common siege trench: and the advantage of this no one can doubt; certainly no officer will doubt it, who has had to lead soldiers, in a dark night, under an enemy's walls, after having given them a pick-axe in exchange for their musket, and had to direct them, in such a situation under fire, to make what they never saw or perhaps heard of before. The difficulties attending the extension and arrangement of a large body of untrained soldiers, under such circumstances, every military officer can appreciate.

The same authority allowed the regiments of infantry whilst at Chatham, to receive instruction in other important exercises connected with the duties of the engineers; and the distinguished conduct of the 13th regiment, in the assaults of the Burmese stockades, may have been to a certain degree owing to the escalade, which they practised at Chatham, just before they embarked for India.

Highly valuable as this connection between the infantry and the military engineer school of practical instruction is to both, it is not sufficient; for the infantry soldier should be taught, whilst he is yet a recruit, that the construction of intrenchments is a part, and a very important part, of his military duty. Every recruit before being dismissed from drill, as fit to join the ranks, should, for this reason, be made to erect some small portion, as a yard, of breast-work; a very easy task; but which, if required to be done by authority, under their officers' guidance, would have the effect of causing intrenchments and their value, to receive in time due consideration.

That it would be desirable to instruct the infantry to a certain limited extent, in the construction and defence of intrenchments, is very generally admitted; and there can be no doubt, but that every well-disciplined army, like our own, would be still more formidable in the field, if thus instructed. That working wears out the clothes of soldiers is an objection which stands seriously in the way of such occupations, for it is true that it does destroy the clothing; and this is one part of the defective system to be corrected; for the fatigue or working dress has become unfit for its true purpose; by degrees it has been made a second neat dress, instead of one for work. By far the best fatigue dress is the old English frock, put on as our own peasantry wear it: and this some foreign nations have adopted, of blue colour with different facings. With such a dress over a soldier's clothing, he can work, or carry loads, without spoiling his clothes; and the same frock at night, when he has to lie out, helps to keep him both clean and warm. Whatever may be thought of it in peace, it is well suited for war.

By thus connecting still more intimately the exercises of the infantry with engineer duties in the field, the mode of applying field intrenchments to the support of contending armies would improve. It is susceptible of improvement; and the best school for the engineer to study it is amongst troops. Nor is all infantry to be strengthened by the same methods; for whilst well-trained infantry might maintain their ground best by having only strong points of support, amongst which they could act offensively, bad infantry might require many barricades, or almost continued lines. Whether redoubts or continued lines are to be preferred, therefore, will depend in some degree on the efficient state of troops defending them.

It is not intended here to enter upon any details of construction; yet it is not out of place to remark, that no army can be complete in its code of field exercise, unless that code include rules and exercises for intrenchments in battle.

The rules and exercises for intrenchments are peculiarly a part of the exercise of the infantry; for when the engineers in the field are called upon to intrench a position, it is the infantry of the army who actually execute the works. A small publication, under the unassuming title of "Strengthening Outposts, in reference to the Duties of Officers in command of Pickets," perhaps comes nearer to what is required than any other published; but its author should not have called his subject a "threadbare one." It is one only beginning to reassume great importance. Discipline and tactics have now recovered what they lost in the middle ages, and field intrenchments will probably re-assume the same comparative importance in which they were held in ancient times; for modern improvements in projectiles, have not in any degree diminished the value of their support in battle.

The subject here discussed is not one suited to the present period of peace. Military exercises are now irksome, and military subjects tedious. The civil duties in which the Royal Engineers are engaged are, under present circumstances, far more interesting. But we must not forget that we are a component part of the army maintained for national defence; that the country in the late war suffered great losses from the imperfect state of the Engineer department; and that it is for the Members of the Corps themselves to show what is required to make them properly efficient.

There is no risk in our being less frequently or usefully employed in civil pursuits, by maintaining and improving our military system, and upholding our character as a military body; if we neglect this in the present day, the contrary probably would be the result.

NOTE

FROM

JONES'S "SIEGES."

It is a curious fact, that the superb expedition fitted out, regardless of expense, to effect an object dependant on the speedy reduction of the fortified places of Flushing, Bathz, Lillo, Liefkenshoek, and Antwerp, should have been sent from England, without any means whatever for bringing forward the engineers' stores, although some thousand horses were embarked for other purposes.

It is, however, proper to mention, in extenuation of this oversight, that, about a fortnight before the armament sailed, the Master General, on a pressing representation of the necessity of this service being attended to, ordered an equipment of one hundred horses, with drivers, to be transferred from the Artillery establishment, and embarked for the use of the engineers; but owing to some cause the order was never carried into effect. The consequence was a delay of at least three, if not four days in the reduction of Flushing; for if only fifty horses had been sent for the engineers' service with the left wing, the entrenching tools, &c. might have been landed on the Bree Sand, at the same time with the field brigades of guns, and have been brought up in sufficient quantities to have commenced operations against Flushing with vigour, on the night of the 1st of August, instead of the night of the 5th of August. It is altogether impossible to calculate the delay, or consequences which would have arisen from this want of carriage, had the tools and stores for the attack of Antwerp been forwarded by any considerable land movement, but, in all probability, they would have been fatal to the success of the enterprise.

It is not, however, at sieges only, that a horse-equipment for the conveyance of tools and stores would prove useful, but on every movement for offence or defence.

No one can doubt that the greater or less efficiency of an army depends on all its component branches, with their equipments, possessing corresponding powers of movement, so as to form altogether one complete body or machine. In this particular, no distinction can be made between cavalry, infantry, artillery, commissariat, or engineers.

But how stood the case on every expedition during the late war? With respect to the three first, it was so clearly evident that it would be useless to send troops into the field without ammunition, or artillery without guns, that a complete and well-organized establishment, of very great magnitude for those purposes, was invariably kept up in England, and a portion of it sent with every corps about to take the field.

Such establishments were also, on a smaller scale, kept up for the commissariat and hospitals; and on landing in an enemy's country, as the troops must be fed, and the wounded removed, every means of transport which could be procured, was necessarily in the first instance added to their means.

The engineers, however, being totally unprovided with the skeleton of an equipment, could not be thus patched up; and no commander ever brought himself willingly to abstract from immediate and pressing services the drivers and horses necessary to create an entirely new establishment, till some misfortune, failure, or great emergency, rendered it imperative for safety, or that victory demanded it to secure her trophies.

It would be useless to recall the many instances in the early part of the last war, in which corps could not take advantage of various defensive expedients that presented themselves, such as destroying roads, blowing up bridges, retrenching posts, &c. from want of a field establishment of intrenching and miner's tools moving with them.

This deficiency of organization of the engineers' service, was so strongly felt by the Duke of Wellington in Spain, in 1811, that he fitted out a field-train depôt of 30 mules, which was successively increased to 50, 70, 80, and in 1813, to 120 mules, moving in a body. Subsequently, in 1814, this arrangement was modified into a proportion of 25 mules, marching with each division of the army; and the stores and tools they carried were found most highly serviceable on various occasions.

Napoleon, after the experience of nineteen years' incessant warfare, by a decree, dated 25th March, 1811, fixed the establishment of horses, waggons, and drivers, with their lading, for the engineers' department of the French army, as follows:—

Six troops of drivers for the field, and one in depôt: each troop for the field to consist of,

Men and Officers.		Horses.	
Officers	3	Draft horses	226
Non-commissioned officers	5	Spare horses	8
Brigadiers	6	Riding horses	16
Trumpeters	2	Total	250
Artificers	7		
Privates	121		

Carriages.

Waggons with 4 horses, for intrenching tools	30
" with 6 horses, for intrenching tools	4
" with 4 horses, with bridge equipage	5
" with 6 horses, with bridge equipage	5
Waggon with 4 horses, for miner's tools	1
" with 4 horses, for petards and gunpowder	1
Forge carts with 6 horses	4

To convey 1,700 pickaxes, 170 miner's picks, 1,700 shovels, 1,700 long-handled shovels, total 5,270 intrenching tools; 680 felling axes, 4,020 bill hooks, total 1,700 cutting tools; and 8,318 kil. weight of machinery and stores. Every article was made to a particular pattern and weight, and each waggon had its particular lading assigned to it.

One troop formed part of each corps d'armée, and constantly moved with it, the same as its other equipments.

The foregoing is an example of splendid military organization, and is certainly far beyond that desirable or necessary for England to possess. Some engineers' carriage establishment ought, however, to be created; and we should steadily keep in view to improve the shape and manufacture of all our field stores, implements, and tools, so as to combine strength with lightness and portability. We should fix the relative proportions of each nature of article, of which given outfits of tools and stores ought to be composed, construct carts best adapted for their stowage and conveyance, apportion their lading and mode of packing, and decide on the proportions of tools and stores, in a certain number of carts, to accompany corps of different strength; so that, whenever a force shall embark for service, their field stores shall embark with them, as an organized equipment prepared to march as soon as landed and horsed.

It should be mentioned, that draft animals are far more readily to be procured in foreign and hostile countries than drivers, as corps of troops are frequently dispatched from England without any field equipment, in consequence of the nature and place of their operations being contingent on passing events. Such was the force sent under Sir J. Craig, in April 1805, first to Gibraltar, then to Malta, and ultimately, in December, to Naples. Immediately on landing, ample numbers of horses were purchased and allotted to the engineers; but although the stores were laden on carts, and prepared in every particular to march, they never could start for want of drivers, and such few articles as reached the frontier were forwarded by water-carriage to Gaeta. No one can possibly doubt the superior confidence to be reposed in a disciplined soldier over a foreign peasant, when acting as a driver for the first time under fire; and these considerations united, seem to point out drivers as being more essential to the efficiency of the department than even horses, and that a certain number should be embarked with every equipment of stores.

This object might possibly be attained without any additional expense, by enlisting a certain portion of each company of sappers to act as drivers, from men accustomed to carting work in the country. Being a good driver would not interfere with being a skilful sapper. Indeed men of that class are generally the most handy with the pick and shovel.

In Spain, mule carriage was undoubtedly a principal cause of the efficiency of the army. The commissariat and stores, by that means of transport, became as moveable as the troops; and it should be mentioned, in justice to the Spanish muleteers, that after the first campaign, they felt as confident, and moved forward, or to the rear, with as much order and coolness, on the eve of and during an action, as when the army was not in presence of an enemy. Such mode of conveyance will therefore, in all probability, be again resorted to, whenever the Peninsula becomes the scene of hostilities; and that the experience of the past war may not be lost, the following proportions of stores, tools, &c. drawn out in Spain, after some years' experience, as being those best adapted for given numbers of mules, are here inserted.

On future services, as the tools to be carried will be lighter, the number of each article for similar means of carriage will be increased.

List of a Field Equipment of Engineers' Stores for various Numbers of Mules.

INTRENCHING TOOLS.	Proportion for an Equipment of Mules.					
	100	50	30	25	20	12
Pickaxes	496	248	160	144	128	96
Spades	100	50	38	38	30	22
Shovels	404	202	158	130	124	90
Spare helves { Pickaxe	240	120	60	40	40	20
Spare helves { Shovels	240	120	60	40	40	20
MINER'S TOOLS.						
Miner's picks	10	4	3	2	2	..
Ditto pointed shovels	10	4	3	2	2	..
Jumpers	6	2	1	1	1	..
Borers { 2 feet	2	2	1	1	1	..
Borers { 1½ do.	1	1	1	1	..	..
Borers { 1 do.	1	1	1	1	1	..
Jumping bars	2	2	1	1	1	..
Miner's sledge hammers	6	2	2	1	1	1
Crow bars { 5½ feet	3	1	1	1	1	..
Crow bars { 4½ do.	4	2	2	1	..	1
Sand bags, bushel	600	240	..	..	..	..
Hand hammers { Large	2	2	1	1	1	..
Hand hammers { Small	2	2	1	1	1	..
Gads { 1st size	2	2	1	1	1	..
Gads { 2nd do.	2	2	1	1	1	..
Gads { 3rd do.	2	2	1	1	1	..
Scrapers	3	3	2	2	2	..
Needles	3	3	2	2	2	..
Wedges	2	2	1	1	1	..
MASON'S TOOLS.						
Mason's hammers	18	9	8	6	4	2
Wood mallets	2	2	..	..	..	..
Trowels	6	6	..	..	..	..
Chisels, of sorts	20	20	..	..	..	..
Iron levels, with plumb bobs and lines	4	4	..	..	..	..
CARPENTER'S AND SAWYER'S TOOLS.						
Felling axes	54	17	22	15	10	7
Broad axes	11	6	8	5	3	1
Bill hooks	200	80	80	60	40	20
Hand saws	47	23	22	22	20	6
Grindstone, 16 in. draw, × 3½ in thickness	1	1	1	1	..	..
Spikes boxes	1	1½	1⅓	1⅓	15 lbs.	15 lbs.
Nails, of sorts, boxes	1	1½	1⅓	1⅓	15 lbs.	15 lbs.
Saws { Tenon	2	1	..	..	..	..
Saws { Turning	2	1	..	..	..	..
Files for { Pit saws	120	120	120	120	60	..
Files for { Cross-cut	36	36	36	36	18	..
Files for { Hand	24	12	12	12	12	12
Files for { Tenon	24	12	..	..	..	..
Setters { Pit saws	2	2	2	2	1	..
Setters { Cross-cut	1	1	1	1	1	..
Setters { Hand	2	2	2	2	1	1
Planes, double and single iron { Trying	2	1	..	..	..	..
Planes, double and single iron { Jack	2	1	1	1	1	..
Planes, double and single iron { Smoothing	2	1	1	1	..	..
Planes, double and single iron { Of sorts	4	2	2	2	2	..
Plow plane, with irons complete	1	..	..	..	..	..
Adzes	10	6	6	4	4	2
Gauges	2	2	2	2	2	..
Augers, of sizes	12	6	6	4	4	2
Drawing knives	4	2	2	1	1	1

List of Field Equipments, &c.—continued.

Carpenter's and Sawyer's Tools—*continued.*	Proportion for an Equipment of Mules.					
	100	50	30	25	20	12
Chisels { Mortice	6	3	3	2	2	..
Chisels { Firmer	12	6	6	2	2	..
Scribing gauges	6	3	3	2	2	..
Chalk lines and reels	7	6	6	6	2	2
Hammers { Claw	4	2	2	2	2	2
Hammers { Rivetting	2	1	1	1	1	..
Oil stone	1	1	1	1	1	..
Rag stones	2	1	1	1	1	..
Two-foot rules	10	6	6	6	4	2
Pit saws	4	4	4	4	2	..
Cross-cut saws	2	2	2	2	2	..
Chalk ... lbs.	5	5	5	5	2	..
Gimlets { Spike	6	3	3	2	2	2
Gimlets { Common	18	9	9	4	4	4
SMITH'S TOOLS.						
Small pack-saddle forge	1	1	..	..	..	..
Anvil, small	1	1	..	..	..	..
Vice, large	1	1	..	..	..	..
Steelyards	1	1	..	..	..	..
Hammers { Sledge	1	1	..	..	..	..
Hammers { Hand	1	1	..	..	..	..
Hammers { Bench	1	1	..	..	..	..
Hammers { Lett	1	1	..	..	..	..
Pincers, pairs	1	1	..	..	..	..
Files { Flat	9	9	..	..	..	..
Files { ½ round	6	6	..	..	..	..
Files { Round	3	3	..	..	..	..
Tongs, of sorts	4	4	..	..	..	..
Slices	1	1	..	..	..	..
Pokers	1	1	..	..	..	..
Hand vices	1	1	..	..	..	..
Steel for repairing tools ... lbs.	40	40	10	10	10	10
Coals ... bushels.	50	50	..	..	..	..
VARIOUS STORES.						
Fascine chokers ... pairs.	32	8	..	..	..	..
Hambro' lines ... skeins.	16	9	8	8	10	4
Paints { White lead ... lbs.	5	2	2	2	..	..
Paints { Lead colour	10	5	5	5	..	..
Paints { Linseed oil ... pints.	4	2	2	2	..	..
Paints { Turpentine ... pints.	1	1	1	1	..	..
Paints { Brushes { Large	2	1	1	1	..	..
Paints { Brushes { Middling	3	2	2	2	..	..
Paints { Camel-hair pencils	12	4	4	4	..	..
Large blocks { Double	1	..	..	..	..	..
Large blocks { Treble	1	..	..	..	..	..
Rope { 2-inch tarred coils	1	1	1	1	1	..
Rope { 3-inch white, for tackle, small coils	1	..	..	..	..	..
Marquees { Captains'	1	..	..	..	..	..
Marquees { Subalterns'	1	1	..	..	..	..
Round tents	10	3	1	1	1	1
Handscrew jack, middling size	1	..	..	..	..	..
Sap forks	2	..	..	..	..	..
Saucisson, made up ... yards.	100	100	100	100	50	..
Canvas ... yards.	12	12	12	12	6	..
White tracing tape ... yards.	3000	3000	3000	3000	1500	..
Needles { Sewing	12	12	12	12	6	..
Needles { Packing	6	6	6	6	3	..
Coarse thread ... lb.	1½	1½	1½	1½	1	..
Twine ... lbs.	3	3	3	3	1	..

N. B. No mules for carrying plans and official papers are included.

In the two first columns for 100 and for 50 mules, the stores requiring it are supposed to be secured in boxes.

In the third column, viz. for 30 mule loads, the felling and broad axes are supposed to be carried in tarpaulins or canvas bags, to save weight.

In the fourth column, viz. for 25 mules, the felling and broad axes, and bill-hooks, are carried in tarpaulins; with 20 mules, the handsaws also, and nails, spikes, and steel, are carried in tarpaulins. Under 20 mules there should be no boxes carried.

The above will serve to show the very trifling weight of a liberal engineers' field equipment. One hundred carts, drawn by one or two horses each, with one hundred drivers, would serve to move stores and tools sufficient for a large army;* and as 5,000 drivers, and 10,000 horses were kept on foot last war for the efficiency of the guns and ammunition, an establishment of two troops for the conveyance of stores and tools could not be deemed unreasonable, or an oppressive addition to the burdens of the country; particularly as the horses and drivers, when not in the field, might, with much utility and saving of expense, be employed on the public works, in lieu of contractors' horses and drivers.

* One-horse carts, even in hilly districts, constantly drew 15 or 18 cwt.; now, as a pickaxe weighs only 5 lbs., and a shovel only 4½ lbs., ten horses in ten carts would, under all circumstances, be able to move forward intrenching tools sufficient for the employment of 2,000 men. Such an establishment in Spain, to the amount of fifty carts, would, consequently, have converted positive deficiency of stores into absolute abundance at the several sieges.

Note.—There is great room for improvement in the general construction of most of the tools which were furnished to the Government by contract during the late war, and of which a great quantity are still on hand. Sir J. Jones mentions in one or two places, that the soldiers always preferred working with the French tools when they could be procured, as being lighter and easier to use in every way; but independent of the construction, the contract tools are in other respects inferior; the quality of the material of which they are composed is bad, and gross frauds were practised, owing to the want of sufficient attention to the examination of the stores when furnished. The axes were not steeled at the edge, or if they were, the quantity of steel was so trifling, that the first time the tool was ground the whole disappeared: the jumpers were made in the same way. In these two instances I speak from my own knowledge; I have little doubt that others equally glaring might be discovered.

ED.

Table showing the Quantities of Intrenching Tools which were provided for various Siege Operations, with the Quantities expended at them, as far as can be ascertained.

Operations.	Intrenching tools provided.	Intrenching Tools expended.	Duration in Days.	Authority and Remarks.
Capture of Olivenza, 1811	225	. .	3	Jones's Journal of Sieges.
2nd siege of Badajos, 1811	3,500	. .	13	
3rd siege of Badajos, 1812	3,000	1,500	20	
Siege of Ciudad Rodrigo, 1812	2,200	. .	10	
Siege of the Forts of Salamanca, 1812,	400	. .	10	
Siege of Burgos, 1812	600	2,000	32	A French depôt was found.
Siege of San Sebastian, 1813	4,000	. .	59	Jones's Journal.
Siege of Saragossa, 1808 and 1809 . .	20,000	. .	52	
Siege of Tortosa, 1810	10,000	. .	13	Rogniat Relation des Sièges.

Return of Intrenching Tools and Engineers' Stores, embarked for Service of the Army, under the command of Major General Sir Edward Packenham.

29th October, 1814.

Spades		1700
Spare helves for ditto		50
Shovels, iron		400
Ditto, with long handles		250
Pickaxes		50
Ditto, miners'		50
Spare helves for pickaxes, common		200
,, ,, miners'		50
Mattocks		360
Barrows, wheel		390
,, hand		140
Hand, hatchets		928
,, bills		400
Axes, felling		721
,, broad		286
Planes, long		6
,, trying		3
,, jack		7
,, smoothing		6
Saws, hand		6
,, ditto files	dozens,	3
,, ditto setters		3
,, crosscut		36
,, ditto files	dozens,	18
Saws, crosscut, setters		6
,, pit		6
Saw, pit, files	dozens,	6
,, ditto setters		4
Adzes, wheelers'		80
Ballast baskets		1000
Sand-bags, bushel		60,000
Iron crows, 5½-feet		35
,, 4½-ditto		35
Spikes, 10-inch		1600
Screw-drivers, large T		12
,, common		10
Chisels, firmer		7
,, socket		10
Screw jacks, large		5
,, small		17
Drawing knives		26
Gimlets, spike	dozens,	5
,, common	,,	10
Hand hammers, claw		100
Iron squares, figured		30
Stones, rag	dozens,	10
,, grind, with troughs		5
Drag chains		13

Rope coils, white, 3-inch	7
,, 2½-do.	9
,, 2-do.	6
,, tarred, 3-inch	17
,, ,, 2-do.	17
Blocks, 10-inch, treble	2
,, double	15
Masons' levels, 5-feet	20
Penmauls	180
Iron assorted { Flat, 99 bars; Round, 86 do.; Square, 24 do.; Casement, 10 bundles; Nail rod, 18 do. }	cwt. 66
Steel, sheer ... cwt.	½
,, blister ... ,,	½
Forge carts with bellows	6
Anvils	6
Bick irons	6
Painted covers	6
Grease boxes	6
Spare bellows, forge cart	4
Chests of tools	6
Gouges	20
Augers (8 to a set) ... sets,	20
Lanthorns, Muscovy	8
,, tin	38
,, dark	12
Oil, sweet ... gallons,	5
,, linseed ... ,,	20
Carts, trench	50
Horse harness rope, near and off wheel ... sets,	100
Whips	50
Leggins	50
Stoppers and lanyards ... 50,	100
Headstall halters with chain reins	100
Handscrew levers, 6 feet	10
Birch brooms	30
Coals ... chaldrons,	38½
Chalk ... cwt.	2
Chevaux de frize ... barrels,	30
Spears for ditto ... bundles,	30
Tarpaulins, large, for covering temporary magazine	9
Locks, stock, with staples	20
,, pad, with hasps and staples	16
Hinges, ĿL 12 inches ... pairs,	16
,, hook and strap ... ,,	20
Sap forks	40
Fascine choakers	8
Sledge hammers, miners'	10
Spunyarn for tying fascines ... fathoms,	2000
Platforms of oak for mortars, 16 × 16 feet { A, 13 planks; B, 13 do.; C, 11 do.; D, 13 do.; E, 12 do. }	5
Platforms of oak for mortars, 16 × 8 feet { S, 16 do.; T, 16 do.; U, 16 do. }	3
Sleepers for do. 8 × 8 inches, 16 feet long	40
Spikes for platforms, 7 inches	1600
Fir timbers of different dimensions { about 700 feet running or cubical feet. }	200
Fir boards, 1 inch ... feet superficial,	1000

ARTIFICERS' TOOLS.

Sets of tools, carpenters'	3
,, masons'	8
,, collar-makers'	8
,, wheelers'	4
,, miners'	3
Masons' levels, 10-feet	8
,, 5-do.	8
,, plumb rules	8
,, facing rules, 6-feet	8
,, ,, 4-ditto	8

CAMP EQUIPAGE.

Tents, with poles, pins, and mallets, captains'	5
,, ,, subalterns'	7
,, round	6
For round tents, poles	6
,, pins	240
,, mallets	12
Blankets	100
Canteens, wood, with straps	100
Haversacks	100
Camp kettles	12

II.— *Notes on the Charges of Military Mines.* *By Lieutenant* DENISON, *Royal Engineers.*

VARIOUS rules have been laid down from time to time by the different authors who have written upon the subject of the charges of Military Mines, and as long as the radius of the required crater is equal to the line of least resistance, the results deduced from these rules coincide, or so nearly so as to render the difference unworthy of remark. They all agree that, in cases where the constant proportion between the diameter of the crater and the line of least resistance holds good, as the solids to be removed are in proportion to the cubes of lines similarly situated in each figure, or, which is the same thing, to the cubes of the lines of least resistance, the charges by which these solids are to be moved must be in the same proportion, and therefore, having the charge necessary to produce this effect in a given soil in one instance, we may calculate it in any other by the formula $x = \frac{cL^3}{l^3}$ when x is the charge required, c the charge of the experimental mine, L the line of least resistance of the required mine, l that of the experimental mine. Having then by experiment established a sort of scale of charges for any line of least resistance in a variety of soils, we have, by means of the above formula, the power of calculating the charges necessary to produce given effects, under the limitation at first expressed of the fixed ratio between the line of least resistance and the diameter of the crater.

The form of the crater has been variously assumed as a cone, a frustrum of a cone, or a paraboloid. The cone was assumed to have its apex in the center of the charge; this however was found to give too small a deblai. The frustrum of the cone had the radius of its smaller extremity equal to half that of the larger, and its solid content was equal to $\frac{11}{6}$ of the cube of the line of least resistance. The paraboloid, which was the figure assumed by La Valliere, had its focus in the centre of the charge, and its solid content differs in this case by $\frac{1}{29}$ in excess from that of the truncated cone. When the vertex of the paraboloid is cut off by a plane passing through the centre of the charge, the difference in excess becomes only $\frac{1}{276}$, a quantity quite inappreciable. We may therefore assume, that the frustrum of a cone, whose height is equal to the radius of its base, and to twice the radius of its smaller section, will be an approximation to the solid content of the common or two-lined crater sufficiently close for all practical purposes. In different soils, experiment is the only guide to the quantity of powder necessary to raise a given mass; and this has shown, that in common earth $11\frac{1}{2}$ or 12 lbs. is sufficient to remove a cubic toise: from this follows at once the miner's rule, that the charge for a two-lined crater is equal to $\frac{1}{10} l^3$; and to the practical correctness of this rule all the authors who have written on the subject give their testimony.

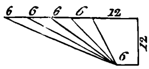
We owe to Belidor the discovery, that if two charges of powder be placed in chambers at the same distance under ground, one being sufficient to produce a common crater, and the other much larger than necessary for that purpose, the latter will produce a larger crater than the former. This seems to be a natural consequence; but many had denied the fact, under the idea that the powder, if used in excess, would only blow out for itself a sort of cylindrical hole; that in fact, the effect would, instead of increasing, diminish. Belidor tried a variety of experiments, and came to the conclusion, that as powder, when fired, would expand equally in every direction, the effect on the surrounding ground would be to form what he called a globe of compression, or a sphere whose centre was the centre of the charge, and whose radius was equal to the distance from this point to the edge of the crater. Having ascertained this distance in a common crater with the same line of least resistance as his globe of compression, and also in the latter, he considered the charges to be in the ratio of the cubes of these lines, forgetting that the solids were in no measure similar in figure. Other authors have followed Belidor in his general investigation, but have considered the charges as proportional to the squares of the radii of the crater. Others again, among whom is Colonel Pasley, have based their rules entirely upon experiment, without any reference to the figure of the crater, and have attempted to establish at once a fixed proportion to the cube of the line of least resistance, for the charge of each crater. The accompanying table shows at a glance the enormous discrepancies between the results deduced from the different rules.

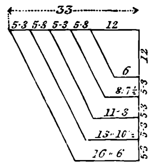
Ratio of Charges, that for the Common or Two-lined Crater being Unity.

	One-lined Crater.	Four-lined Crater.	Six-lined Crater.
Mouzé	1	4	9
Belidor	1	4	11·2
Pasley	1	10	40

Colonel Pasley's rules, being based upon direct experiments, are more to be relied upon than the theoretical deductions of Mouzé and Belidor: but as others have arrived at different results, basing their calculations also upon experiments, though not of their own making, I shall proceed with the comparison.

General Marescot's rule says, multiply the squares of the radii of the craters by the radii of explosion, and the charges will be in proportion to the products; and in this case, the charge for a two-lined crater being unity, that for a four-lined crater will be 6·32, and for the six-lined crater 20·1. Messrs. Gumpertz and Lebrun take a different view of the subject, and say, that as a certain charge of powder (3660 lb.) with a line of least resistance of 12 feet, produced a six-lined crater, and this same charge, placed at the depth of 33 feet, will only produce a two-lined crater, thus this proportion will hold in all other mines, and their rule is as follows:—As 12 feet (the line of least resistance of the mine whose crater of 36 feet radius has been produced by charging it as a common mine of 33-feet line of least resistance) is to (a), the line of least resistance of a mine which is to produce a six-lined crater, so is 33, to x, the line of least resistance of a common mine, whose charge will produce a six-lined crater at line of least resistance (a).





And the lines of least resistance of other surcharged mines will vary in the following proportions deduced from the figure:

	Radius of Crater.	Lines of least Resistance of common Mine.
3-lined crater	18	17·3
4 „ „	24	22·6
5 „ „	30	27·9
6 „ „	36	33·0

The charges calculated by this rule are as follows, the charge for the two-lined crater being taken as the unit.

Two-lined Crater.	Four-lined Crater.	Six-lined Crater.
1	6·64	20 8

Captain Macaulay follows the same principle as Messrs. Gumpertz and Lebrun, but, using a different example, arrives at results differing in a slight degree from theirs. His charges for the different mines will be as follows:

Two-lined Crater.	Four-lined Crater.	Six-lined Crater.
1	6·33	19·7

M. d'Obenheim concludes, from various calculations, that the charges of mines with the same line of least resistance, are as the fourth powers of their radii of explosion; or more generally for all mines, that they are directly as the fourth powers of the radii of explosion, and inversely as the lines of least resistance: this formula gives the charges for the four and six-lined crater, with reference to that of the two-lined crater as unity, as below.

Two-lined Crater.	Four-lined Crater.	Six-lined Crater.
1	6·25	25

The following table gives at one view the proportions of the charges, as determined by different authors.

Common or Two-lined Crater.	Four-lined Crater.	Six-lined Crater.	Names of Authors.
1	4	11·2	Belidor
1	4	9	Mouzé
1	6·64	20·8	Gumpertz and Lebrun
1	6 33	19·7	Capt. Macaulay
1	6·25	25·0	d'Obenheim
1	10· 0	40·0	Colonel Pasley
1	6·32	20·1	Marescot
1	8	27·0	When the radius of the crater is taken as the line of least resistance, of a common mine.

The conclusion forced upon us by the discordant results in the above table is, that data are yet wanting for the determination of the charges of mines, the radii of whose craters exceed the line of least resistance. Any facts therefore which bear upon the subject will be most valuable, as we can only hope to arrive at a practical conclusion from the collation of numerous experiments made under every variety of soil and line of least resistance.

The following experiments were made at Tournay, by Messrs. Mesgrigny and la Motte, in 1689.

No. 1 was made in a soil consisting of strong sand mixed with clay, weighing about 124 lbs. per foot cube. The line of least resistance from the surface to the floor of the chamber was 12 feet; another chamber was placed directly beneath the first, at a distance of 12 feet from the sill of one to that of the other; a gallery was also driven at a distance of 10 feet from the chamber, and on the same level with it. This mine was charged with 200 lbs. of powder; the diameter of the crater was 24 feet: the explosion destroyed the chamber below and eight feet of the gallery leading to it: it injured the gallery on the same level as the chamber, but did not altogether destroy it. The quantity of powder required to raise a cubic toise by this experiment appears to be 13 lbs. 10 oz.

No. 2 was made in the same soil as No. 1. The line of least resistance being 23 feet, a gallery was driven on the same level as the chamber, and 28 feet distant from it: it was charged with 400 lbs. of powder. The explosion destroyed the gallery, but took very little effect on the surface of the ground.

No. 3 was made in the same soil, the line of least resistance being again 23 feet: a gallery was driven at a distance of 22 feet from the line of least resistance and 10 feet above the charge. This gallery was filled with stone; the charge was 600 lbs.: the explosion destroyed the gallery, but produced little effect on the surface.

No. 4 was made in the same soil, the line of least resistance being 25 feet. The charge 1386 lbs.; the diameter of the crater made by the explosion was 50 feet, and the quantity of powder, per toise cube, 10½ lbs.*

No. 5 was made in the same soil, the line of least resistance (described as in the last case) being 12 feet. The charge 150 lbs.; the diameter of the crater 24 feet; and the quantity of powder, per toise cube, 10 lbs. 4 oz.

No. 6 was made in the same soil, but going deeper it was necessary to pierce a stratum of indurated sand, the weight of which was 126 lbs. per cube foot. The line of least resistance measured, as in the two last cases, was 35 feet: the charge 4000 lbs. The diameter of the crater 70 feet, and the quantity of powder, per toise cube, 11 lbs.

No. 7 was made in the same soil. Two chambers were placed, each having a line of least resistance of 12 feet: the distance between the chambers was 10 feet, and the charge of each 100 lbs. They were exploded simultaneously: the diameter of the crater in one direction was 30 feet, and the other 21, and the quantity of powder, per toise cube, 10¼ lbs.

* In this experiment the length of the line of least resistance is explained in a different manner than in the preceding. Here the expression is, "Le fourneau ayant 25 pieds de terre par dessus."

No. 8 was made in the same soil, with a line of least resistance of 12 feet: the charge was 300 lbs. The diameter of the crater 30 feet, and the quantity of powder, per toise cube, 5 lbs.

No. 9 was made below a mound of earth rising four feet above the surface of the ground. The chambers were made at the angles of a square, and the lines of least resistance were in all cases 20 feet, and the charges 450 lbs.; but the explosion produced hardly any effect.

No. 10 was made in a strong clay, of which a foot cube weighed 133 lbs. The line of least resistance was 15 feet, and the charge 300 lbs. The diameter of the crater was 30 feet, and the charge, per toise cube, 10½ lbs.

No. 11 was made in an old mass of masonry, the thickness of which at bottom was 10 feet, at top 8 feet, its length 20 feet, and height 42. A chamber was made at the centre of the mass, on a level with the ground, and charged with 80 lbs. of powder: the effect was very good, the bottom of the mass being blown out.

No. 12 has not sufficient detail to render it useful.

No. 13 was made at Mont d'Anzen near Valenciennes, in a loose sand, of which a foot cube weighted 132 lbs. The line of least resistance was double, the chamber having 15 feet of earth over it, and 15 feet between it and the scarped side of the mound. The charge was 300 lbs.; and the explosion produced a practicable breach 30 feet wide, most of the effect having taken place laterally.

No. 14 was made in the same mound. The line of least resistance vertically was 18 feet, and horizontally 35 feet: the charge 450 lbs. The diameter of the crater was 36 feet, and no effect was produced on the scarped face of the mound. The charge, per toise cube, was 9 lbs. 1 oz.

No. 15 was made in the same mound. The line of least resistance vertically was 30 feet, and laterally 46 feet. The charge 2050 lbs. The diameter of the crater was only 48 feet, which was attributed to the want of consistence in the soil.

No. 16 was made in the same mound. The line of least resistance being vertically 45 feet, and laterally 66 feet: the charge 6900 lbs. The diameter of the crater was only 72 feet.*

No. 17 was made at an old tower near Valenciennes: this tower was built on a mound of made earth; its foundations were 19 feet deep and 11 thick, made

* In the two last experiments the charges were too small to produce two-lined craters.

of good rubble masonry; it was square, each face being 40 feet long. Above the foundations, one angle was formed of two masses of masonry, 42 feet high, 10 feet thick at bottom, and 8 feet at top; one of these masses was 28 feet long, and the other 20 feet. The other portions of the tower above ground had been demolished previous to this experiment. The mound surrounding this tower was 20 feet high, 173 feet in diameter at bottom, and 146 feet at top. The powder was lodged in four chambers under the angles of the tower; under the part where the heavy fragments of the wall were left standing, a charge of 2000 lbs. was placed; there were two charges of 1300 and one of 1200 lbs.; the mines were exploded simultaneously; the effect was to lift the tower bodily out of the ground to the height of 10 feet, after which it crumbled to pieces.*

No. 18 was made in a strong clay, the cube foot of which weighed 133 lbs.; the line of least resistance was 15 feet; the charge 308 lbs.; the diameter of the crater 30 feet; and the charge, per toise cube, $10\frac{2}{3}$ lbs.

No. 19 was made in the same clay; the line of least resistance was 29 feet; the charge 2300 lbs.; the diameter of the crater 58 feet; and the quantity of powder, per toise cube, $11\frac{1}{8}$ lbs.

No. 20 was made in the same soil, but on sinking deeper, below the clay, a stratum of indurated sand was found, and the mean weight of a cubic foot of the whole was 136 lbs.; the line of least resistance was 41 feet, and the charge 6700 lbs.; the diameter of the crater 82 feet, and the charge, per toise cube, $11\frac{1}{2}$ lbs.

No. 21 was made in a soil of which the first seven feet was a strong clay, weighing 140 lbs. per foot cube, and below that an indurated sand weighing 132 lbs. per foot cube; the line of least resistance laterally was 12 feet, and vertically 20 feet, the mine being placed above an old stone quarry; the charge was 150 lbs. and the explosion took effect in a lateral direction; not horizontally, for the earth on a level with the chamber was not affected.

No. 22 was made in the same spot, but the chamber was placed in the clay; the line of least resistance was 7 feet, the charge 35 lbs.; the diameter of the crater 14 feet, and the charge, per toise cube, 12 lbs.

No. 23 was made in the glacis of the citadel of Tournay; the soil was clay mixed with sand, weighing 150 lbs. per foot cube; the line of least resistance 17 feet; the charge 500 lbs. of powder; the diameter of the crater 39 feet; and the charge, per toise cube, 12 lbs.

* The inside of the tower was vaulted, but the vaults were filled with rubbish.

No. 24 was made in the same place; the line of least resistance being $21\frac{1}{2}$ feet; the charge 900 lbs.; the diameter of the crater 43 feet; and the charge, per toise cube, $10\frac{2}{3}$ lbs.

No. 25 was made in the same place; the line of least resistance was 34 feet; the charge 3600 lbs.; diameter of crater 68 feet; and charge, per toise cube, 10 lbs. 13 oz. This explosion destroyed the pier and one of the galleries of the counter-mines of the citadel, although it was built of good masonry, and was 56 feet distant from the chamber, on the same level.

No. 26 was made in the same place, in a soil mixed with rubbish, which had been made about 15 years, but had not much consistence; the line of least resistance was 20 feet; the charge 660 lbs.; the diameter of the crater 40 feet; and the charge, per toise cube, $9\frac{1}{2}$ lbs.

III.—*Account of the Demolition of the Glacière Bastion at Quebec, in* 1828.

In order to proceed with the new works, according to the plan laid down for the formation of a Citadel at Quebec, it became necessary to remove a portion of the old French works, called the Glacière Bastion, to give place to a new counterguard, intended to cover the escarp of both faces of Dalhousie Bastion, from the high ground on the Plains of Abraham.

The 5th company of Royal Sappers and Miners having been out of England between four and five years, and the arduous duties of the corps in Canada affording them little or no time for instruction in their field duties, it was considered that the demolition of this work, by a system of mines, would not only afford most useful instruction to the company, but would probably be the most economical and effectual method of shaking down its escarp.

The commanding engineer having given his permission, and obtained the sanction of the commander of the forces, the company commenced driving the galleries Nos. 1, 2, and 3 by day-work, and continued them till they had formed junctions with each other: and, with the exceptions of meeting with rock or masonry, each squad generally averaged about eight feet a day. The nature of the soil was clayey, occasionally mixed with fragments of rock; made ground, but having acquired, from the length of time it had lain together, a considerable degree of compactness.

The galleries being completed, the company was told off in three brigades, consisting of one serjeant, three corporals, and nine privates, with orders to relieve each other every six hours; and the remainder of the company off duty were employed in making the coffers, hose, and casing-tubes; and occasionally relieved such men as felt oppressed by too long confinement under-ground.

On Monday, the 11th of February, the branches and chambers were commenced, at the points x, y, and z, leaving each squad nearly an equal portion of labour; and, as soon as the coffers were properly fixed and filled, and the train laid, each squad commenced a fresh branch, and the excavation was employed in tamping the one just completed. (*See Plate.*)

By this arrangement, the whole of the branches and chambers, measuring about 370 feet in length, were excavated, the powder placed in the chamber, the train laid, and the whole tamped up, and ready for explosion, on the Monday following. A coffer 13 inches cube, containing 70 lbs. of powder, was placed its own depth in each counterfort, at its junction with the scarp; and another of 12 inches cube, containing 50 lbs., was placed its own depth in the back of the scarp, equidistant from those in the adjacent counterforts.

The line of least resistance, opposite the 70 lbs., was nearly 9 feet, and opposite the 50 lbs., nearly 8 feet, and the average height of the scarp was from 21 to 25 feet.

It is not thought necessary to enter into the detail of the dimensions of the galleries, branches, &c. as the system pursued was strictly conformable to the instructions received from Chatham.

On Tuesday, the 19th of February, the Earl of Dalhousie, Governor General, and Commander of the Forces in his Majesty's North American Provinces, accompanied by his staff, and a great number of others, both civil and military, attended to witness the explosion.

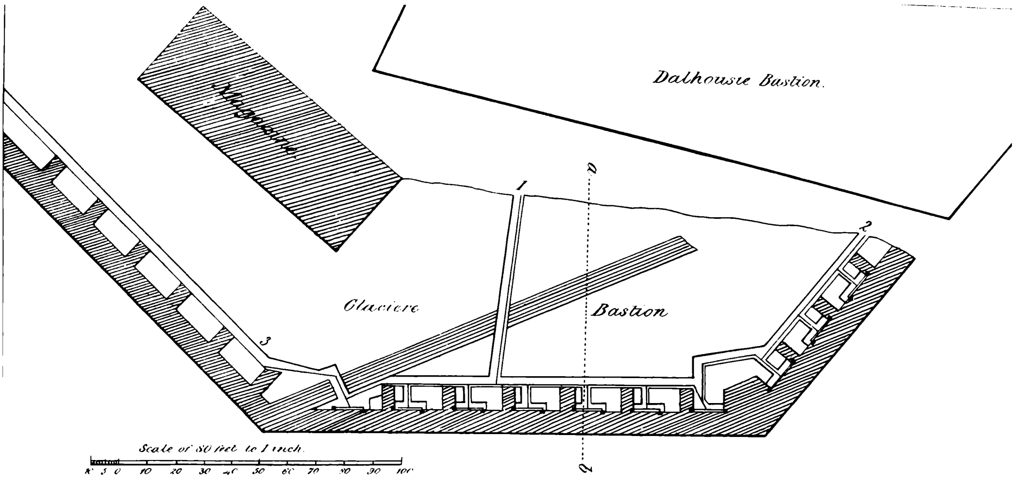
The galleries being in several parts very wet, and fearing from the length of time it required to prepare the mines, that the powder in the hose might get damp, it was determined to fire the mines at the three points, 1, 2, and 3, and thereby produce a more simultaneous explosion: but the sapper stationed at No. 3, having taken the signal from the bugle where his Lordship and the spectators were stationed, instead of waiting for the repeating bugle on the spot, the whole of the mines, 20 in number, were exploded from that point.

The effect produced far surpassed the most sanguine expectations of the officers employed upon this service.

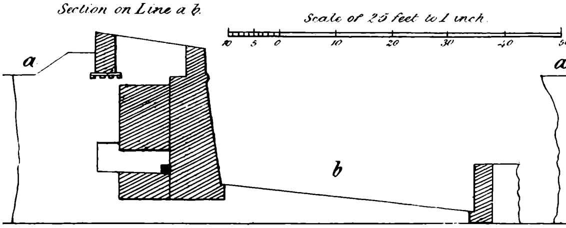
The explosion not only crumbled the escarp to pieces, without projecting a stone 50 feet from its original position, but brought down the whole of the parapet, together with its interior revetement; forming throughout the whole line a most practicable breach.

The only parts which descended in masses were the exterior revetement of the parapet, and the earth between that and the interior revetement, showing the enormous power of the intense cold in Canada, which strikes nearly four feet into the ground.

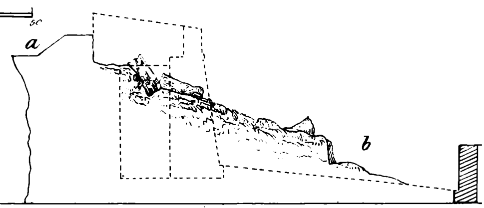
The escarp was of rubble masonry, and in an excellent state of preservation.



Section on Line a b.



Section on Line a b after the Explosion



Sketch of the Dock Entrance at Flushing after the Explosion.

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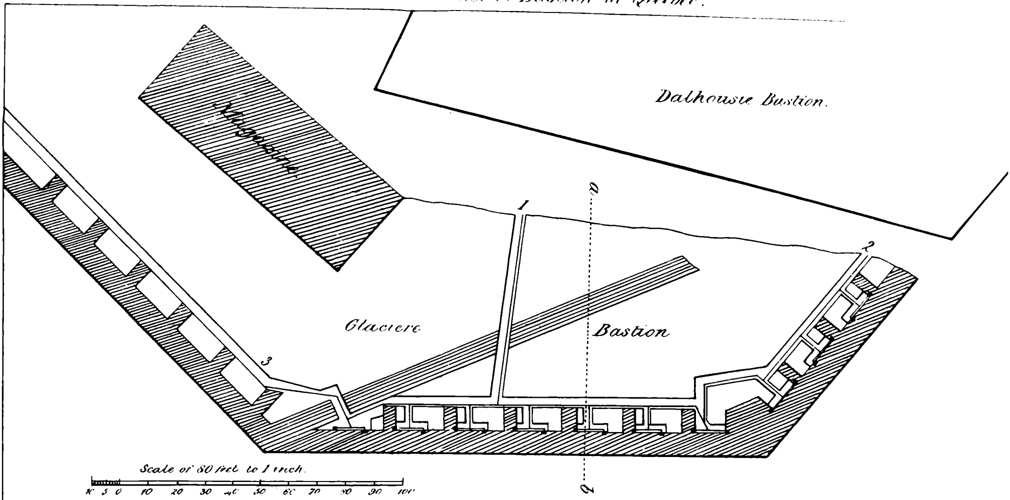
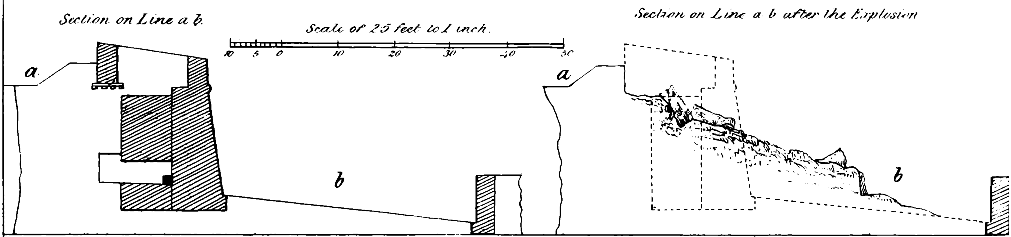
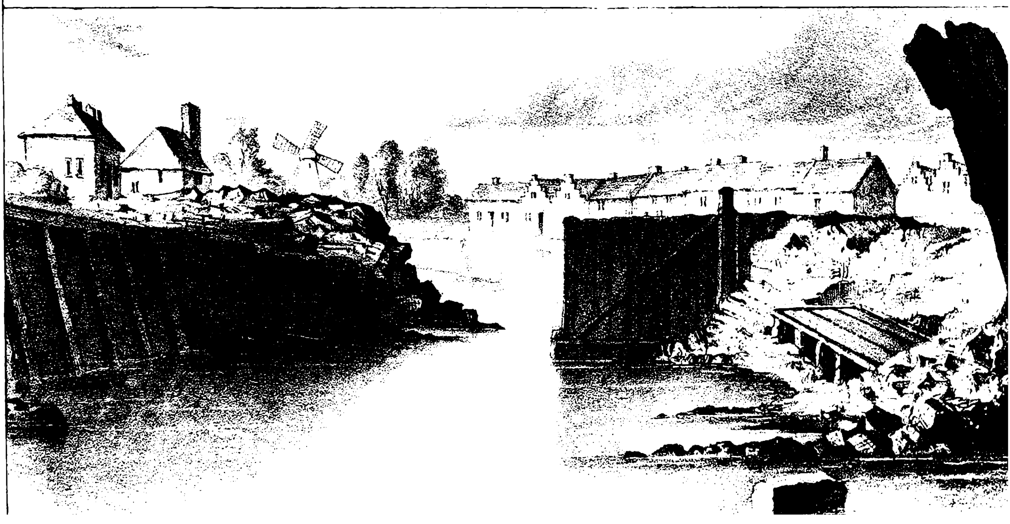
Plan & Sections of the Glaciere Bastion at Quebec.





Sketch of the Dock Entrance at Flushing after the Explosion.



Remarks deduced from the foregoing Practice.

1st. As the mines were exploded from one point, instead of three as intended, and as the interval of time between the first and last explosion, in a distance of at least 220 feet, did certainly not exceed three seconds, it is presumed that a simultaneous explosion of mines (requiring great length of hose, much time to adjust, and great additional labour), can seldom or never be required, and if resorted to, that the effect would not be materially increased.

2ndly. From the immense masses in which the earthen parapet descended without being shaken, it is almost evident that, in a cold climate, during the winter season, rock may be excavated with greater facility than earth, when both are equally exposed to the effects of frost.

3rdly. That the distance to which a gallery may be driven without the aid of bellows, depends entirely upon the state and temperature of the atmosphere. In the present instance, No. 1 was driven at least 140 feet, and the lights burnt tolerably well, though eight men were frequently employed in it.

CAPTAIN MELHUISH,
Royal Engineers.

Two N. C. O. and eight sappers divided into two equal parties, for placing the boxes in the chambers, and adjusting and laying the hose-tubes ready for tamping—one good carpenter amongst them.

Three sappers preparing hoses.

Five do. tamping parties.

The operation occupied five weeks' working time; but much delay took place from the small number of sappers at first employed, and the men not being quartered on the Island.

The effect of the explosion was most complete, the whole escarp, with the 12-feet parapet which crowned it, being thrown down *en glacis*, and forming a practicable road into the fort at more than one point; but particularly in front of the casemates, where a column of subdivisions might have stormed.

Corfù, June 12th, 1826.

V.—*A short Account of the Demolition of the Piers of the Entrance Chamber of the large Basin at Flushing, in* 1809. *By Colonel* FANSHAWE, *Royal Engineers.*

SUCH erroneous accounts having been offered to the public respecting those leading data which rendered the destruction of the piers of the flood-gates of the great basin at Flushing, in 1809, an interesting mining operation, it may be useful to any officer that feels disposed to compare the practical result on that occasion, with the calculations of theory, to have before him the following details, which have been taken from notes kept by me at the time of execution.

The evacuation of the island of Walcheren having become necessary, the British Government determined on, "the demolition of the sea-defences and basin of Flushing," and a body of nearly 400 civil artificers and "navigators" was sent from England, and placed under the officers of Royal Engineers to whom the work of demolition was confided.

The destruction of the piers of the flood-gates at the entrance of the basin, appeared to the officers the first object of consideration, and this was to be effected by mines, the disposition and charges of which should be so arranged, that the effectual destruction of the piers would not hazard that of the town by which the basin was surrounded.

The length of each pier was 128 feet; the thickness varied from about 27 to nearly 33 feet; and the height above the floor of the entrance-chamber was 26 feet; the whole of solid brick-work, except a small arched channel, or culvert, which ran longitudinally through the upper part of each pier.

The object being to render these piers unserviceable with the least possible injury to the town of Flushing, it was proposed so to place the charges that the foot of each wall should be blown into the entrance, or lock-chamber, and that the upper part of the wall, instead of being thrown upwards by the immediate effect after explosion, should fall as its consequence; or be so rent as to be incapable of partial repair.

The position fixed upon for the charges, was 2 feet above the floor of the lock-chamber, and with a line of least resistance towards the face of each pier, of 9 feet.

The explosion was to take place at low tide, when there would be 7-feet depth of water in the entrance-chamber.

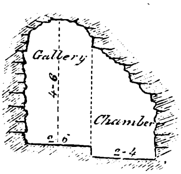
Four mines were determined for each pier, to be equally distributed and fired together; the charge of each to be three barrels of gunpowder, or about 270 lbs.

A shaft 7 feet square was sunk for each mine, in the ground immediately at the back of the piers; and upon reaching the required depth in each, a gallery, 4 feet 6 inches high, and 2 feet 6 inches wide, was driven through the brick-work to the position for the charge.

The miners were divided into gangs of six to each mine, and each gang was subdivided into three reliefs; so that two men were in the gallery at a time, one working with a pole-pick and wedge, or a hammer and chisel, whilst the other was clearing out the rubbish from the gallery, and filling the bucket, which was drawn up the shaft by two labourers.

The general average of work accomplished by the miners, was about $1\frac{3}{4}$ inch length of gallery per hour; some did more, others much less.

Having reached the length intended for each gallery, a return was made for the chamber, of which the following is a section.

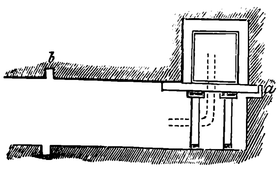


The boxes to contain the charges were, in the clear, $19\frac{1}{4} \times 19\frac{1}{4} \times 22\frac{1}{4}$ inches, made of $1\frac{1}{2}$-inch deal; the bottom covered with tarpaulin, and the cover made to fit exactly, with ledges.

The auget was fixed to, or rather housed into, the centre of the side of the box towards the gallery; it was made $1\frac{1}{2}$-inch square in the clear, of $1\frac{1}{4}$-inch deal; the cover of it (after the saucisson was laid) was fastened with wooden pegs.

The saucisson was the leader of a fireship, about 1 inch diameter, filled with gunpowder, and afterwards passed through a painted canvass hose; the whole of which was laid in the auget.

Plan of the gallery and chamber showing the timber stoppages.



The mines being charged, the upper part of each chamber was filled in with bricks; then (a chase (*a*) being cut, as shown in this diagram,) planks were laid edgewise, so as to close the whole entrance: two stout planks were then placed vertically ; and these were secured by four pieces of stout oak scantling, placed horizontally from the opposite side of the gallery, and wedged very tight. The whole space opposite the entrance of the chamber was stopped with bricks and filled sand-bags ; then another partition of timber across the gallery, at the chase (*b*). The remainder of the gallery was built up with sand-bags, and at the entrance of the gallery another partition of timber was placed, and the whole of the lower part of the shaft, to the height of the gallery, was made as solid as possible with a bed of timber.

Throughout the gallery, and up the shaft, the auget had bricks built around it, to secure it from damp. The shaft was filled with sand-bags, bricks, and rubbish, to the very top.

A slight bridge was thrown across the entrance-chamber from pier to pier, and the mines were connected together by the saucisson, and fired by a portfire, equidistant from the centre of each charge, allowing 4 inches for every right-angle.

The mines were exploded at low water, and the flood-gates were opened. The effect of each charge (excepting two on the eastern side, where the powder had become damp, and the explosion consequently only rent the pier) was to blow out the bottom of the wall, and to destroy the adjoining part of the floor, which was of oak. The bottom of the piers being thus removed, the upper part almost immediately fell.

So completely was the desire that the town should not suffer fulfilled, that not even a square of glass was broken in the lock-house, situated about 30 feet in rear of the western pier, whilst the effectual destruction of the piers themselves assumed the appearance shewn in the annexed sketch.

EDWARD FANSHAWE,
Colonel, Royal Engineers.

VI.—*Extract of a Letter from Colour-Sergeant* HARRIS, *Royal Sappers and Miners, to Colonel* PASLEY, *Royal Engineers, giving an Account of the Mode in which a stranded Ship was blown to pieces.**

THE Arethusa was a ship of 350 tons, and went on shore in the hurricane of the 10th of August, 1831, close to the commanding Royal Engineer's Quarters at Barbadoes. I had orders from Major, (now Colonel) Reid, to try to blow her to pieces, which was done in the following manner. Two old oil tin cans, which held 30 lbs. each, were filled with powder; $\frac{1}{2}$-inch hose was then made with calico, filled and put through $1\frac{1}{4}$-inch lead pipe, which was then soldered to the tin cans. The ship lay on her larboard side with the keel about 2 feet out of the sand, and at low water, (which was about 3 feet deep on the outside of the ship, the side nearest the sea), we put one of the cans under her keel, about 10 feet from the stern, and brought the end of the pipe through the side of her, as it was the best place for firing. When it was high water, it was about 6 or 7 feet deep, and we then fired the charge, and made a hole in her about 10 feet long, and upon an average 4 feet wide, through her keel, planks, timbers, and lining, and carried a piece weighing nearly 100 lbs. to a great distance. The next charge was put under the keel the same way, about half way from the hole just made to the bow, and that load had also a good effect, but it did not carry away so great a piece as the first. The next was loaded in the same manner, but with only 24 lbs. of powder, that was put under her keel as before, but near the bow: this load did not carry off a great deal, but shook her much. We then got the lining off the bow; there were 5 knees or timbers still remaining, which held the ship together; we put a sand-bag on the lower one of the five, containing 24 lbs. of powder: the explosion of this broke the beam it rested on and the two above it: we put nothing against it, only a bit of wood, to keep it in its place before it was fired. The next charge contained the same quantity, and was put on the

* To procure the greatest resistance to the powder on the side next the sea, the charges were never fired until high water.

lowest one of the two that remained. When that was fired, the bow dropt in pieces: the stern was done in the same manner as the bow, and every load that was fired had the desired effect: one or two missed, in consequence of the water getting in the cans.

(Signed) JOSEPH HARRIS,

Late Colour-Sergeant, Royal Sappers and Miners.

Colonel Pasley, C. B.
Royal Engineers.

VII.—*Notes on the Formation of Breaches by Artillery.*

The questions addressed by Marshal Soult to the different artillery schools in France, contain a summary of the points to which the attention of officers should be constantly drawn; and the published details of the experiments carried on at Metz, afford very valuable information upon those points which were investigated by the committee. I have, in the abstract I have attempted to give, confined myself altogether to the first experiment, for the purpose of establishing a comparison between the effect of the point-blank fire of artillery at short distances, with a full charge, and that of a plunging or pitching fire, (as shown in the experiment carried on at Woolwich, in the year 1822, against a portion of a detached escarp, constructed according to Carnot's system). I annex also, for the purpose of comparison, Note 34, from Colonel Jones's account of the 'Sieges in Spain.' In conducting these sieges, from the absence of a proper Engineer establishment, it was found impossible to carry the approaches up to the covered way, and establish batteries on its crest: it was necessary, therefore, to take advantage of commanding points at long distances, from whence the escarps could be seen to the foot, and there to erect heavy batteries for the purpose of opening a narrow and perilous road, through which the valour of the troops would enable them to force an entrance. Had the works of Badajoz, Ciudad Rodrigo, and St. Sebastian been properly covered from distant fire, all our efforts against them would have been perfectly futile. As it was, however, the sieges in the Peninsula present several remarkable instances of the efficiency of a well-sustained distant fire against the best masonry scarps.

W. D.

Abstract of the Experiments at Metz.

In the year 1833, Marshal Soult, who was then Minister of War, forwarded a circular letter to the different schools for the artillery throughout France, calling their attention to the various points upon which it was desirable that more precise and definite information should be obtained. The following is the list of subjects referred to :—

1. To determine the relations which exist between the initial velocities of projectiles, and the charges of powder of equal weight, but of different strength, this strength being expressed by the ranges of the eprouvette, or by any other equivalent mode.

2. Between the initial velocity, the charge of powder, (the force of the powder being supposed constant) the weight of the projectiles, the calibre of the gun, the length of the bore, and the windage.

3. Between the range, the initial velocity, the weight of the projectile, and the angle of projection.

4. To ascertain the length of bore which gives the greatest range; the maximum charge; the effect of alteration in the length of the cartridge, in the shape and capacity of the chamber, and in the position of the vent.

5. To establish the law of the resistance of the atmosphere, and to explain the principal causes of the irregularities which affect the direction of the shot.

6. To explain the theory of ricochet firing; the relation between the initial velocity, the angle of elevation, the lengths of the first and second bounds of the shot, and the total range.

7. To make the necessary experiments to ascertain the penetrations of shot in earth, masonry, wood, metals, and liquids: the thickness necessary under different circumstances, and with various materials, to withstand the effect of shells: the effect of the explosion of shells from mortars and howitzers; the cavity created in earth by this explosion, either with the ordinary bursting charge, or with the cavity of the shell completely filled with powder.

8. To give a theory of the penetration of projectiles.

Marshal Soult then directs, that at each school a commission, composed of officers and professors, shall be formed, which shall report to him the particular objects in the above list with which they purpose to occupy themselves, the experiments which they conceive necessary to determine these objects, the amount of material necessary for the purpose, and the probable expense.

Of these questions, the three last are of the greatest interest to the officer of Engineers. Any facts which tend to throw light upon the theory or practice of ricochet firing, will guide him in his attempts to modify, or to neutralize altogether, the destructive effect of this system, when used in the attack of fortresses; while the resistance of different substances to the action of shot and shells, forms a necessary element in the determination of the thickness of parapets and buildings intended to protect troops against the action of projectiles generally.

The report, therefore, of the commission appointed at the school at Metz, which devoted its researches principally to these points, is of great interest to officers of Engineers; and I have attempted, in the following pages, to give a brief abstract of the details of the first experiment, and of the conclusions derived from it, combining them, at the same time, with the information I have been able to procure from other sources upon the same subject.

The first experiment made by the committee was for the purpose, partly, of ascertaining the penetration of shot and shells of different calibres in masonry and earth; and partly of determining the best mode of directing artillery for the purpose of forming a breach, and the time required to render such breach practicable. With this object two batteries, one of four 24-pounders (French), and the other of four 16-pounders, were constructed opposite a portion of the left branch of the horn-work of the citadel of Metz, which work was constructed by Vauban, between 1676 and 1680: each battery was to form a breach about 20 metres in length, and a third breach was to be formed by the mine.

The revetement, which it was thus proposed to breach, was formed of rubble masonry, the facing of calcareous oolite from the quarries of Jaumont, and the interior of a species of blue limestone yielding an hydraulic lime. The mortar was composed of sand and hydraulic lime; the height of the escarp varied from 19 to 21 feet, measured from below the cordon to the bottom of the ditch; the thickness at the top was 4 feet 8 inches, and at bottom 8 feet 6 inches, with an exterior slope of $\frac{1}{5}$: it was strengthened in the rear, for its whole height, by counter-forts, 7 feet in length, 5 feet 4 inches wide at the root, and 4 feet at the tail, and 16 feet distant from centre to centre.

With regard to the quality of the masonry, the following facts will enable some idea to be formed. In forming a gallery by blasting, the miners were employed for twenty-one hours in excavating a cubic yard. Another gallery, excavated by the pick and chisel, required fifteen hours labour per cubic yard; while in an open coupure, country masons, working by the task, demolished a cubic yard in seven hours thirty-six minutes.

The 16-pdr. battery was placed in the re-entering place of arms, at the distance of 33 yards from the scarp, and the breach was commenced at the distance of 7 feet from the bottom of the ditch; the 24-pdr. battery was constructed on the crest of the glacis, at a distance of 35 yards from the escarp, and the breach was commenced about 8 feet from the bottom of the ditch. The guns were placed about 16 feet apart; and as each of them had to form a horizontal section through the revetement of the same length, they were all at first directed to the left extremity of their allotted field of action, and after that every successive shot struck the revetement at about 1 yard to the right of its predecessor: 5 shots from each gun having thus marked out the breach, a steady fire was kept up at 5-minute intervals, with a charge of powder equal to half the weight of the ball, care being taken always to fire at the most projecting part of the masonry; and the result was, that the revetement was entirely cut through at the distance of 7 feet from the bottom of the ditch, by 212 rounds of the 16-pounders, or 53 rounds per gun. It was then decided to form five vertical sections, at intervals of five yards apart, so as to cut the revetement into four equal parts; and as there were only four guns employed, the two sections to the right and left were commenced first, leaving the centre section for the last. The fire was directed from below upwards, taking care to cut through the lower part completely, before beginning upon the upper, for fear of choking the lower part with rubbish from above, which would afterwards impede the effect of the shot. After ten rounds the revetment to the left of the breach fell, *en masse*, into the ditch, carrying with it the untouched mass, eleven yards in length, of the centre; and seven rounds more, from one gun, was sufficient to bring down the rest of the masonry, and form a breach twenty-five yards wide. The time occupied in forming this breach was five hours thirty-seven minutes; and as the mass of masonry amounted to two hundred and fourteen cubic yards, it follows that a cube yard of masonry was destroyed in little more than one minute and a half.

The breach thus formed was still very steep towards the top, where it was supported by the counter-forts, and it required twenty-six more rounds to complete their destruction, and to render the breach practicable. The breach was formed by the 24-pounders, in a similar manner to that described above, only the first shots were fired at a distance of 4 feet from each other, and the horizontal section was thus made after thirty-four rounds per gun. Four vertical sections only were made, dividing the breach in three parts, one eleven yards in length to the right, and two others of five yards and a half to the left, and after nine rounds per gun, the revetement fell into the ditch, bringing with it a large portion of the earth of the parapet; three rounds more, however, from the two guns to right and left were necessary to bring down a portion of masonry which still adhered to the standing portion of the revetement. The breach thus formed was twenty-four yards wide, and the time occupied in forming it four hours three minutes. The mass of masonry destroyed was two hundred and five cubic yards, which corresponds to the destruction of a cubic yard in about one minute and a quarter. In comparing the results of the two operations, we find that the times are about in the inverse ratio of the calibres, and the expenditure of powder and shot is about equal in both cases.

The counter-forts still supported the earth in a steep slope at the top of the breach, and it required thirty-eight rounds to render it practicable, and even then the parapet had a mean thickness of 11 feet 6 inches in both breaches after the destruction of the masonry. Eight-inch howitzers were employed with different charges, for the purpose of cutting away the parapets. With a charge of 2lb. the shells did not penetrate far enough into the ground to be of any service, and their explosion taking effect towards the exterior, was more dangerous to the besieger than the besieged: with charges of 2lb. 10oz. and 4lb. the penetration was about one yard, and 5lbs. of bursting powder, produced a great effect in bringing down the earth of the parapet: with a charge of 5lb. it often happened that the fuze was broken off close to the shell, before the composition had time to burn below the point of rupture, so that in these cases the shell did not explode.

Some 5-inch shells were fired from the 24-pounders, but their effect was very trifling; they could not be fired with a larger charge than $1\frac{1}{4}$lb. without the risk of breaking to pieces against the sand and gravel of the parapet, and with this charge their penetration was so small as not to produce any sensible effect.

The general rules on the subject of forming breaches by cannon, as deduced from a comparison of the above experiments, with those adduced by Vauban, Gassendi, and others, are as follows:

1st. With regard to the position of the battery. This is generally determined by the nature and position of the work to be breached; but as a general rule, a sufficient distance should be left between the breach and the salient of the work, to allow space for the lodgment, and to render it unnecessary to cut away the salient angle itself. It is advisable therefore to advance towards the gorge of the ravelin, or the shoulder of the bastion, so as to fulfil this object, without however interfering with the descent into the ditch, or exposing the battery to a close and plunging fire.

To determine whether the battery shall be placed in the covered way, or in the lodgment on the crest of the glacis, a section must be made, showing as correctly as possible the height of the escarp, breadth of ditch, &c.; and then deciding at what height from the bottom of the ditch it will be necessary to cut through the escarp, in order to ensure a practicable breach. By the experiments before detailed, it is plain that the breach would have been perfectly practicable had the horizontal section been made at half the height of the escarp, but it was thought better to begin at about one-third from the bottom of the ditch: the height of the escarp was here only 20 feet, and as this height cannot be said to secure a place from escalade, and as the breach was perfectly practicable, though commenced at 6 feet from the bottom of the escarp, it may be laid down as a rule, that the horizontal section should never be commenced nearer than 6 feet to the bottom of the ditch. This is contrary to Vauban's opinion, who says that it should be made at 2, 3, 4, 5, or at most 6 feet; and to Bousmard, who says it should be made as low as possible.

Having fixed the point at which it will be proper to make the horizontal section of the escarp, it will be easy to decide whether the battery should be placed in the lodgment, or in the covered way: it is hardly necessary to add, that wherever it is possible, it should be placed in the former. The mode of making the horizontal section before detailed, seems preferable to that prescribed by Vauban, who recommends that the fire of all the guns should be concentrated upon particular points, and continued until the masonry be completely cut through. As to the fire by salvos recommended by Bousmard, it was found in the first place to be impracticable, as whatever attention was paid both to priming the guns and firing by word of command, some delay always took place between the fire of different guns, even when they were all collected in battery close to each other; much more therefore must this be the case on service where, generally speaking, the guns are placed in pairs, each pair being separated by a traverse. Should it even be found practicable to fire in salvos, the vibration in masonry extends to so small a distance from the point struck, that the effect produced by the shock of shot striking the wall simultaneously, at distances of 3 or 4 yards from each other, would not differ from that produced by consecutive blows.*

2nd. With regard to the vertical sections, it appears from the experiment, that

* A breach was formed at Ehrenbreitstein by a battery of four 24-pounders, firing with a charge of 10 lbs. of powder, at a distance of 40 yards. The scarp was formed of a badly cemented wall of greywacke; the guns were fired in salvos at every second round; and at the 43rd round the breach was considered practicable.

an interval of 30 feet may be left between them; Bousmard recommends but two, one at each extremity of the breach. As a general rule, however, it appears advisable to form as many vertical sections as there are guns in battery; taking care that the two extremes, which determine the length of the breach, should be made if any thing quicker than the intermediate sections.

The authors who have written on the subject of the attack of fortresses, differ materially in their statements of the time required for the formation of a breach. Gassendi, in the Aide Memoire, allows four or five days, and three days more to render it practicable after the fall of the revetement; Bousmard gives 36 hours. The experiments above detailed seem to show that this is far beyond what is necessary, as the 16-pounders formed a breach in 5 hours 37 minutes, and the 24-pounders in 4 hours 3 minutes, after which about 50 minutes more were required to destroy the counterforts, and forty 8-inch shells after that rendered the breach completely practicable. If we allow then two hours as the time necessary for removing the guns, and substituting howitzers in their place, the assault may be given within four hours after the fall of the revetement; so that the whole operation would require with the 16-pounders, 9½ hours, and with the 24-pounders, 8 hours.

The third breach which was formed by the mine, was about the same size as those formed by the batteries: it required 306 hours labour, and was charged with 1544 lbs. of powder in five chambers: viz. two at the tail of the counter-forts to the right and left of the breach, with a charge of 464 lbs. in each; two in the intermediate counter-forts, charged with 200 lbs. each; and one in the earth in rear of the breach with a charge of 216 lbs. The explosion of these mines threw the masonry in large blocks into the ditch, but these were not covered with earth, and the breach, although practicable, was difficult of access. There were five blocks of masonry of more than one cubic yard, two of more than two cubic yards, three of more than three cubic yards, and two lying contiguous to each other, one of eight, and the other of six and a half cubic yards.

W. D.

Report of Experiments carried on at Woolwich, in the Year 1822, against Carnot's detached Revetement.

In the summer of 1822, the Duke of Wellington being Master-General of the Ordnance, it was determined to make experiments on the possibility of breaching walls protected by earthen counter-guards, as proposed by Carnot, in his system of defence, by firing over the crests of such counter-guards.

It was first desirable to ascertain the smallest elevation which shot could be fired, if it were practicable to throw shot at all, which clearing the counter-guard, should fall sufficiently in their flight between it and the wall, to strike the latter low enough to open a practicable breach, and what charge and elevation were most suitable for this purpose; and next it was to be determined, whether shot so thrown had sufficient momentum to ruin masonry.

Experiments were accordingly made with the first object, in twenty-eight days, between August 2nd and September 24th, 1822, by firing over a bank of earth, 66 feet long, and in section similar to the upper part of Carnot's counter-guard, having its crest 12 feet above the level of the experimenting batteries. The distances from the top at which the different shot would have struck the wall, were known by the height at which they struck a bank of earth thrown up at the proper distance (60 feet), in rear of the counter-guard; and, for those which struck the ground between the two mounds, by measuring the distance from the foot of that in rear, and all which were stated to strike lower than 12 feet, were therefore thus obtained.

The two first days' practice were considered as preliminary: from the results of the others it was decided, that with elevations of 10° and 11°, it was not possible to strike the wall lower than 16 feet from the top; that only 2-7ths of the shot and shells so fired would take effect upon the wall at all; and of those that did, only about 1-28th at more than 12 feet from its top, or 1-97th of the whole numbers fired. This opinion was formed after 487 rounds from different descriptions of heavy ordnance had been fired, at ranges of 400 and 500 yards, with elevations not exceeding $11\frac{1}{2}$°.

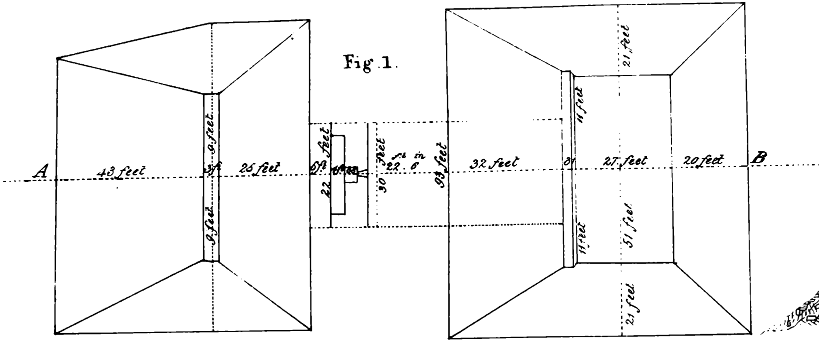
Four hundred and eighty rounds, at similar ranges, were fired at elevations of 15°, and it appeared that between 2-7ths and 3-8ths would have taken effect, of which 3-7ths, or 1-6th of the whole number of rounds, would have struck the wall lower than 12 feet from its top. The details are given in the following table:—

Results of Experimental Practice made at Woolwich in August and September 1822, to ascertain whether it would be practicable to fire Shot over Carnot's Counter-guard, and strike the Wall in rear low enough to open a Breach.

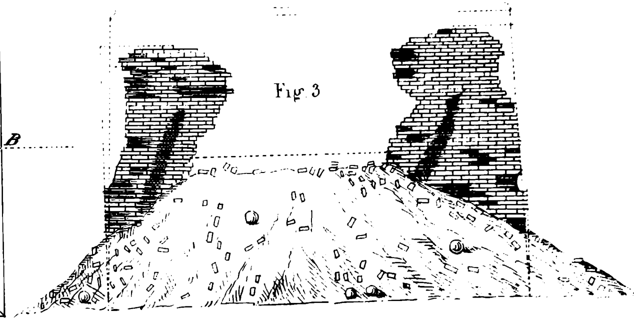
Days of Practice.	Date.	Nature of Ordnance.	Range.	Charge.	Elevation.	No. of Rounds.	Shot or Shells struck the Wall from Top, at 1 to 2 feet.	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	20 to 22	1 to 12	12 to 22	Total.	Proportion. Of Rounds which struck the wall.	Of those striking the Walls that struck below 12 Feet.	Of the whole Number of Rounds fired that struck below 12 Feet.
				lb. oz																			
3rd	Aug. 7	24-pounder iron 9 ft.	400 yards.	0 12	10	37	2	5	..	1	..	..	..	..	..	..	..	8	..	8	more 1-5th		
5th	9	do. do.		1 0	9¾	30	3	2	1	..	4	1	..	..	..	..	..	11	..	11	more 1-3rd		
9th	16	68 carronade wt. shot		1 0	9¼	30	4	2	1	2	1	2	..	..	..	..	..	12	..	12	2-5ths		
		do. do.		1 0	9¼	20	..	2	4	..	2	2	..	..	..	..	..	10	..	10	1-half		
10th	19	do. do.		1 4	7½	30	..	2	..	6	..	2	..	..	..	..	..	10	..	10	1-3rd		
		do. do.		0 14	11½	20	1	..	..	..	..	3	..	1	..	..	..	4	1	5	1-4th		
21st	Sept. 4	do. do.		1 0	9¼	40	..	2	4	2	..	1	..	..	..	..	..	9	..	9	near 1-4th		
26th	Aug. 27	8-inch iron howitzer		1 6	10	40	3	2	1	1	2	1	..	..	..	..	..	10	..	10	1-4th		
		Total—not exceeding 11½° elevation at 400 yds. range	400	..	..	247	13	17	11	12	9	12	..	1	..	..	..	74	1	75	more 3-10ths	1-75th	
4th	Aug. 8	24-pounder iron 9 ft.	500 yards.	0 9	10¾	40	2	..	1	2	..	1	1	..	..	..	..	6	1	7	more 1-4th		
6th	Aug. 12	8-inch iron howitzer		1 4	9½	40	..	2	..	1	1	2	..	..	..	..	..	6	..	6	more 1-7th		
7th	13	do. do		1 8	7½	20	1	..	..	..	1	..	..	..	..	..	..	2	..	2	1-10th		
		10-inch do.		2 0	10¼	30	2	1	2	1	2	2	1	..	..	..	..	10	1	11	more 1-3rd		
8th	14	do. do.		1 10	9½	30	3	1	3	3	2	1	..	..	..	..	..	13	..	13	more 2-5ths		
11th	20	68 carronade wt. shot		1 4	9	40	2	3	2	4	1	2	2	..	..	..	..	14	2	16	2-5ths		
15th	26	8-inch iron mortar		1 11	10	40	..	5	2	1	2	1	..	..	..	..	..	11	..	11	more 1-4th		
		Total—not exceeding 10¾° elevation at 500 yds. range	500	..	..	240	10	12	10	12	9	9	4	..	..	..	..	62	4	66	more 1-4th	1-16th	
		Total—not exceeding 11½° elevation	..	..	..	487	23	29	21	24	18	21	4	1	..	..	..	136	5	141	more 2-7ths	1-28th	1-97th
12th	Aug. 21	8-inch iron mort	400 yards.	1 0	15 elevation.	20	..	..	2	..	..	2	1	2	4	..	..	4	7	11	more 1-half		
13th	22	do. do.		1 0		40	1	2	..	2	..	1	2	1	1	2	..	6	6	12	3-10ths		
17th	28	8-inch iron howitzer		0 11		50	5	2	4	2	1	7	1	1	1	..	..	21	3	24	near 1-half		
22nd	Sept. 16	do. do.		0 11		30	1	..	2	3	1	..	2	1	2	..	1	7	6	13	more 2-5ths		
23rd	17	16-inch do.		1 3		30	..	..	1	1	1	2	1	3	2	..	2	5	8	13	more 2-5ths		
24th	18	do. do.		1 2		30	..	..	1	4	1	..	1	1	2	..	3	6	7	13	more 2-5ths		
20th	3	68-pdr. carron. wt. shot		0 11		40	3	1	3	4	..	2	1	..	2	..	..	13	3	16	2-5ths		
25th	19	do. do.		0 13		30	..	1	3	1	3	1	..	1	..	3	..	9	4	13	more 2-5ths		
		Total—at 15° elevation and 400 yards range	400	..	15	270	10	6	16	17	7	15	9	10	14	5	6	71	44	115	near 3-7ths	near 2-5ths	
14th	Aug. 23	8-inch iron mortar	500 yards.	1 5	15 elevation.	40	1	1	1	1	..	..	3	3	..	1	1	4	8	12	3-10ths		
18th	29	8-inch iron howitzer		0 14		40	..	..	2	1	4	1	3	1	..	..	..	8	4	12	3-10ths		
28th	Sept. 24	do. do.		0 14		30	1	..	..	..	1	..	..	..	2	..	1	2	3	5	1-6th		
27th	23	10-inch do.		1 8		30	2	..	..	..	2	3	2	1	2	1	1	7	7	14	near 1-half		
19th	2	68-pr. carronade shot		0 13		40	1	1	..	2	..	2	3	2	2	1	..	6	8	14	more 1-3rd		
26th	20	do. do.		1 0		30	1	1	1	1	1	1	..	..	..	..	1	6	1	7	near 1-4th		
		Total—at 15° elevation and 500 yards range	500	..	15	210	6	3	4	5	8	7	11	7	6	3	4	33	31	64	more 3-10ths	near 1 half	
		Total at 15° elevation	..	..	..	480	16	9	20	22	15	22	20	17	20	8	10	104	75	179	near 3-8ths	near 3-7ths	5-32ds
		Total.............	..	..	..	967	39	38	41	46	33	43	24	18	20	8	10	240	80	320	about 1-3rd		

DRAWINGS *to illustrate the* **PRACTICE** *against* **CARNOT'S WALL.**
carried on at **WOOLWICH** *by order of His* **GRACE** *the* **MASTER GENERAL** *in Aug^t 1824*

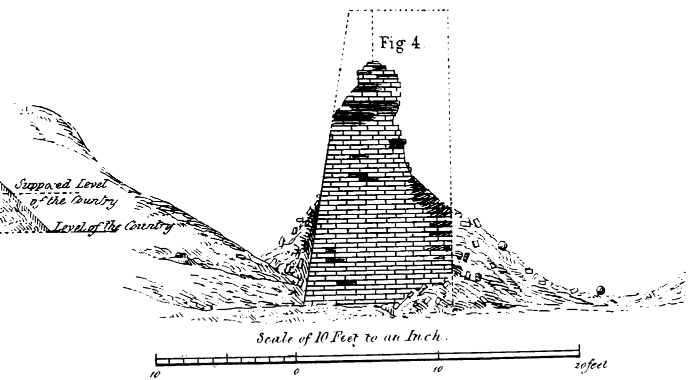
PLAN of the RAMPART, WALL, and COUNTERGUARD.



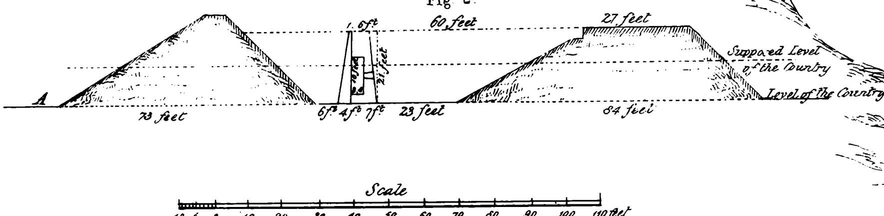
Front View of the Wall showing the effect of the 1^st & 2^nd days fire



Side View of the Wall after the Second Day's fire.



Section on the line. A. B.



The two first days being considered preliminary, their practice is not included in the preceding table.

Of the foregoing 967 rounds, only 144 fell short; and of the 503 rounds remaining unaccounted for, it was considered that all except 37 would have struck the bastion in rear of the wall, if, according to the arrangement of Carnot's system, such work had been constructed there.

The foregoing experiments having proved that shot or shells could be fired at angles of 15°, so as to strike the wall, even at its foot, it remained to be determined whether, when so fired, their momentum was sufficient to breach it, the small charges necessarily used to attain the first object rendering this doubtful.

A portion, 30 feet in length at bottom and 28 at top, of a wall corresponding to that proposed by Carnot, was accordingly built with bricks in the summer of 1823. It was 21 feet high, 6 feet thick at top, 7 at bottom, and had one loop-hole in a recess; to support which, in continuation, it was strengthened by a buttress 4 feet square at each end, the whole carefully built, and well cemented. An earthen counter-guard was thrown up in front, and a mound in rear, the former being at the distance, and having the same section, as that proposed by Carnot, the latter represented his bastion, being at the same distance, but was only carried up 4 feet higher than the wall, and was therefore 8 feet lower than that proposed by him.

On the 5th of August, 1824, a year after the completion of the wall, eight 68-pounder carronades, in battery 500 yards from the crest of the counter-guard, three 8-inch and three 10-inch iron howitzers, at a distance of 400 yards, in all 14 pieces, fired 100 rounds each in about six hours, the howitzers firing live shells filled with powder, and the carronades solid shot.

A practicable breach, 14 feet in width, was made by their fire, and the buttresses were much injured.—*Fig.* 3 and 4, *plate* 1.

The splinters of the shells proving inconvenient to the men in the nearer battery, the loading of the shells was diminished.

On the 6th August the firing recommenced from eight 68-pounder carronades, at 500 yards; two 8-inch iron howitzers, and four 10 inch ditto, at 400 yards: 50 rounds per piece were fired in two hours, when the breach was examined, and found to be complete in every respect, and the buttresses to be in the ruinous state shown by the darker shade of *fig.* 3, and also by *fig.* 4, *plate* 1.

On the 5th and 6th August, two of the 8 and two of the 10-inch howitzers, and four of the carronades, had been placed on high traversing platforms, so as to raise them nearly to the natural level of the country, according to Carnot's system; but his Grace the Master-General, who examined the breach at this period, having given directions that all the ordnance should be placed on common platforms, the use of the traversing platforms was discontinued. It had previously been observed, that no advantage or superior accuracy of fire attended raising the guns.

His Grace also ordered that the rubbish should be cleared from the breach; and it was found that the wall was about 5 feet in perpendicular height in front, with a rounding of rubbish of about $2\frac{1}{2}$ or 3 feet on the top, and about $8\frac{1}{2}$ or 9 feet in height towards the rear.—*Fig*. 5, *plate* 2.

On the 11th August the batteries recommenced their fire from eight 68-pounder carronades at 500 yards, and six 10-inch howitzers at 400 yards, when 85 rounds from each howitzer, and 100 from each carronade, were fired in three hours and a half, by which time the wall and buttresses were one mass of ruin. —*Fig*. 6 and 7, *plate* 2.

The charge of the shells had been so much reduced, to avoid splinters reaching the batteries, that a considerable number did not burst.

From careful observation, it appeared that about one-fourth of the shells and one-fifth of the shot struck the wall.

The increased rapidity of the fire is remarkable, that of the third day being nearly double that of the first, although the reduction in the height of the wall, from 21 to 5 feet, rendered the operation obviously more difficult. A sketch of the counter-guard, *fig*. 2, shows the effect of the shells on its superior slope.

NOTE FROM JONES'S "JOURNAL OF SIEGES."

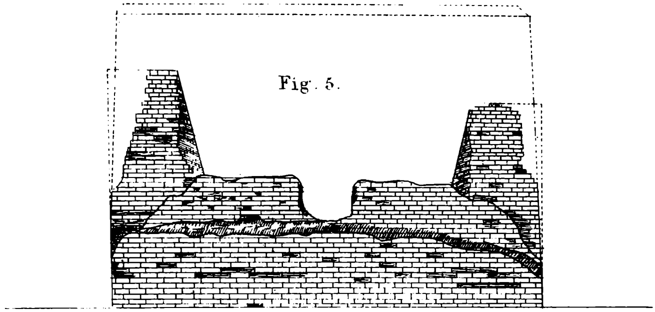
Circumstances will sometimes occur, that a place may be taken, by forming a breach from distant batteries, where neither time or means will admit of a more matured operation. Such, for instance, were the captures of Monte Video and Ciudad Rodrigo; and it is to be hoped, that whenever such chances again offer, similar enterprise on the part of the British commanders will induce similar chivalrous attempts, and be crowned with similar success. Therefore it may be useful to endeavour to form some rough calculation, from the experience of these sieges, of the time required to form a breach of given dimensions, with given means, from given distances.

DRAWINGS *to illustrate the* PRACTICE *against* CARNOT'S WALL,

Carried on at WOOLWICH *by order of His* GRACE *the* MASTER GENERAL *in Augt 1824.*

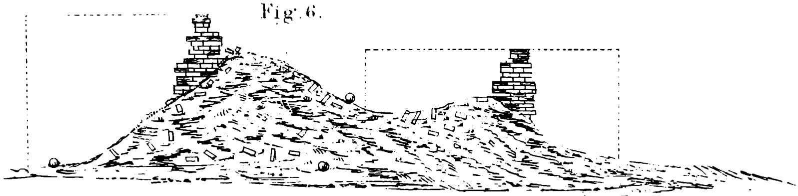
Front View of the WALL when the rubbish was cleared away from the BREACH after the Second days fire

Fig. 5.



Front View of the WALL after the third & last days fire

Fig. 6.

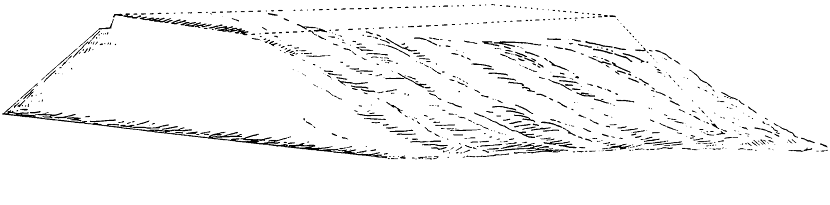


Side View of the WALL after the third days fire.

Fig. 7.

General View of the Counterguard in front of the WALL after the last days fire.

Fig. 8.



Dean & Munday Lith.

Referring to the Journals we obtain the following facts :

	Sieges.	Measurement of Breach thoroughly accessible.	No. of Shot fired.	Distances of Battery from Breach.	
1812.	Christoval	15 Feet	1600	450 Yards.	
	Badajos, principal breach	180	14,000	540	
	Ditto flank breached	100	9500	530	Wall casemated.
	Ditto curtain	40	3000	545	Bad masonry.
	Ciudad Rodrigo, principal breach	105	6700	560	
	Ditto lesser breach	30	2080	570	Bad masonry.
1813, July.	St. Sebastian, principal breach	100	13,000	620	Average distance of batteries.
	Ditto lesser breach	30	5000	620	Ditto.
August.	Ditto addition to breaches	330	41,000	520	Ditto.
		930	95,880	4955	

Taking the average of these nine operations, we find that a breach of 103 feet (being an opening sufficiently great to warrant an assault) can be made practicable by the expenditure of 10,653 shot from the distance of 550 yards. Now, assuming the rate of firing at 20 rounds per hour, that expenditure will occupy 532 hours firing of a single gun, or 35 hours firing of a battery of 15 guns, which number is selected as being about the average force of the batteries at the above operations.

This calculation being assumed as correct, to find the time required for making a breach from the same distance, with any other number of guns, becomes merely a simple rule of proportion ; it being however observed, that some addition to the periods must be made when the guns are fewer, and some deduction when they are greater, it being invariably found in breaching, that the more numerous the engines employed, the greater is their proportional effect. The above calculated periods for forming breaches may be much abridged, by the free use of 10-inch shells filled with powder, to be lodged in the clay behind the wall, as soon as the masonry gives way.

The effect of shot fired for this purpose was observed to be very inconsiderable, many of them serving apparently only to ram the clay more firmly ; while the shells from the garrison, which fell into the parapet of the trenches, frequently in their explosion blew away a considerable portion of the parapet, or made large and deep holes in the solid ground.

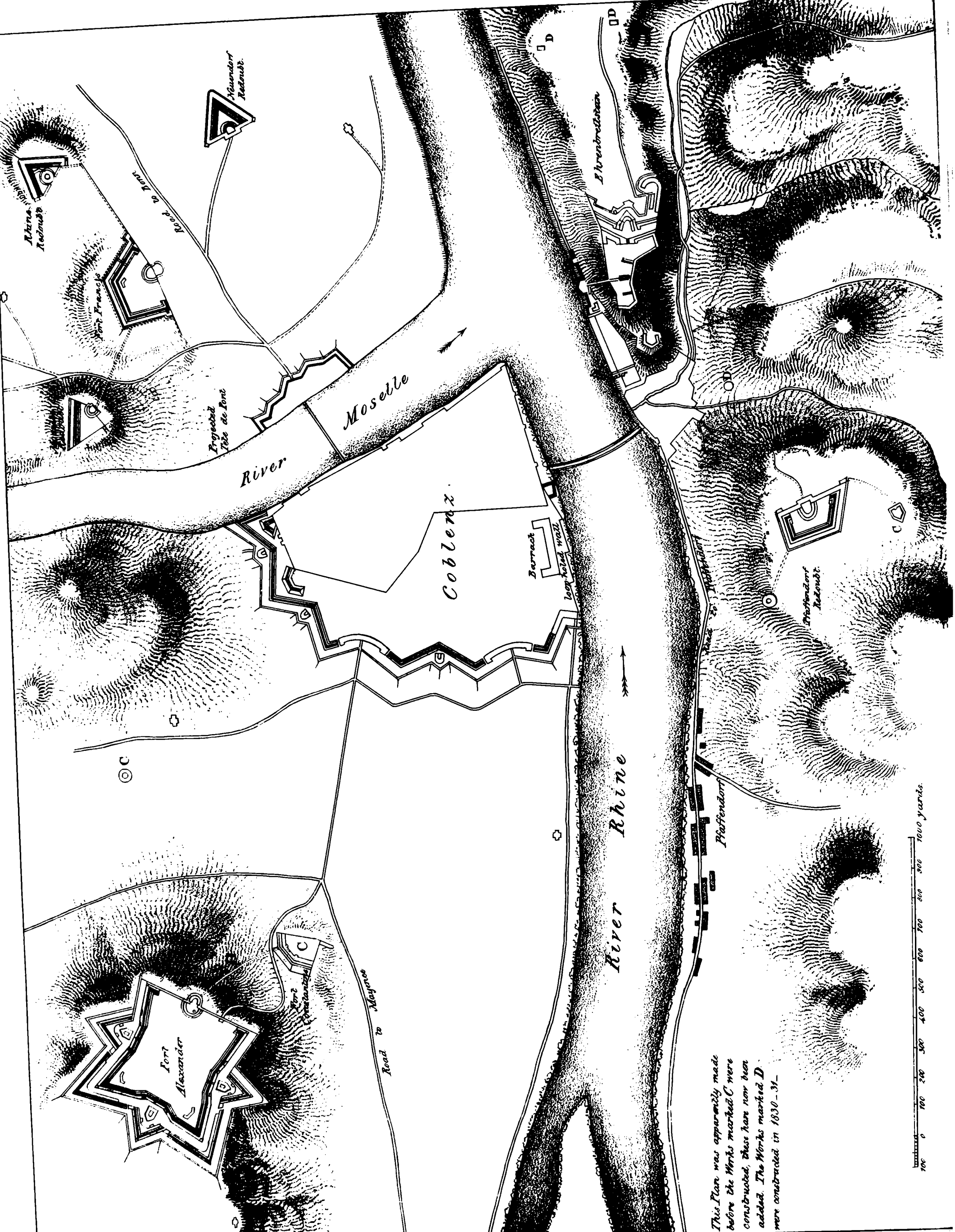
It may not be without its use to observe, that the quantity of ammunition necessary for forming a breach in the ordinary defensive walls of Spain and other southern countries, is far greater than in those of northern countries, as the cement used in their construction, after a few years, attains a solidity surpassing that of the stones which it unites ; and the consequences are, that walls built with moderate sized, or rather with small rough stones well bedded, and their interstices well filled up with mortar, become so completely one body, and so incapable of being split into large pieces, that they can only be brought down from distant batteries by being literally pounded into small particles. It would not perhaps be too much to assume, that double the means would be required to breach such a wall, over those necessary to breach the ordinary brick revetements of France and Flanders.

From the foregoing papers it appears, that a breach about 100 feet wide may be rendered practicable by batteries at a distance of 500 yards, by the expenditure of about 10,600 24 lb. shot, firing with a full charge. That from about the same distance it requires 5600 68 lb. shot, and 4200 8 and 10-inch shells, fired à ricochet, to make a breach of the same width, when the scarp is covered by a counter-guard, as proposed by Carnot: and that from a battery placed on the crest of the glacis, about 310 24 lb. shot, and 30 or 40 8-inch shells, will produce the same effect. The weight of shot therefore expended in forming a breach under these different circumstances will be as below.

Distance.	Fire.	No. of Shot.	No. of Shells.	Total Weight of Iron.
Yards.				
500	Direct	10,600	....	254,400
500	Ricochet	5,600	4,200	660,100
50	Direct	310	40	9,040

The disproportion between the direct and ricochet fire would have been more glaring still, had guns of the same calibre been used on both occasions, for the effect of one 68 lb. shot would be far greater than that of the three 24 lb. shot, fired at the same angle, and the 8 and 10-inch shells used in the ricochet practice were probably more effective than shot of the same weight.

W. D.



River Moselle
Coblenz
River Rhine
Ehrenbreitstein
Fort Alexander
Fort Constantine
Fort Francis
Neuendorf Redoubt
Road to Bonn
Road to Mayence
Projected Tête de Pont
Barrack
Loopholed wall
Pfaffendorf
Pfaffendorf Redoubt
1000 yards
This Plan was apparently made before the Works marked C were constructed, these have now been added. The Works marked D were constructed in 1830-31_

VIII.—*Memoir on the Fortifications in Western Germany, compiled from various sources.*

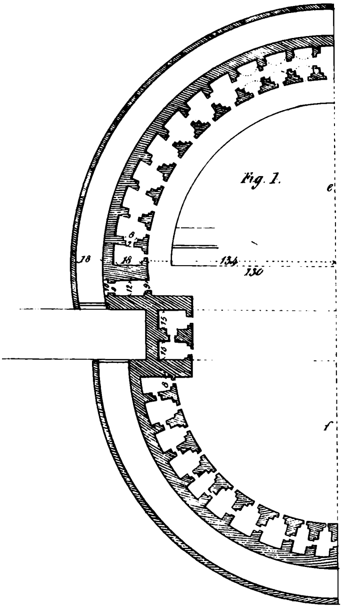
Observations on the German Frontier of the Rhine.

THE States of Germany having entered into arrangements for the further security of the Frontiers of the Rhine; Cologne, Coblenz, and Mayence, have been strengthened, that they might be always available as centres of operations, and as grand military depôts. It was contemplated, that the country in front of this line would be covered to the north by the Belgian fortresses (having Juliers in their rear), and by the very rugged territory of Luxembourg, which town is still occupied by a Prussian garrison. To the south, the defence of the river Saar has been improved, particularly at Saar Louis and Saar Bruck, from whence the country is full of defiles to Landau, on the Queich. This river crosses the plain to Germersheim on the Rhine, at which point there are to be strong fortifications.

As the French hold one side of the Rhine to some distance below Strasbourg, the tête-de-pont of Germersheim would be very formidable to any advance they might make on the right bank; and to prevent their advance into Germany by the defiles of the Black Forest, very extensive works are to be constructed at Ulm on the Danube, which would be then available as a military depôt and centre of operations. The French contributions of 1815 are devoted to these arrangements; but the Prussian proportion has been made over entirely to that government: the expenditure of the remainder is regulated by the Diet at Francfort, to whom there is a committee of engineers attached. As yet the Diet have only expended the interest of this money, but the Prussians have laid out much larger sums.

Coblenz.—Coblenz contains about 12,000 inhabitants. The new enceinte being much larger than the old, there is a considerable vacant space, part of

Tower Redoubt.
at the Gorge of Fort Alexander.



Scale to Fig. 1. 90 feet to 1 inch.

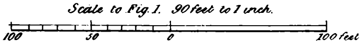


Fig. 2.
Redoubt in the main Ditch

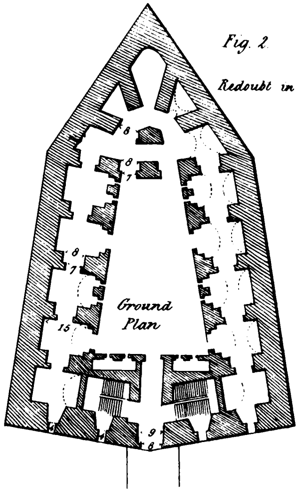


Fig. 3.
Elevation of the Gorge.

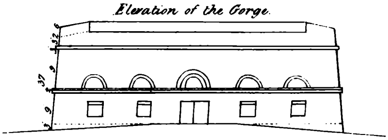
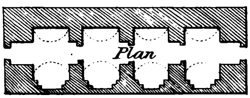
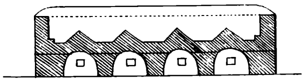


Fig. 5.
Flanking Battery.
for the Ditch of the Ravelin.



Longitudinal Section. Fig. 6.



Interior Elevation. Fig. 7.

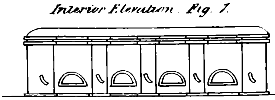
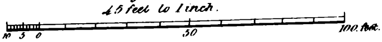


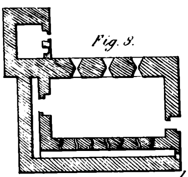
Fig. 4.
Mortar Battery
at the Saliants.

Scale to Figs 2. 3. 4. 5. 6. 7. 8. & 9.
45 feet to 1 inch.



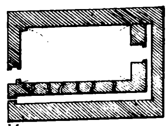
Powder Magazines.

Fig. 8.



Left.

Fig. 9.



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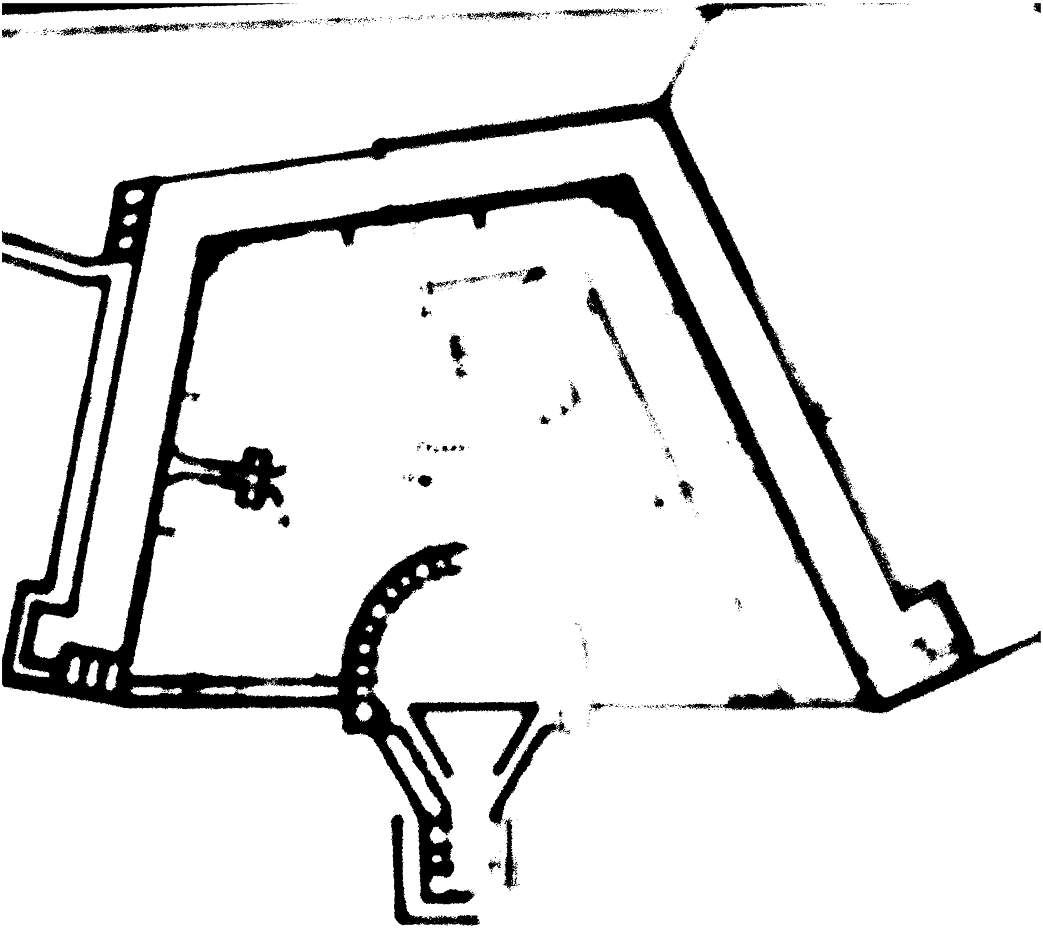


secure the passage of the main ditch, which has a flank of two tiers of five guns each.

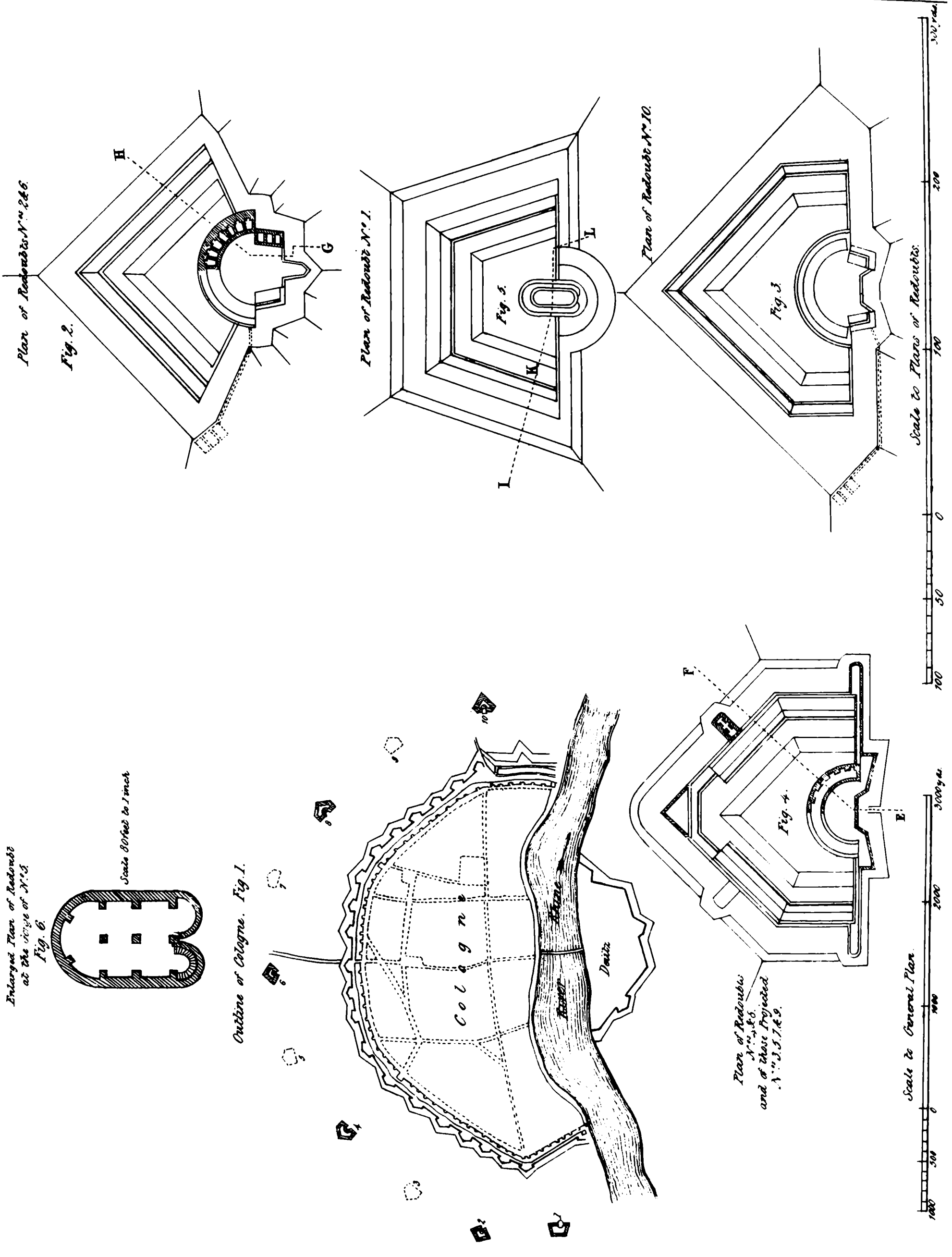
There is a good glacis in front; but the steep ground on the sides and rear is only protected by the guns of the town, and by those of the adjoining works of Fort Constantine (of which the projecting part has two tiers of embrasures), and a tower of Montalembert's projection, but apparently smaller than the diameter of 75 feet, as recommended. A subterraneous passage between Forts Alexander and Constantine was completed in 1830.

Enceinte of the Town.—The town forms a centre for the support of the surrounding works, and is secure from a coup-de-main. The rampart, having obtuse angles, is little subject to enfilade, and the Carnot escarp is well covered: but the town, being commanded from the sites of the works, would be greatly exposed after their loss to an enemy's fire. It appears, that even now, an attempt might be made to annoy the town from the Pfaffendorfer-height, by an enemy strong enough to resist the sorties of the garrison.

Fort Franz, plate 4.—Fort Franz, and the smaller outworks between the Rhine and the Moselle, being commanded (with the ground in their rear) by Ehrenbreitstein, have been constructed on a less expensive scale than the works on the heights. They have a good command of the ground in front, and the tête-de-pont will give greater security to their communication with the town.

General Observations.—The commanding situation and height of Ehrenbreitstein gave it great advantages, which have been ably increased by the formidable works now completed. By its immense quantity of casemated fire, directed towards the heights, on the right bank of the Rhine, an attack on that side with the usual means would be hopeless: the other parts of its enceinte have been also strengthened, although the old works were considered to be too strong to reduce by force. Fort Alexander gives also a great degree of strength to the opposite side of the town; and the other outworks, having casemated keeps, are considered to be equal to resist the attacks of an enemy for a considerable time, when there is only the usual garrison in the place. But these works, being on the summits of eminences, would also afford shelter for troops drawn up close in their rear, and cover the communications to the town; they therefore, when the garrison is large, become fortified positions, affording great facilities to their offensive operations, and allowing the whole disposable force to be brought (in the event of a regular attack on a work) on either flank of the trenches.

These arrangements are principally attributed to General Von Aster, who


Plan of Redoubts Nos 2 & 6.
Fig. 2.
H
G
Plan of Redoubt No. 1.
Fig. 5.
L
K
L
Plan of Redoubt No. 10.
Fig. 3.
Scale to Plans of Redoubts.
300 yds.
200
100
0
50
100
Enlarged Plan of Redoubt at the Gorge of No. 5.
Fig. 6.
Scale 80 feet to 1 inch
Outline of Cologne. Fig. 1.
Cologne
Rhine
Deutz
1
2
3
4
5
6
7
8
9
10
F
E
Fig. 4.
Plan of Redoubts Nos 4 & 8.
and of those Projected Nos 3, 5, 7 & 9.
Scale to General Plan.
3000 yds.
2000
1000
0
500
1000

which is now laid out in streets; but that near the river is reserved for military purposes. The garrison generally amounts to 11,000 men.

Strangers are at present restricted from seeing any of the works with the exception of Ehrenbreitstein; but this order is now of little use, as the details are generally known to the engineers of other countries. It is indeed well ascertained, that three French officers worked at them as masons for several months. Plans of Coblenz were obtained from three foreign officers; they differed in some of the minor points, but the most accurate is shown in *plate* 1.

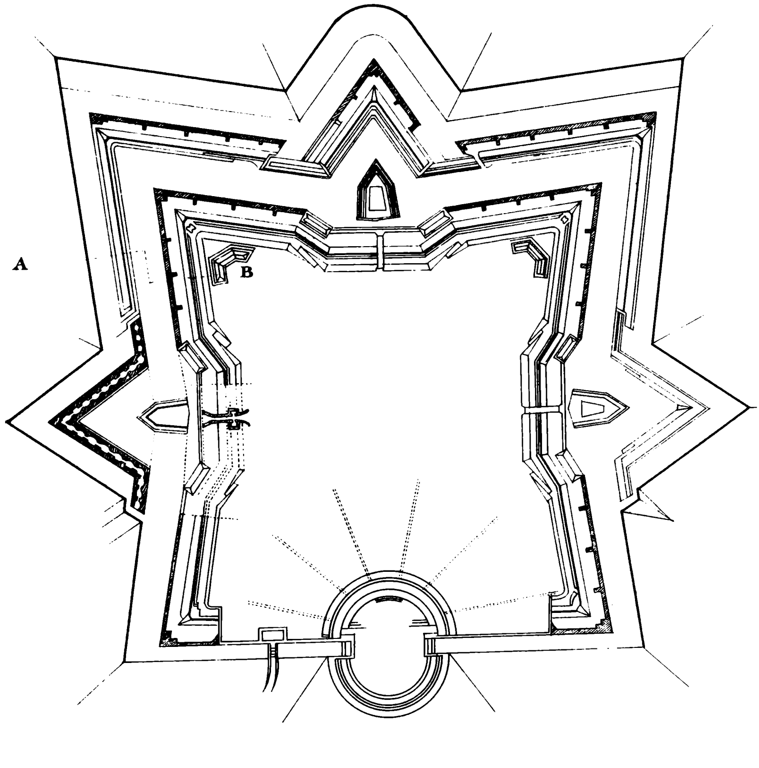
It is to be observed, that foreign officers take a degree of interest in new fortifications and military projects, not generally felt in this country; and although they are not disposed to give any information respecting their own works, yet as to those of other powers they are far less reserved. A more accurate knowledge of places may be generally thus acquired, than by endeavouring to procure the details by personal observation. The following information has been principally obtained by the exchange of memoranda on such subjects.

Ehrenbreitstein.—The castle of Ehrenbreitstein, called also the Fort of Frederick William, has been reconstructed since 1815. The casemates are fully equal to contain the men, provisions, and stores required for the most protracted defence. They also protect the head and machinery of the inclined plane, communicating with the work below, in which there is a harbour for barges. They contain a double tier of embrasures on the side opposite to the Rhine, commanding the heights of Azimeer: the narrow glacis in front is countermined, and the two advanced works are also said to be so. The escarps, in every part of the enceinte, appear to be at least 35 feet high, except where the rock is precipitous.

Pfaffendorfer-height.—The Pfaffendorfer-height is occupied by a work resembling in its details that of Kaiser Franz (*plate* 4), and by two smaller redoubts. The oblong tower between this height and Ehrenbreitstein, which was constructed this year, to enfilade the valleys of the two small rivers, has two tiers of guns in its casemates, and its general construction appears to resemble that of edoubt, *fig.* 6. *plate* 5.

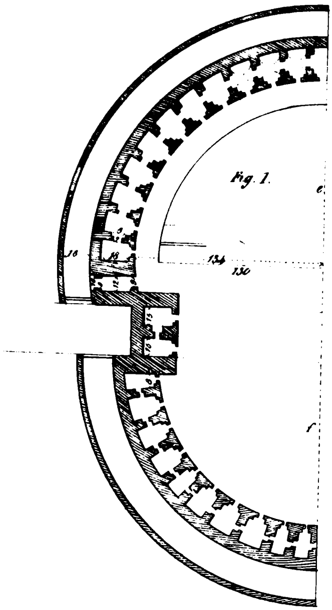
Fort Alexander, plate 2.—The outline of Fort Alexander is taken from the project of Montalembert, called the Fort Royal, but the details are more simple, and are adapted to the escarps of Carnot. It may be considered objectionable in this construction, that the counter-guards are only flanked by one tier of four guns: as, when this fire is overcome, they would afford places of lodgment to

Fort Alexander at Coblenz



Scale of English Yards.

Tower Redoubt
at the Gorge of Fort Alexander



Scale to Fig. 1. 90 feet to 1 inch.

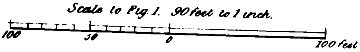


Fig. 2.

Redoubt in the main Ditch

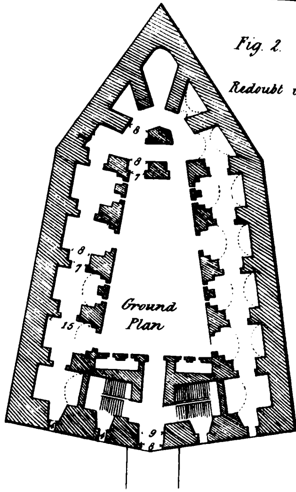


Fig. 3.
Elevation of the Gorge.

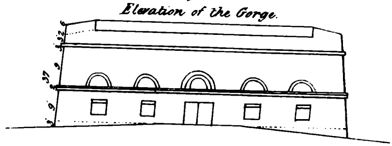
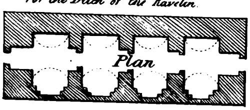
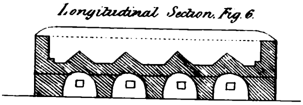


Fig. 5.
Flanking Battery
for the Ditch of the Ravelin.



Longitudinal Section. Fig. 6.



Interior Elevation Fig. 7.

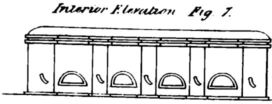
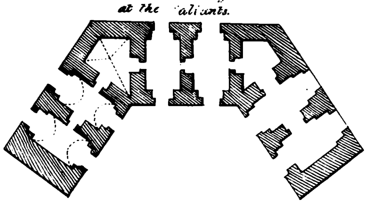
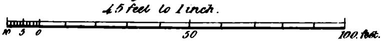


Fig. 4.
Mortar Battery
at the Saliants.



Scale to Figs. 2. 3. 4. 5. 6. 7. 8. & 9.
45 feet to 1 inch.



Powder Magazines.

Fig. 8.

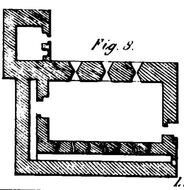


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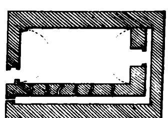
Fig. 9.



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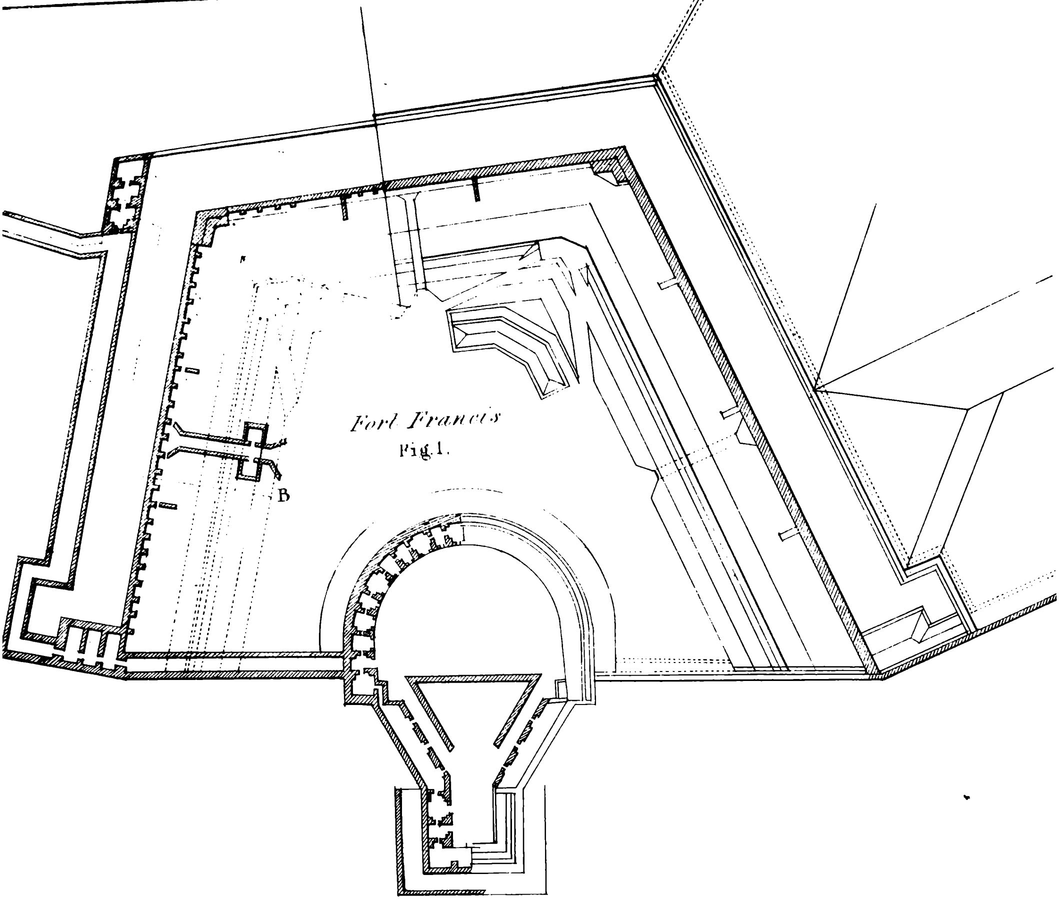


Scale to Plan, 120 Feet to one Inch.

Fig 2

Section on A.B. of Fort Alexander

Scale 45 Feet to one Inch.

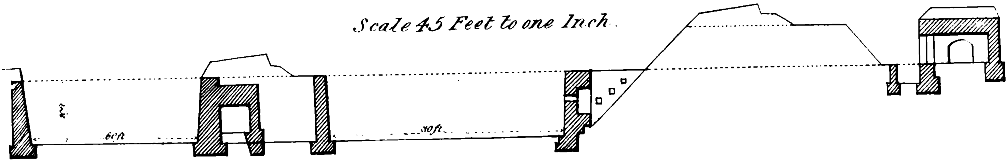
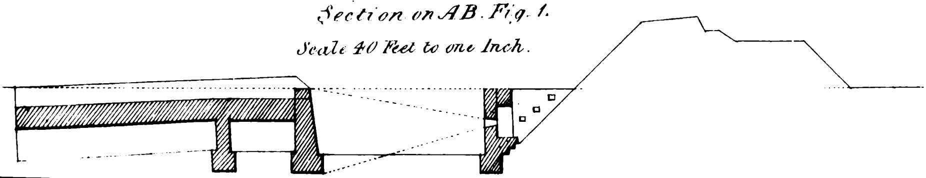


Fig 3.

Section on A.B. Fig. 1.

Scale 40 Feet to one Inch.



secure the passage of the main ditch, which has a flank of two tiers of five guns each.

There is a good glacis in front; but the steep ground on the sides and rear is only protected by the guns of the town, and by those of the adjoining works of Fort Constantine (of which the projecting part has two tiers of embrasures), and a tower of Montalembert's projection, but apparently smaller than the diameter of 75 feet, as recommended. A subterraneous passage between Forts Alexander and Constantine was completed in 1830.

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These arrangements are principally attributed to General Von Aster, who was much noticed by Napoleon, but has since entered the Prussian service. It is stated that the first project of securing the site of Fort Alexander, by a line of towers, was abandoned through his representations.

Cologne.—Cologne contains about 50,000 inhabitants. It is the seat of Government for the Prussian provinces of the Rhine, and the head-quarters of a division consisting of about 25,000 men.

Plate 6.—The works have been carried on since the war by small parts, as a regular annual expenditure. The old enceinte has been thus repaired, where ruinous, to make it available against an escalade. The alternate bastions of the earthwork in front have been strengthened by a casemated keep, having three guns in each flank, with a caponière communication across the intermediate ditch, and the whole line appears to be well kept up.

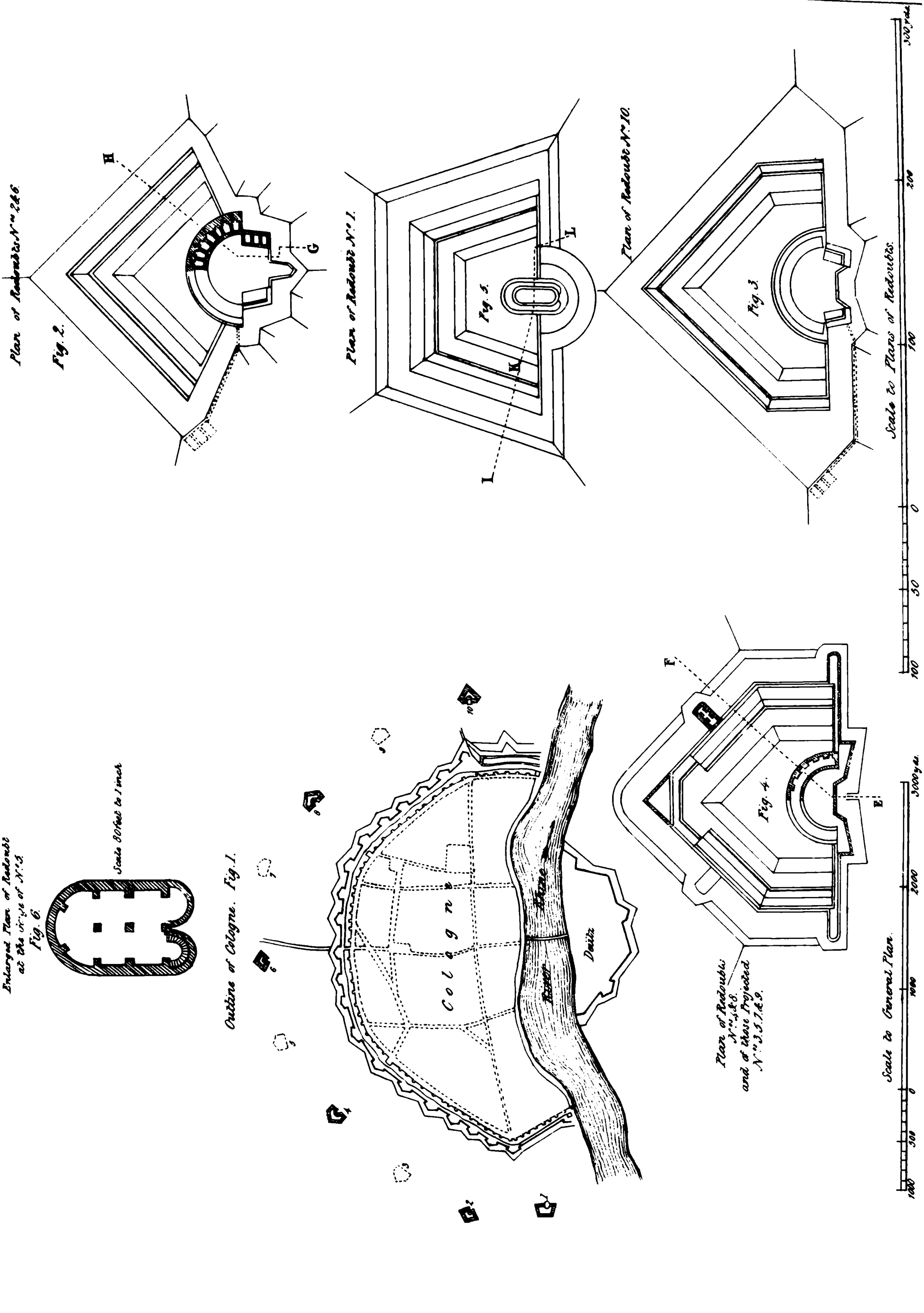
Plate 6.—The enceinte of Deütz has been altered from the old work, the alternate bastions having been strengthened by a casemated barrack across the gorge, and the rampart between formed into a plain salient angle.

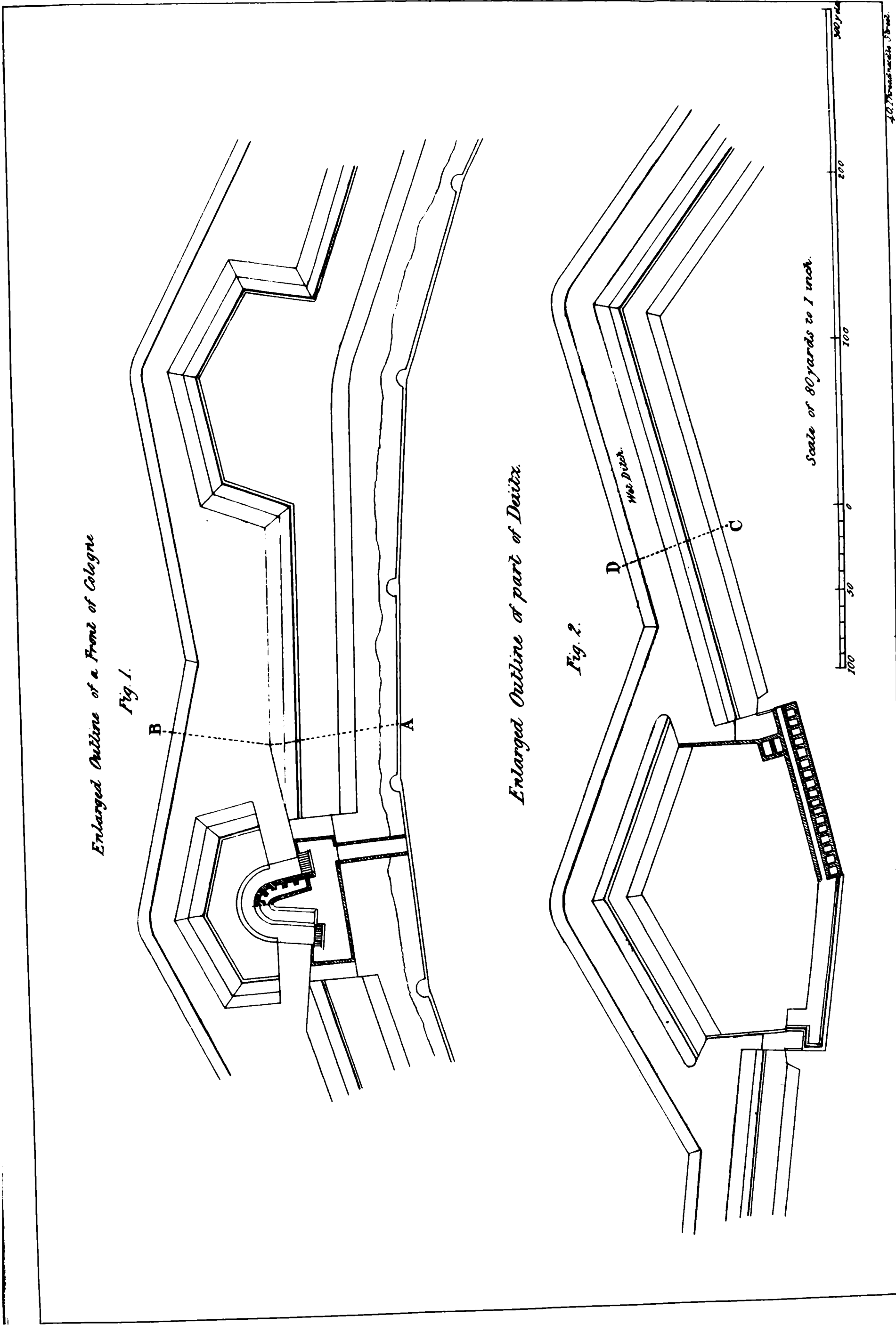
New Redoubts.—Redoubts have been projected since 1815, at the distance of about 600 yards from each other, forming a line about 500 yards in advance of the place. The following sketches have been collected, showing the gradual improvement that has taken place in this description of work, which, from a slight external inspection, appear to be generally correct.

Plate 5.—The redoubts first constructed are shown in *fig.* 2. They appear objectionable from the profile having been made so high (in order to secure the keep from distant fire) as to leave several feet of the escarp exposed, the earth from the ditch not being sufficient for the glacis, which remains incomplete: this defect has been in some degree concealed, by trees being thickly planted round the work. The sketch being erroneous in this point, probably shows the proposed remedy.

The details of a redoubt, constructed about a year or two subsequently, are shown in *fig.* 3. The profile is nearly as in the former redoubts; and, consequently, the sketch has a similar error to the last.

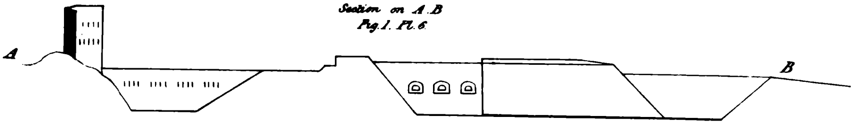
To redoubts of a yet later construction, the following general description will apply. It appears from the sketch, that the salient angle is enclosed by a Carnot wall, forming an area, from which a gallery descends to the counter-mines under the glacis: this area also protects three mortar casemates, which are directed on the capital. The caponière, which flanks the ditch, is also protected by the musketry fire of the Carnot wall (from which it projects), as also by the rampart;


Plan of Redoubts Nos 2 & 6
Fig. 2.
H
G
Plan of Redoubt No 1.
Fig. 5.
L
K
L
Plan of Redoubt No 10.
Fig. 3.
Scale to Plans of Redoubts.
300 yds
200
100
0
50
100
Enlarged Plan of Redoubt at the Gorge of No 5
Fig. 6.
Scale 80 feet to 1 inch
Outline of Cologne. Fig. 1.
Cologne
River Rhine
Deutz
Fig. 4.
F
E
Plan of Redoubts Nos 4 & 8. and of those Projected Nos 3, 5, 7 & 9.
Scale to General Plan.
3000 yds
2000
1000
0
500
1000

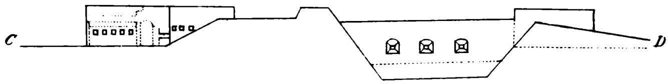


Dean & Munday, lith. 40 Threadneedle Street

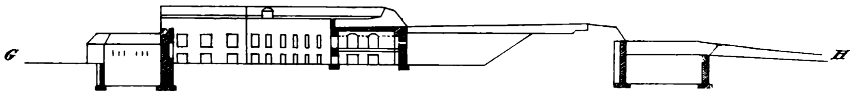
Section on A.B
Fig. 1. Pl. 6.



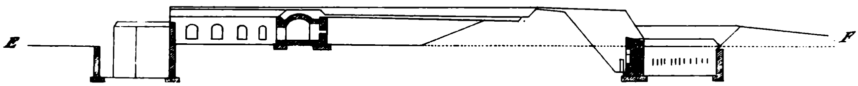
Section on C.D.
Fig. 2. Pl. 6.



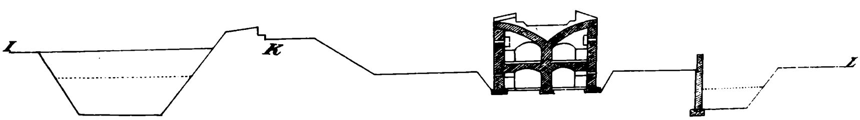
Section to Fig. 2.
Pl. 5.



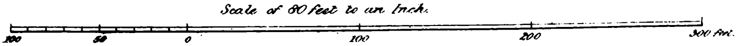
Section to Fig. 4.
Pl. 5.



Section to Fig. 5.
Pl. 5.

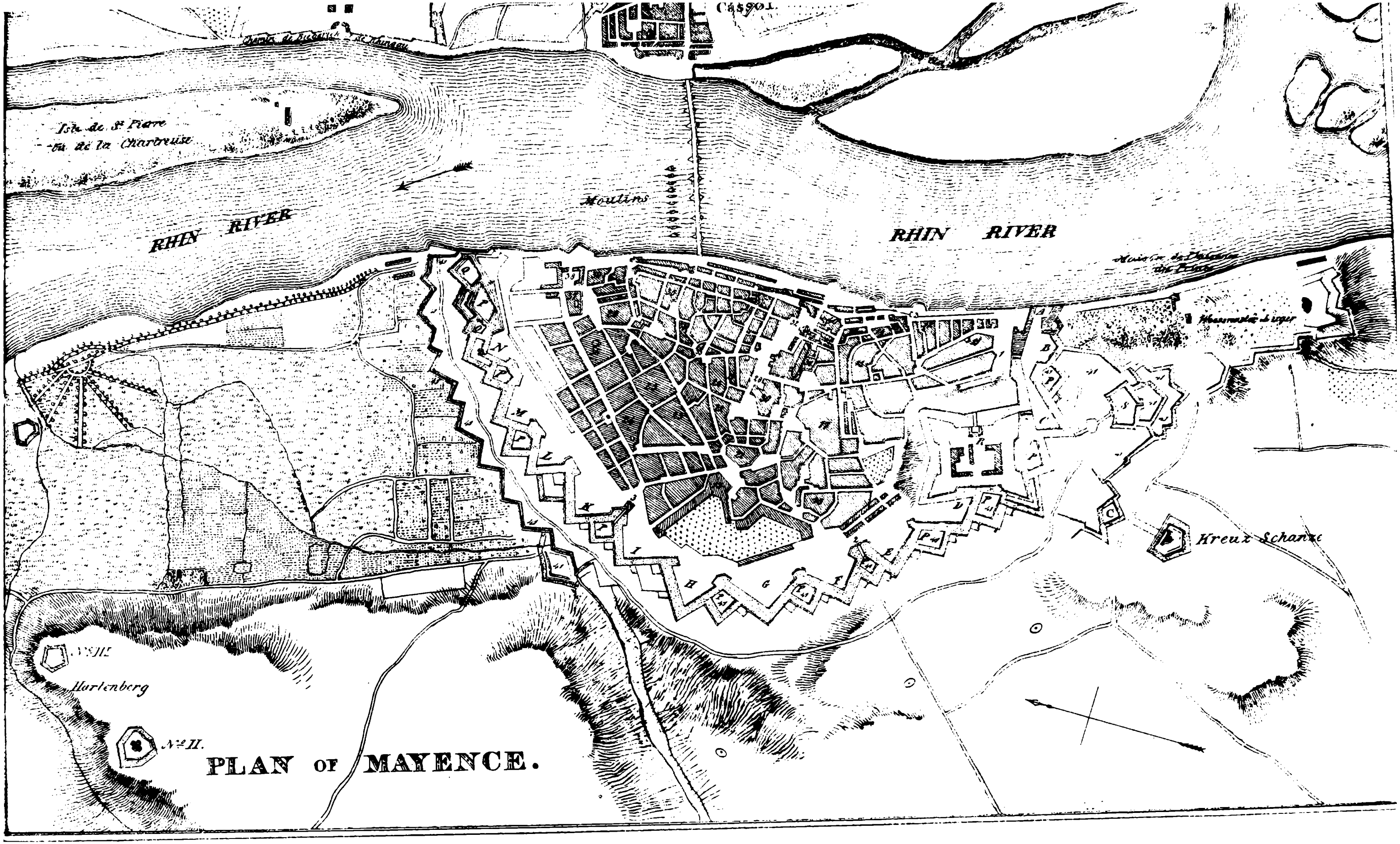


Scale of 80 feet to an Inch.



Dean & Munday, Lith^rs

40 Threadneedle Stre



PLAN OF MAYENCE.

and in the event of an enemy attempting to pass the ditch upon it, he has still to descend the wall, which is enfiladed in its rear. The circular keep is shown without flanks in the sketch, which is generally the case in these works. It appears also to show correctly the glacis as now formed.

Plate 5, *fig.* 5, a redoubt constructed with a wet ditch having no revetement: the slope of the rampart was planted with couch-grass at the time of its construction, which appears to answer very well. The enlarged plan and section of its keep show the internal arrangement, by which a tier of embrasures, and two tiers of loopholes, with a good vent for the smoke, can be obtained under the platform, at a comparatively small height.—See *plate* 7.

The country round Cologne being very flat, it would be advantageous, with a large garrison, to raise epaulements between the redoubts, which might be flanked by them both in front and rear. A line would thus be formed, which would cover any troops sent to assist the redoubts, either by their fire or by sorties, and which would not be of material service to the enemy after their reduction. The advantage of keeping the enemy thus at a distance by the redoubts, would be very great, as the old wall of the town is exposed, and the bastioned line in front is not adapted to resist an assault.

Mayence, plate 8.—Mayence contains about 20,000 inhabitants. Although in the state of Hesse Darmstadt, it is occupied as a fortress of the empire by a garrison of 13,000 men, consisting of Austrians and Prussians, in equal numbers. A military governor is appointed every three years by those nations alternately.

The interior enceinte of Mayence has had slight repairs required to place it in a serviceable state. The escarps are above 30 feet in height generally. A considerable depôt of stores was formed in the citadel, after the French revolution of June 1830, since which it is difficult to obtain admittance. The old works, which formed a kind of outer enceinte, have been demolished.

The works round Cassel are in earth, and have been lately repaired. The tête-de-pont in the interior is to be large and casemated: the foundation is built on piles. These additions are not shown in the sketch.

Fort Montebello is also of earth on the land side. The gorge (towards the river) is shut in by a cremaillered wall 15 feet high, in the centre of which is a casemated barrack, which is too small to contain the troops required, or to serve as a keep for so large a work. The whole has been lately placed in a serviceable state.

*

The new works, to replace the exterior enceinte round Mayence, have been laid out under the directions of the Austrian General Scholl, who, it appears, has been allowed so small a sum by the Diet, both for their construction and for the purchase of the land, that he has been obliged to follow, in a great degree, the tracings of some works constructed in 1793.

The Weissenau Lager (or camp) is nearly of the same outline as the old work. In its front the rampart is without revetement; but there is a loop-holed counterscarp, which also serves as a communication to the redoubts of the covert-way, and to the countermines, which consist of galleries directed straight to the front, from 200 to 300 yards in length, having occasional apertures in the sides for the heads of branches. Parts of the counterscarp are arranged for sorties, as shown in section *c, d*, (*plate* 9, *fig*. 6): they would require moveable platforms, which might be formed of palisades, with battens on the upper part. The troops descend into the front ditch by ramps (shown by dotted lines), which, being revetted on both sides, and enfiladed by the casemates (marked E), have no gates.

The redoubts command the counterscarp, the ascending planes of the sorties, and have a reverse fire on their ditches in their rear. The centre caponière enfilades the front ditch, and communicates directly with the gallery of the counterscarp, and with the large casemate in the interior of the work.

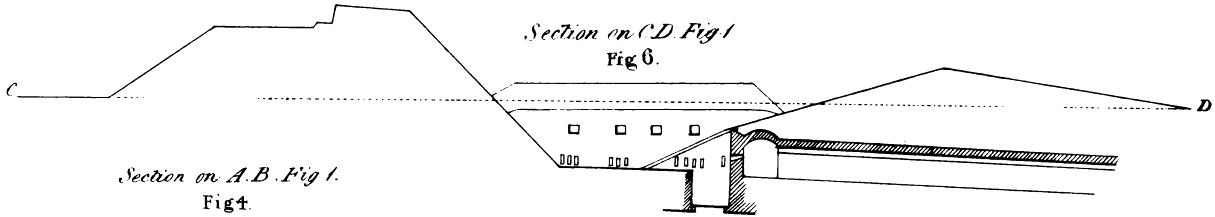
The whole of the casemates may contain on emergencies 2000 men, and the rear of the works enclosing them has been lately palisaded.

The section *c, f*, (*plate* 9, *fig*. 5) shows a revetement which gave way. It was 24 feet high, 6 feet thick at the top, and eight feet at bottom, without counterforts, being in front of an old wall. The parapet, 12 feet high, was made after the masonry had been built about two months, orders having been given to expedite the work. A number of men were ramming the earth of the parapet at the time, and nine men underneath the wall were killed by its fall.

Kreuz Schanz, plate 9.—The Kreuz Schanz (Redoubt of the Cross) is only flanked by caponières in the ditches at the front and rear, but the faces are partially seen by the redoubt in the covertway, and the flanks are protected at a distance by the enceinte of the town. The salient angle being cut off, and having an advanced casemated escarp, four mortars can be placed in arches under the parapet; and there is a musketry fire on the covertway in front. Four

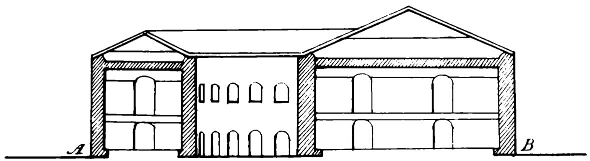
Section on C.D. Fig 1

Fig 6.



Section on A.B. Fig 1.

Fig 4.



Section on G.F. Fig 1.

Fig 5.

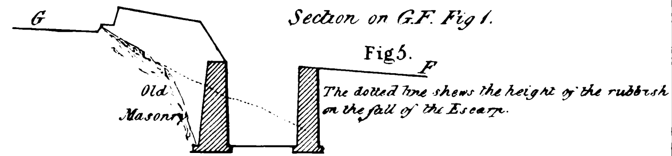
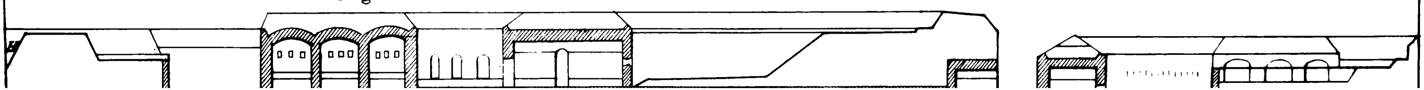


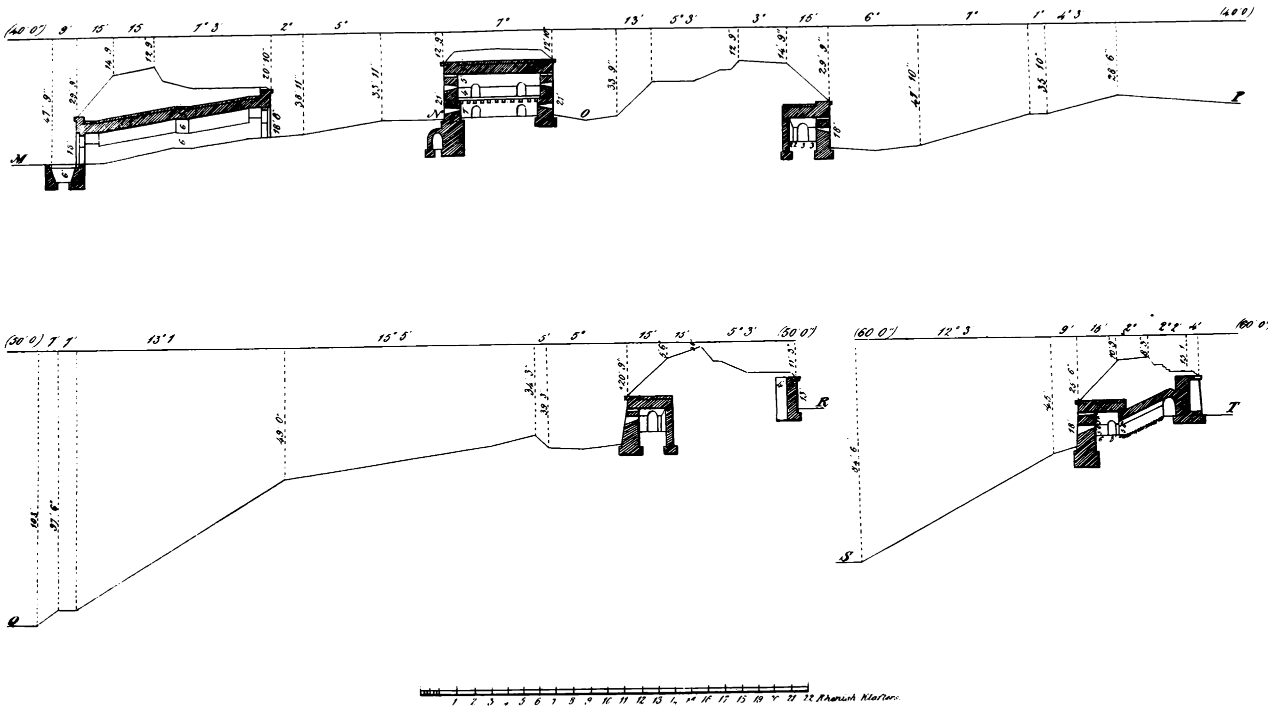
Fig 3

Section on H.I. Fig. 2.

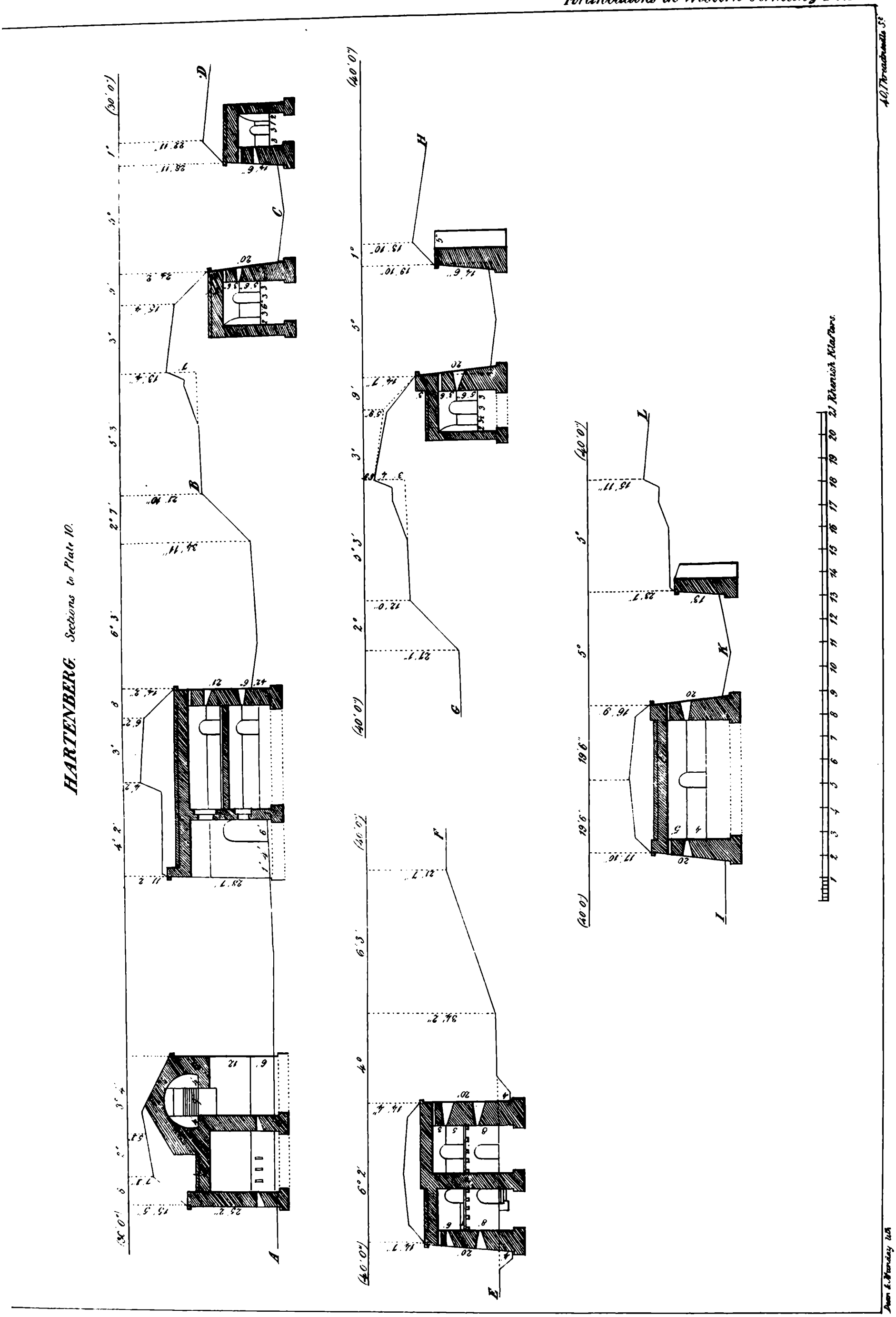


HARTENBERG.

Sections to Plate 11.

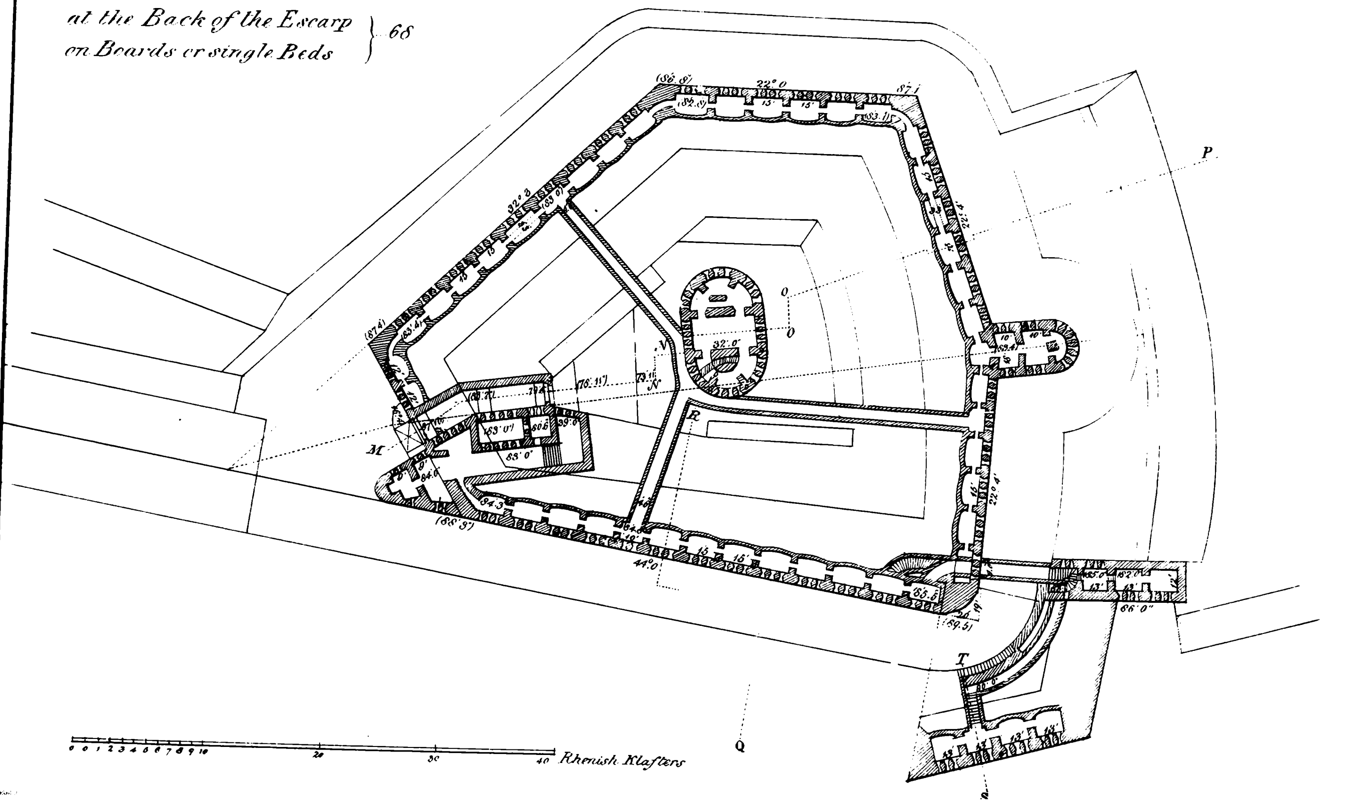


Dean & Munday lith.
40, Threadneedle St.


HARTENBERG. Sections to Plate 10.
21 Rhenish Klafters.
Dean & Munday lith.
40 Threadneedle St.

Hartenberg Redoubt, N.o 3.

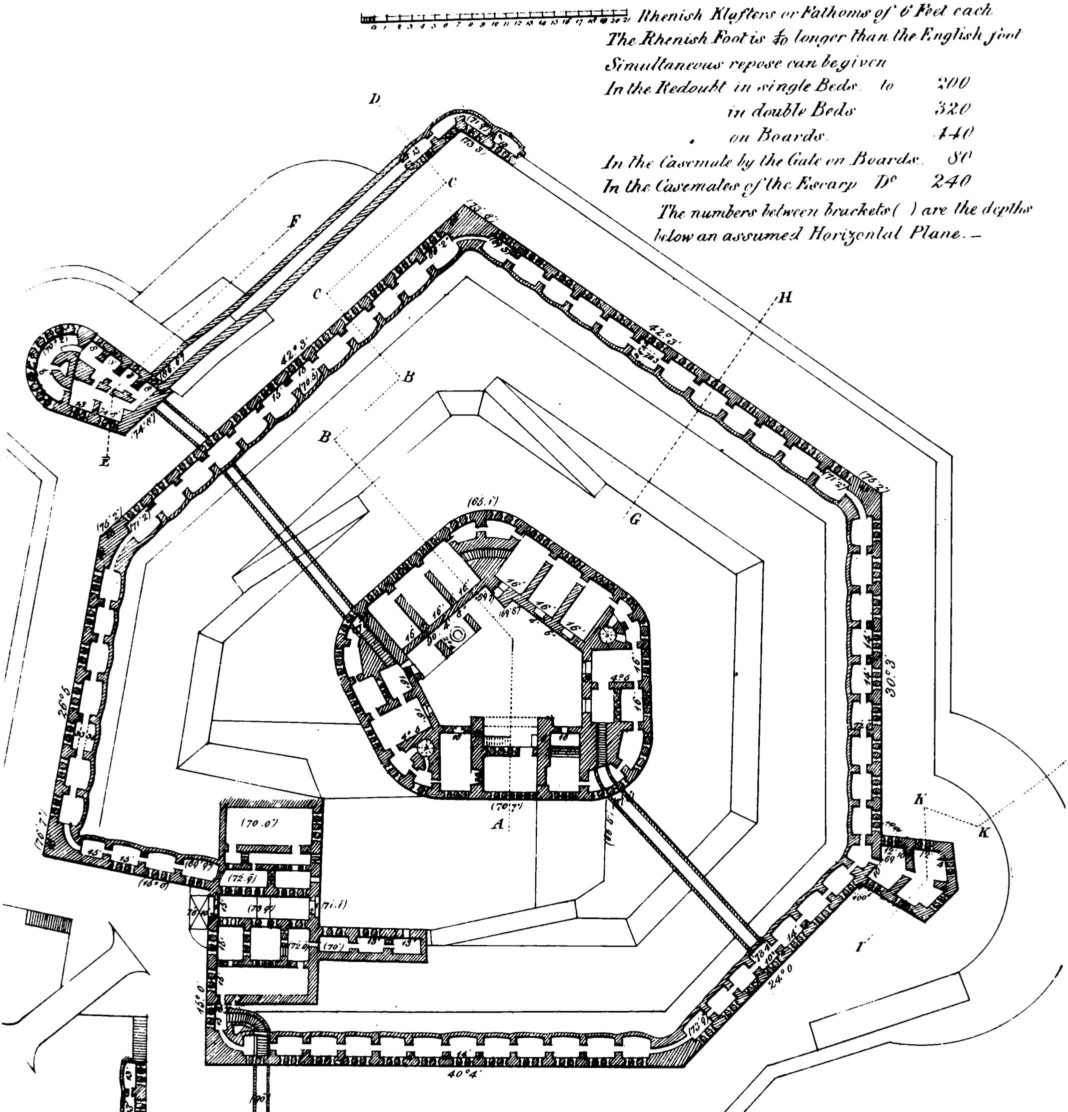
Simultaneous repose can be given
In the walled Blockhouse... 40.
In the Casemate by the Gate... 52
at the Back of the Escarp } 68
on Boards or single Beds }



Hartenberg Redoubt No. 2.

Rhenish Klafters or Fathoms of 6 Feet each
The Rhenish Foot is $\frac{1}{30}$ longer than the English foot

Simultaneous repose can be given
In the Redoubt in single Beds to 200
in double Beds 320
on Boards 440
In the Casemate by the Gate on Boards 80
In the Casemates of the Escarp Do 240
The numbers between brackets ( ) are the depths below an assumed Horizontal Plane. –



galleries of countermines extend to the front, one of which is more than 200 yards long, but they are generally (as also those of the Weissenau Lager) only a few feet below the surface. The interior communications are commodious and secure to the casemates, which might contain on emergency about 300 men.

Between the Kreuz Schanz and Hartenberg redoubts, are five or six casemated block-houses, generally encompassed by a small work without flanks: they are very insignificant; their sites are *nearly* shown by marks on the plan.

Hartenberg Redoubt, plates 10, 11, 12, *and* 13.—The plans and sections of the two redoubts of the Hartenberg, are fully detailed by tracings from the official plans. The arrangements give great facilities for sorties. The escarps are well covered, except that in rear of redoubt No. 3, which is built near the edge of a steep bank, and is referred to on the plan. This redoubt does not appear to be of sufficient importance for its situation, the ground in the rear being only protected by the distant fire of the place, and the ditches in front being without flanks; the space within is also very confined, and the small number of troops occupying the work would not allow of sorties formidable to the force that must be engaged in the attack.

There is also a new work in progress on the right bank of the Rhine above the town, near the site of Fort Gustavus. Pile-driving was carried on there to a considerable extent in October 1831.

The Austrian Engineers generally prefer the construction of General Chasseloup, who has recommended the use of hollow escarps, detached caponières in the centres of fronts, and redoubts in the covertway for ditches requiring reverse fires. He was the first who proposed advanced ravelins, which were constructed at Alexandria. The confined nature of these works allow only of some details being shown of this system, and they have not been closely followed, as, in particular, the reverse fires are generally protected at the angles by redoubts in the system recommended.

Remarks on the Country on the left Bank of the Rhine.—With reference to the country in advance of the fortresses on the Rhine, a few observations are added, from information acquired, partly in visits made to some of the Belgian fortresses, to Juliers and Landau lately, and to Luxembourg at a former period.

The northern part, formerly considered the strongest, is now perhaps the most insecure, as in the event of the Belgian fortresses being at the disposition of France, an advance might be made on Cologne, the principal road only being protected by Juliers, an old fortified town, principally depending on the strength of a square citadel and large outwork, which have been lately repaired.

Luxembourg.—The adjoining country of Luxembourg is exceedingly rocky and broken, the roads lead through the capital, which is very strongly fortified, and has a large Prussian garrison well found in stores and provisions; but, from the defiles near, it may be easily blockaded.

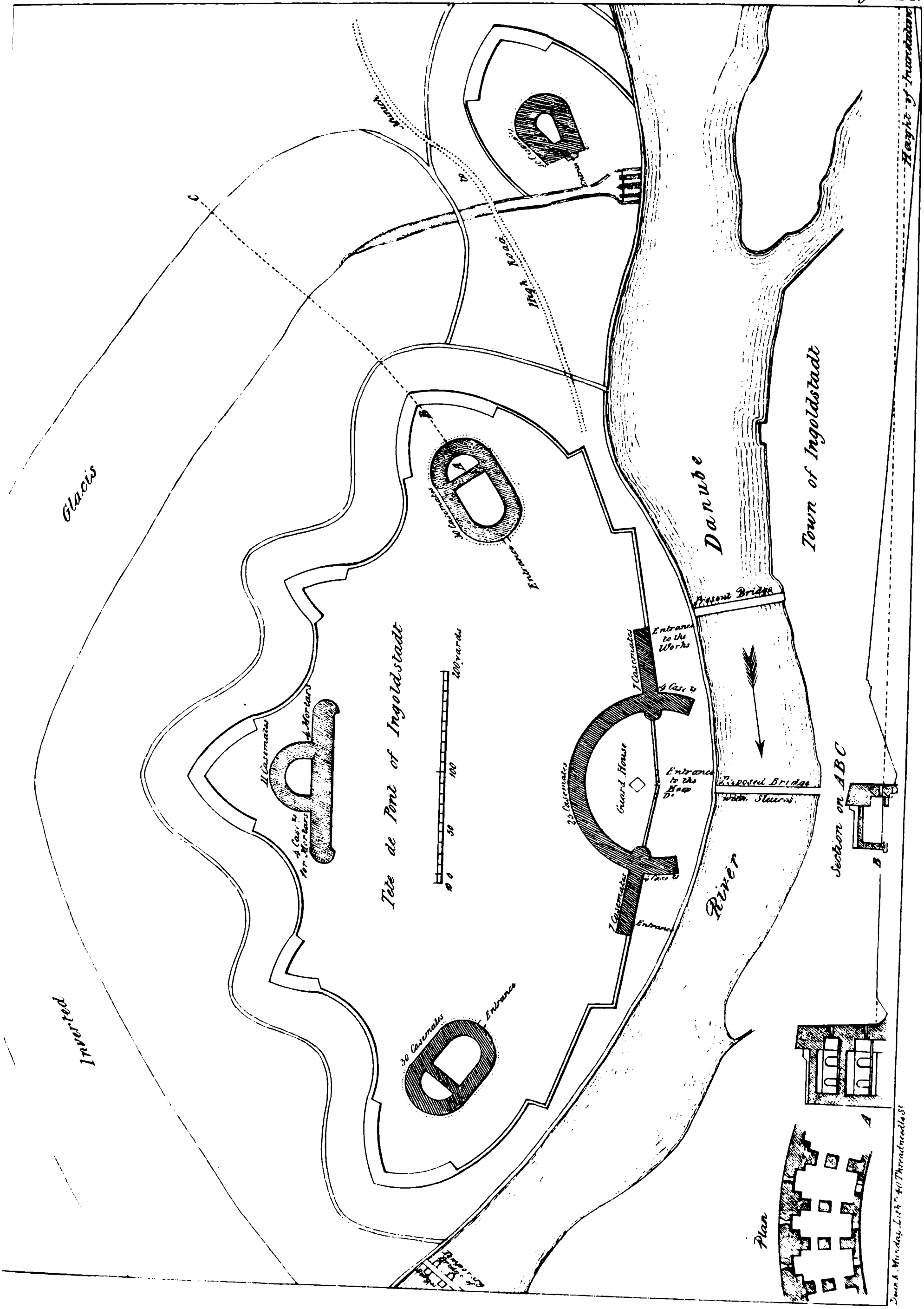
Trèves.—Trèves is in a great degree protected by Luxembourg, but, as it may be attacked by an army following the rivers Saar and Moselle, it is generally understood that it will be made defensible by outworks on the surrounding hills.

Saar Louis and Saar Bruck.—The river Saar is then considered to be a line of defence as far as the rugged country extending to Landau. It is protected by Saar Louis, a small strong town, which has been lately placed in a state of defence, and Saar Bruck, containing 5000 inhabitants, which has considerable fortifications, two large outworks having been added, which with the stores and garrison are complete.

This latter town commands the entrance of a road, made partly through a rough mountainous country, for about thirty-five miles, which is the communication between Metz and Mayence: it was improved at a great expense by the orders of Buonaparte. But the town may be avoided by an army making a detour by Deux Ponts, which however would be attended with considerable risk, against even an inferior force, as Saar Bruck must be masked, and the road passes through continued defiles to the plain of the Rhine.

Landau.—Landau, belonging to Bavaria, contains about 6000 inhabitants, and a garrison of 5000 men. The mountainous country extending from Saar Bruck here becomes more level. By sluices on the small river Queich, a large part of the town can be covered by inundations. The fortifications are Vauban's second system: they are in a very serviceable state. A bomb-proof covering of timber and earth, protected from the weather by a tiled roof, has been lately given to the tower bastions, and two redoubts are projected for the high ground (above the Camichon outwork) which commands the town, and would probably be the side of attack.

Germersheim.—The river Queich will be also of great importance to the new fortifications at Germersheim: it crosses the plain in a parallel line to the Lauter, the French boundary, fifteen miles distant. The celebrated lines constructed by Vauban along this river, are still available after some repair to the sluices; but the town of Weissenburg at the head of the lines being weak, and


Glacis
Inverted
Tête de Pont of Ingoldstadt
Danube
River
Town of Ingoldstadt
Present Bridge
Proposed Bridge
Water Sluices
High Road
Guard House
23 Casemates
7 Casemates
30 Casemates
11 Casemates
4 Mortars
Entrance
Entrance to the Works
0
50
100
200 yards
Section on ABC
Plan

commanded from the adjoining mountains, the lines have been forced at that point, and do not now possess their former reputation.

Remarks on the Country on the Right Bank of the Upper Rhine.—In the event of the French crossing the Rhine at Strasbourg, and proceeding down the right bank, they would probably be opposed at the river Neckar, in which case their rear would be exposed to annoyance from troops, either crossing at Germersheim, or passing through the roads in the Black Forest. In the event of their attempting the latter route (to penetrate into Germany), they might be advantageously opposed at the gorges of the defiles from Ulm, where the principal roads of the country are concentrated.

Ulm.—This town lies between the Danube and some high ground, which has been long considered as most eligible for a camp. This height, which commands the town completely, and would prevent its making any effectual resistance, it is proposed to enclose, by extending the fortifications. Dams across a small river joining the Danube above the town will greatly strengthen that side, and the works generally will be flanked by a casemated fire from detached caponières.

Wurzburg.—Besides the towns under the direction of the Diet, the Bavarians have the large populous towns of Augsbourg and Nurembourg, which are surrounded by old walls, with a few modern works in front. Wurzburg, containing 17,000 inhabitants, is fortified, and has a small citadel on a steep rock. The town is divided by the river Mayn, and commanded so completely, as to render it incapable of any advantageous resistance against a serious attack, which could not be withstood more than a few days. The other defensible towns are Ingoldstadt and Passau.

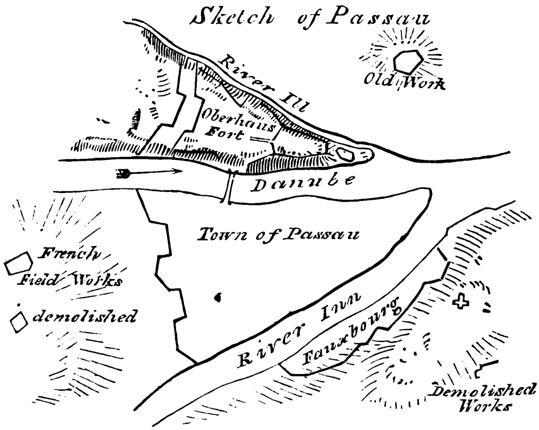
Ingoldstadt, plate 14.—Ingoldstadt contains about 5000 inhabitants. It is intended to give further strength to the town by two detached works of large dimensions, and to fill the ditches by means of sluices in the proposed bridge across the Danube.

These sluices would also form an inundation round the tête-de-pont now in construction; sluices for admitting the water when so raised, between the glacis and the glacis "à contre-pente," being nearly complete. The cavalier casemates shaded dark, are so far advanced, that the greater part of the upper arches were turned in September last (1831). The casemates lightly shaded, are only four feet above the foundation. The enceinte, and the other parts shown in outline, must be considered a mere sketch to convey the general idea.

The masonry already performed is beautifully executed. The revetements are of very hard stone (resembling a coarse grey marble), most accurately cut, and ornamented with a cordon and ogee at the base, and by rustic-work arches above the embrasures, which must have caused a great unnecesssary expense. The arches are formed of very hard red bricks of a large size, and fine quality, some of which were cast to the pattern required. This permitted the centres to be struck as soon as the arches were keyed. The dos d'anes were not finished, but the drains from them passed through the middle of the piers, which are seven feet thick. These works are planned by General Streider, who superintends their execution. They are different from any now constructed, and the cavaliers appear rather to follow the old tracings of Albert Durer, than the towers of Montalembert. By the circular form of the enceinte, the effects of ricochet firing would be in some degree avoided: it is covered by a small contre-pente glacis, to allow of sorties. The sections A, B, C, show the profile of the cavaliers, the supposed one of the enceinte, the contre-pente, covert-way, and the two glacis; with the presumed height of the inundation. There is however little chance of these works being completed, the legislative assembly having limited the expenditure on them to 7000*l.* of the public money in November last; but the King, who has considerable private means, would probably add to this sum, which would only finish the cavaliers that are almost completed. It is indeed of great importance to Bavaria, that there should be a strong fortification here, as it communicates, by an excellent road of thirty miles in length, with Munich, which would allow the Court to take refuge in cases of necessity, and also to concentrate the army in a defensive war, as it gives the means of acting on either side of the Danube. The surrounding country being exceedingly flat, the place could have been made strong at a small expense, after the construction of the proposed sluices across the Danube, which must be well protected from floating ice in the winter.

Passau.—Passau contains 10,000 inhabitants; it is called the Coblenz of the Danube, and is situated at its confluence with the river Inn (which is nearly equal in size), and the Ill. It is the centre of a considerable water communication.

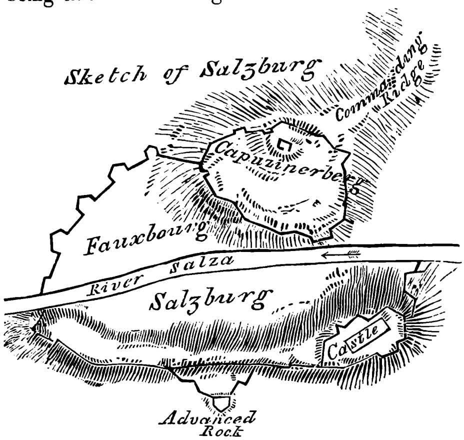
The Oberhaus fort has a very striking resemblance to the old works at Ehrenbreitstein both in plan and elevation, but is greatly decayed, and has not so good a command over the ridge of which it forms the extremity. There is a considerable casemated accommodation still habitable.

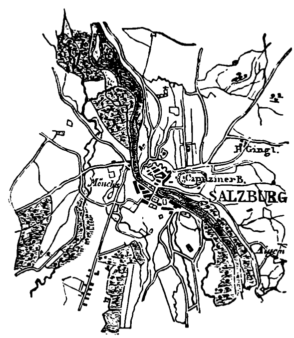


The works enclosing the town and fauxbourg are in ruins. This site was fixed upon by Napoleon (when allied to Bavaria), as most eligible for a grand depôt against Austria; and accordingly considerable earth-works were thrown up on the surrounding eminences, but they are now demolished.

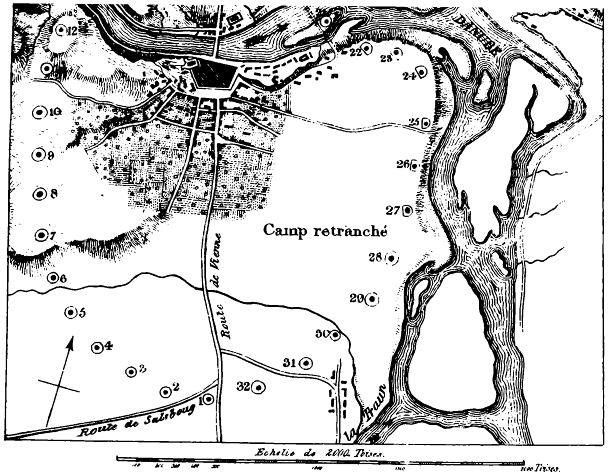
The Austrians having considered it desirable to give further security to the valley of the Danube, which leads immediately to Vienna, between the mountains of the Tyrol and Bohemia, Salzburg and Lintz are fixed upon as the most eligible points for defensive works.

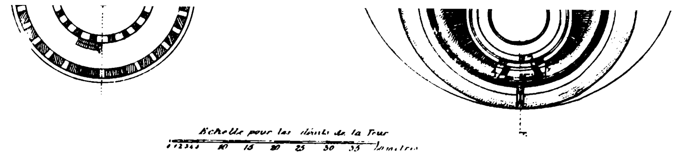
Salzburg is situated on the small river Salza, and contains about 10,000 inhabitants. The castle is about the height of Ehrenbreitstein and is on the summit of the ridge of rock which encompasses the town on the left bank of the Salza. It contains a large casemated accommodation, formerly the palace of the bishop, and is of considerable strength on all sides, from the precipitous nature of the rock, particularly towards the country, which is a level plain. It communicates to the town by a rail-road, and by a circuitous road (for horses and light carts) which passes through three enceintes. There are several batteries on different heights (which command the ridge and town) dependant on the keep of the castle, and having very high escarps: the lowest part of the ridge surrounding the town is 50 or 60 feet high; it is surmounted by a small wall forming the enceinte, and is roughly scarped. In the project for strengthening this side, it is proposed to complete the scarping of the rock, to form it into a regular rampart; and to connect an insulated rock, which has been already cut into the shape of a ravelin sixty feet high, thus forming a good flank to the base of the ridge, and an extensive place-d'armes in front of the principal entrance, which is cut through the rock. It is also intended to add some low works at each extremity adjoining the Salza, to give a flank to that part, and cover the other two entrances of the town, the fire of the ridge over these works being like that of a high cavalier.



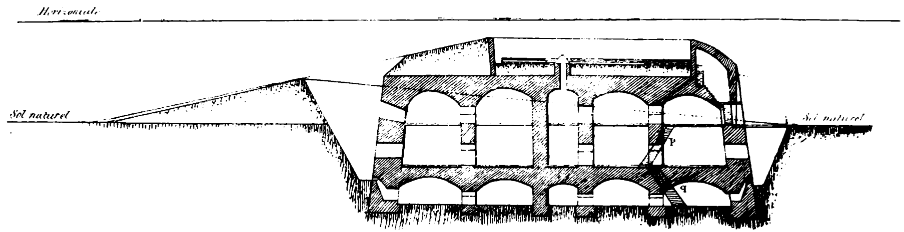


On the right bank of the Salza, the suburb is closed principally by the Capuzinerberg, which externally is broken into rocky precipices. It has a small keep near the summit, about fifty feet higher than the castle on the other side of the river, and an enceinte leading down towards the river (which the rock overhangs) as it enters the town; and on the other is connected to a few regular fronts which join on to the lower part of the river. The country near the town on this side is also nearly level, with the exception of a ridge proceeding from the Capuzinerberg, which obtains an equal height with it at about 1600 yards distance. It is proposed to do little more (on this side) than to improve the old enceinte, although, where the rocks are precipitous, it consists only of a common wall of about twelve feet in height, broken into angles, giving irregular flanks. This is considered sufficient, as the Tyrolese sharp-shooters would be employed in its defence, and there would be then very great difficulties to overcome before guns could be brought near enough to destroy the defences. The site of Salzburg is considered to be too remote from the Danube to support sufficiently

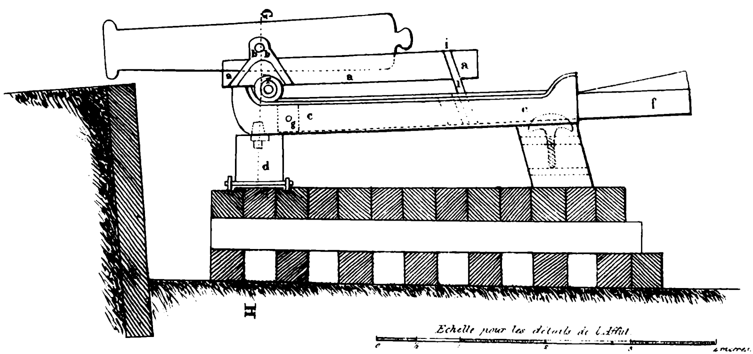




Coupe suivant ABCDEF.



Profil de la Plateforme montant une Piece en batterie.



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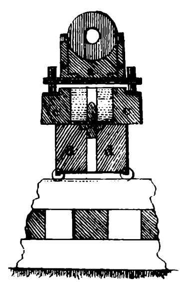
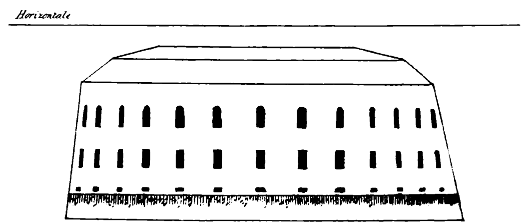


Elevation de la Tour.



the troops engaged in opposing an enemy advancing on Vienna; but as it may be easily made defensible, an estimate has been made for the works required, and it is considered probable that they will be ordered when those of Lintz are completed.

Lintz, plate 15.—Lintz contains about 25,000 inhabitants. It is well built, having three squares, and the streets being generally wide and open. An old redoubt in each was the only work of defence previous to the construction of the present towers, one of which was built about three years since; the others, shown on the plan, were commenced in 1830 and 1831.

The following account of the works at Lintz is taken from the memoir of Captain Allard, of the French Engineers, in the Spectateur Militaire of April 1835:—

"The Maximilian tower is circular. Its diameter at the base is 118 feet, and at top 110 feet; its height about 33 feet, and the mean thickness of the scarp 6 feet 6 inches; it is surrounded by a ditch, which is 26 feet wide at the point most exposed, while it diminishes gradually to the gorge of the work, where it is only 13 feet wide, at which point a drawbridge gives access to the gate of the tower. The earth excavated from the ditch is formed into a glacis, raised sufficiently to cover the masonry of the tower in front from the view of the enemy: this glacis diminishes gradually towards the gorge of the work, where it ceases.

"At the centre of the tower is a hollow circular shaft, 10 feet in diameter: the space between the exterior of this cylinder and the interior of the escarp is divided by a set of piers, upon which rest the arches, forming a bomb-proof covering to the interior of the tower.

"The tower has three floors. The lowest is partly below ground, is used as a magazine and place of depôt for stores and ammunition, and has a bomb-proof covering; the second, which is covered by a simple floor, and lighted by windows, serves to lodge the garrison, and contains the kitchens and all the necessary accommodations. The fire-places are placed between the windows; the smoke is conveyed to the exterior by a metal pipe. The upper floor is left open between the piers, becoming thus one large casemate; the escarp is pierced with embrasures, and two howitzers are mounted upon light carriages, which can be moved from one point of the circumference to another, as may be required. These howitzers, when acting towards the exterior, fire à ricochet over the glacis, but they defend all the ground within the line of towers by a direct fire.

"On the upper, or bomb-proof stage of the tower, which is covered with

3 feet of earth, a battery of eleven 24-pounders is mounted; this is called the deck, from its resemblance to the deck of a man-of-war. The battery is protected by a parapet 33 feet thick towards the exterior, and only 10 feet towards the interior, including thus a circular space, whose centre does not coincide with that of the tower. In rear of the parapet is a circular platform, composed of three rows of heavy timber; the upper and lower rows are arranged in the direction of the curve, while the centre tier is in the direction of the radius; two grooves in the front part of this platform serve to receive and guide the trucks of the carriage of the gun, which is a short 24-pounder, and is mounted in a peculiar manner, as will be seen by the following description.

"The gun is sunk into a beam (marked *a* in the drawing), and fastened down to it by a band of iron fixed to the trunnions; a cast-iron hollow axle is fixed to this beam, and on this are two cast-iron trucks, which run in grooves in the beams composing the lower part, or cheeks of the carriage, and allow for the recoil and working of the gun. The front transom of the carriage has a socket, which fits upon a pivot projecting upwards from the lower part of the carriage, which, as before stated, is moveable upon trucks running in the grooves of the platform, and by which the whole carriage is moved to any point in the circumference of the platform. The two cheeks of the carriage rest in rear upon two blocks, which, when the carriage is moved, are either lifted with it, or made to slide on the platform; between the cheeks of the carriage a sill or lever is placed, which is fixed at one end by a bolt (*g*), and is supported at the other by the elevating screw; on the projecting end of this lever is an inclined plane, which in some measure checks the recoil. The gun rests upon the lever by the intervention of a bolt passed through holes in an iron band, the two ends of which embrace the lever: there are several of these holes by which variations may easily be made in the elevation of the piece. The grooves in the cheeks of the carriage are 4 feet 6 inches long; the lower part of the carriage, which runs on the platform, is 1 foot high and 1 foot 6 inches long; the rear transom, which receives the elevating screw, is moveable, which allows of a rapid alteration in the elevation. A similar alteration may be made in the contrary direction, by moving the bolt which bears on the lever.

"The carriages of the howitzers in the upper story are framed on the same principle as those just described. The front part of the carriage is not upon trucks, as the howitzers are not expected to move like the guns of the battery. The rear supports are connected with bolts, in such a manner as to enable the carriage to be raised or lowered easily. The most striking difference between the carriage of the howitzer and that of the guns, is the position of the trucks upon which the piece recoils, which in the howitzers are fixed to the trunnions; a piece of cast-metal, something like the butt of a musket-stock, is fixed to the piece itself.

"These carriages, as well as the towers themselves, were invented by Prince Maximilian, and form an essential part of the system. They do away with the inconvenience which has been hitherto justly charged to all systems on which towers form the staple defence, viz. that of being unable to concentrate a heavy fire upon any given point. It may be seen by the plan, that in case of necessity, the fire of all the eleven guns may be brought to bear upon one point, as they are easily moved upon the platform, and occupy but a small space.

"The motion of the upper part of the carriage upon the pivot in front allows the gun to be pointed in a direction very oblique to the radius of the tower, without necessitating the removal of the trucks from the grooves in the platform. Between the platform and epaulement, a space of 1 foot 6 inches wide is left for the convenience of the men who load the guns; of these men there are only four for the whole battery. When loading or sponging the guns, they stand upon the edge of the platform: this duty is difficult and dangerous, as the men are exposed above the parapet during its continuance, and it requires steady experienced soldiers to perform it. *

"The six men who work the guns remain in rear of the platform, and raise themselves upon it to perform their duties. The upper story of the tower is on a level with the ground outside, and a communication is made to it by a draw-bridge in rear of the work: from the upper story, a double staircase within the scarp-wall leads to the platform, and the outlet is covered by an arch, the crown of which does not rise above the parapet: in cases of necessity, the guns of the battery can be fired over it. The men who load the guns are enabled to make the circuit of the exterior of the platform, between it and the parapet, by descend-

* The artillerymen would be much exposed to an enemy's fire even on a plain; but as several of the towers are situated on ground commanding that in front, it would be there necessary to elevate the carriages much more, in order to give the necessary direction to the fire. Several experiments were therefore making, on an experimental platform, to overcome this fault, which might be much diminished if the gun were to be placed on a common English sea-carriage recoiling on a plane sufficiently inclined for it to return from its own weight, after being kept back by a catch-lever, so that the gun might be retained while it is loaded; additional space and security might also be given to the artillerymen in front by arched recesses under the parapet.

ing the upper flight of stairs, moving along the landing-place, and ascending the opposite flight, both of which open into the space: but it is more difficult to work the guns in this spot than in any other. Two small expense magazines, each containing about 100 cartridges, are disposed on the sides of the staircase: a staircase leads to the lower stories. The central cylinder of the tower is arched over at top, a small opening being left, which is covered with a metal cap, to guarantee it against the weather, or the effect of projectiles. Ammunition and spare carriages are conveyed from the magazines to the platform, either by the staircase, or through this opening, where a system of pulleys enables heavy weights to be moved from below. A communication is made on each floor with the central cylinder, which, in ordinary times, is used for various purposes; a place of confinement for offenders, a magazine, &c. The garrison of each tower amounts to 150 men, of whom 12 are gunners.

"Having thus given the details of the construction of one of the Maximilian towers, it only remains to describe the entrenched camp at Lintz, where they have been applied on an extensive scale. The principal object in establishing this intrenched camp, was to make Lintz a secure refuge for a beaten army; and it was supposed, that the means of attack would be limited to the field-train, which explains the reason why so little care has been taken to cover the scarps of the upper story, which can be seen from the exterior for a large portion of the circumference of the tower, but which from their thickness are supposed to be able to resist the fire of field-pieces.

"The intrenched camp is surrounded by 32 of these towers, which occupy all the high ground surrounding the town, on both banks of the Danube. The radius of this enceinte varies from half a league to a league: its circumference is about four leagues. The towers are placed at unequal distances apart, but in no case does this distance exceed 600 yards: neither are all the towers exactly similar in construction; they are modified to suit the ground: but the foregoing description will serve as a general type of the plan on which they are constructed. The line of towers is not altogether so regular as is represented on the plan, the form of the ground not permitting it. No. 1 tower is on the road from Lintz to Vienna, by Ebersberg. No. 2 and the following numbers ascend the valley of the river, No. 12 being on the right bank and No. 13 on the left; but between these two are situated, on the very edge of the bank, two towers mounted with guns on depressing carriages, which look into the valley of the river. From these two towers, and flanked by them, two loop-holed walls are carried down the bank, and so far into the bed of the river, as to secure a depth of 8 feet of water at their extremities: these walls, which have a gateway where they are traversed by the main road to Bavaria, and another on the left bank, serve to protect the town from an attack by the valley of the river. The line of towers is continued on the left bank, to a height called Peslinberg, which is important from its position and command. The French intrenched the height in 1809, when they constructed a tête-de-pont in front of the suburb of Ufer; and it is now occupied by a square fort, whose exterior side is 165 yards, and the faces of which are flanked by four towers placed at the angles. From this height, the line of towers descends again to the Danube, which it crosses at the point where a bridge was constructed during the last war. A tower is placed on an island in the river; from thence it follows the bank of the river to the Vienna road, where No. 32 is placed opposite No. 1.

" Nos. 22, 23, 24, 25, 26, and 27, are only half-towers: the want of funds is the reason of this alteration. The Emperor having given Prince Maximilian authority to execute the work, and he having engaged to finish it for a certain sum, the expense of the first tower so far exceeded the estimate, that the Prince determined to construct six half-towers, the saving upon which would compensate for the excess on the others. These half-towers are situated near the Danube, which in some measure protects them: their area is rather greater than the half of the other towers, and they are closed in the rear by a straight wall.*

" In time of war the towers are to be united by a palisaded covered way.

" The following experiment was made some years ago, in order to ascertain the degree of resistance of which these towers were susceptible. A battery was constructed against one of these towers, at the distance of about 300 yards: it was armed with four howitzers, and Congreve rockets, and a fire was kept up upon the tower for about five hours. In a short time, shells having fallen on the roof of the tower, the carriages were broken, the platform injured, and the whole battery on the tower was rendered unserviceable: two Congreve rockets had even penetrated into the upper story. After this first trial, the advocates for the

* The work is, however, cheaply performed, the price of labour being low; the bricks for the arches, doors, and embrasures, and the rough stone for the escarp, being obtained on the spot: one roof for two towers allows (by working at them alternately) the men to work under cover, and the water, where necessary, is conveyed by wooden troughs, from pumps placed at convenient situations.

towers required to be allowed to repair the damage, and remount the guns; and in the following night they made all the necessary repairs in the platform and parapet, and changed the broken carriages, and were ready the next day to open a fire on the battery, which was kept up for five hours, and did great injury to it. The result of this experiment, however, is altogether in favour of the attack, for it proves how very soon the defenders of the towers might be disorganized, and their means destroyed: for although the repairs were quickly made, yet it would not at all follow, that in war the same supply of fresh carriages, men, and materials, would be disposable; and as this damage was produced by one battery, what would have been the effect of two or three? As this tower was soon placed hors-de-combat, should an attack have been made at that time on the place, it could have contributed little or nothing to the defence. This experiment is more conclusive against the principle of the Maximilian towers than any reasoning could be. The invention, after all, turns less on the construction of the towers, which is by no means novel, than on the carriages, and mode of working the guns in the upper battery. The carriage may be looked on as a machine more or less ingenious in its construction; but this is by no means a desideratum in war: solidity, simplicity, and the facility with which changes or repairs may be made, are the first things to be considered; for it must not be forgotten, that a single cannon shot puts an end to the most ingenious and best constructed machine: in like manner, the first shell that falls in the battery will ruin the platform, and the grooves in which the carriages run, and will very probably set fire to the great mass of wood collected together. In the narrow space in which 11 guns are crowded together, it would be difficult, if not impossible, to change a damaged carriage: another inconvenience is the necessity of having such skilful and well-drilled men to work the guns; and as their duty is difficult and dangerous, should they be placed hors-de-combat, the defence of the tower, and its action upon the attack, would suffer very much."

The Austrians have also the fortresses of Leopoldstadt, Theresienstadt, and Josephstadt: they were built after the wars of Frederick the Great, to defend the passes from Silesia to Vienna. In one of these forts, the breach either in the bastion or ravelin may be cut off.—*Plate* 16, *fig*. 5.

The Prussian Rhenish provinces being detached from West Prussia, Erfurt has received additional works to secure it as an entrepôt in front of the line of the Elbe, on which are the fortresses of Magdeburg, Wittenburg, and Torgau.

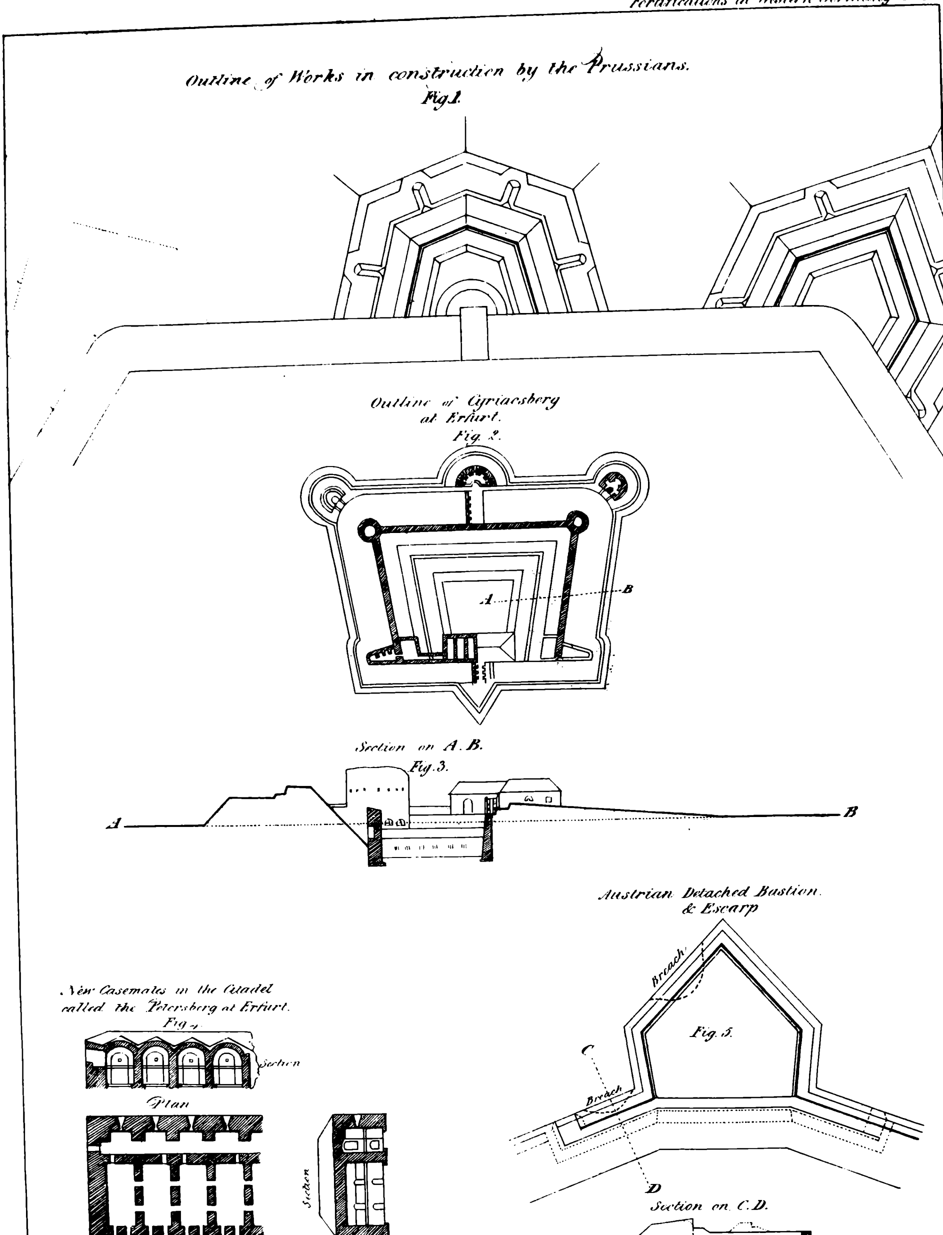

Outline of Works in construction by the Prussians.
Fig.1.
Outline of Cyriacsberg
at Erfurt.
Fig. 2.
A
B
Section on A.B.
Fig. 3.
A
B
Austrian Detached Bastion.
& Escarp
Breach
Fig. 5.
C
Breach
D
Section on C.D.
New Casemates in the Citadel
called the Petersberg at Erfurt.
Fig. 4.
Section
Plan
Section
Scale of yards to the Plan & of feet to the Sections.
100
50
0
100
200
Note. By uncovering the arch connecting the
Casemated Rampart with the Parapet earth
is procured for the parapet of the Intrench-
ment shewn in dots the Arch being only
one feet thick is then broken in

Plate 16.—Erfurt contains about 20,000 inhabitants. It is situated half-way between the Rhine and Berlin, commanding the main road, which also leads to Leipsic and Dresden.

The town is commanded by two hills; the larger, called the Petersberg, being well fortified, and connected with the enceinte, forms a strong citadel: considerable works have been lately constructed. A casemated barrack, forming a keep, and having guns, which bear on the side of the country, as being most exposed to attack; considerable additions are also making to the former exterior works, and the whole will form a very commanding place of great strength.

Plate 16.—The small hill, called the Cyriacsberg, is occupied by an old work, which has been strengthened, and further additions may possibly be made to it. It affords great facilities for sorties on this side, as troops may be drawn up at any time behind the fort, and the reverse of the hill being steep, the communication with the town is secure. These works protect the western side of the town, and the other points are greatly strengthened by the sluices on the river Gera, which passes it; the country being so flat as to allow of its being inundated; and the whole force of the river may be turned through the ditches. Strict measures are taken to prevent the new works from being seen.

Magdeburg.—Magdeburg contains, with the military and the suburbs, about 30,000 inhabitants, and is the principal military depôt of Prussia. It has never been attacked regularly, but was taken by the Austrians under Tilly, in 1631 (principally by escalade along the banks of the river, since which time it has been greatly strengthened), and by the French, after the battle of Jena, by bombardment and famine. It commands the great northern road from the Rhine and Hanover to Berlin.

Wittenburg.—Wittenburg contains 6000 inhabitants. It is a long narrow town, having one side protected by the Elbe, over which there is a good bridge covered by a tête-de-pont. There is a castle in the town, which has a command over the country on the west side, and serves as a keep, and casemates for the garrison. The ditch is wet, with a low revetement. The enceinte has six fronts towards the country.

Two or three small redoubts, thrown up by the French to protect the entrances, still remain: they have wooden blockhouses in the interior, which are in good preservation.

Torgau.—Torgau was fortified by the orders of Napoleon. General Von

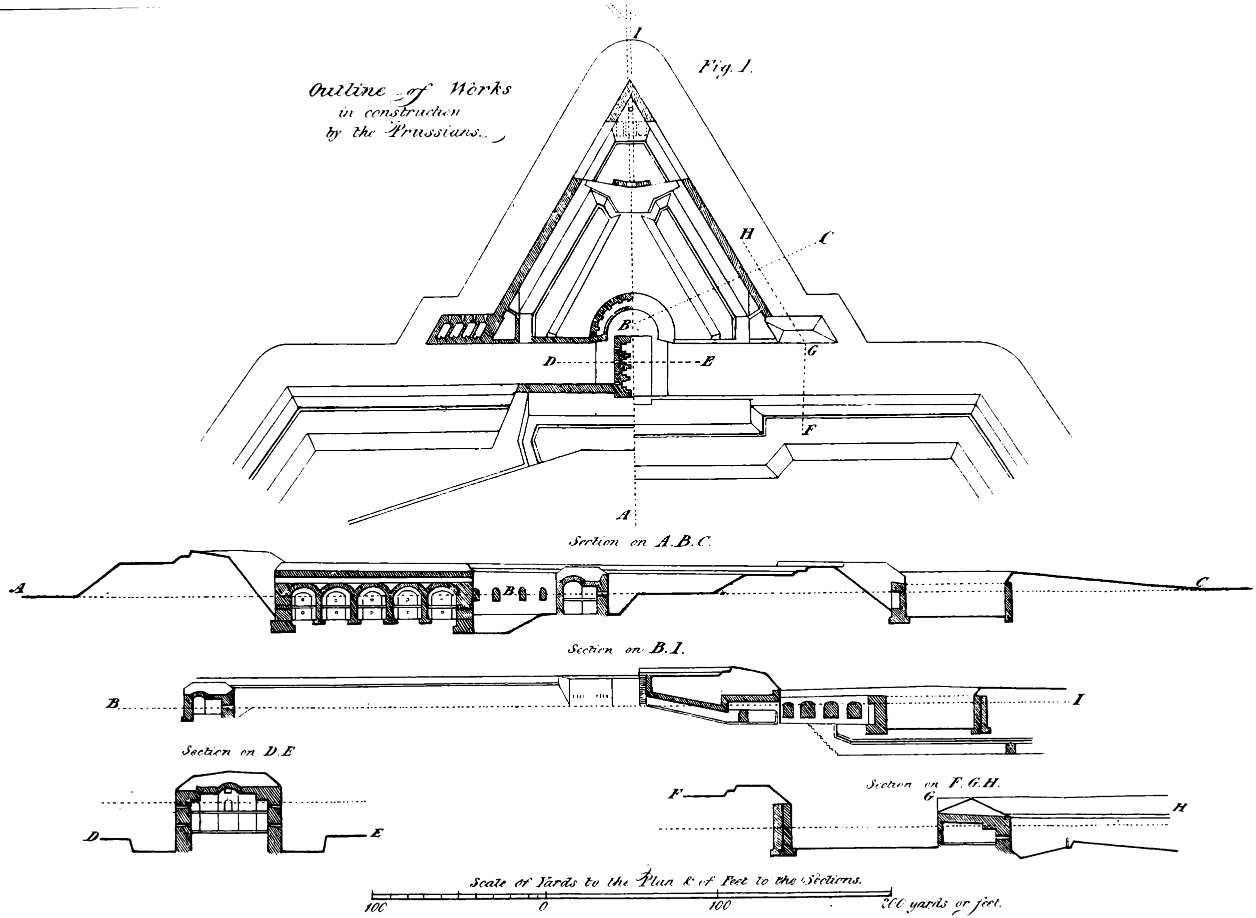
Aster, now at Coblenz, laid out the works. It contains 5000 inhabitants, and is situated on the left bank of the Elbe, which with seven fronts forms the enceinte. On the opposite side of the river is a large tête-de-pont in earth, with wet ditches. The enceinte of the town contains a considerable vacant space. The works have a good profile, the ditches are wet; the fronts about the usual length; the flanks have six guns, and the same number in casemates. The town is slightly commanded at a distance of about 1200 yards, which site is occupied by old works.

Kœnigstein.—In the kingdom of Saxony, the only fortress now kept up is Kœnigstein, fifteen miles from Dresden. In the wars with Frederick the Great it served as a refuge to the Court, and the crown treasures are deposited there in times of danger. It is a rock, having a natural escarp of from 100 to 300 feet in height, with a flat surface of about twelve acres, situate at the summit of a high hill commanding the Elbe. The enceinte is a wall about two feet thick, which allows of the foot being seen from small projections, and of its defence by stones, shells, &c. The entrance is protected by a low hornwork, and ascends to the terre-pleine of the rock by an inclined plane cut through. The casemates would contain about 1000 men with stores: they also cover a deep well, which has a constant supply of water. The guns are mounted on depressing carriages, which allow of their being pointed at fifty degrees below the line of the horizon, and of their being very quickly exercised. They command the Elbe, and the surrounding country, which is nearly flat; but there is a rock called the Lillienstein, about 1600 yards distant, that is about thirty feet higher, from which the fort might be annoyed, as also from a rock about two-thirds of the height, at about the same distance.

The Lillienstein is on the opposite side of the Elbe, but is so steep, and the top so small, that there would be considerable difficulty in forming heavy batteries there.

Details of Prussian Works in construction.—The Prussian engineers prefer obtaining casemated flanks to their ditches by caponières, as being more secure than those of bastions. An example of their construction is given in Fort Alexander at Coblenz; but in extensive works now in progress, a more simple and less expensive tracing has been adopted.

Plate 16.—The rampart, as shown in *fig.* 1, may be formed in some cases by a casemated barrack of two stories in height, communicating under


Outline of Works
in construction
by the Prussians.
Fig. 1.
Section on A.B.C.
Section on B.I.
Section on D.E.
Section on F.G.H.
Scale of Yards to the Plan & of Feet to the Sections.
100
0
100
200 yards or feet.

the ditch with the bastions in front; which have a good cross-fire on the glacis, the salient angles being only 200 yards from the collateral flanks. The bastions at the angles of the polygon cover the front from enfilade, and make it necessary for the batteries which oppose the fire of the flank to be placed in them, and they have then to contend with a double tier of guns across the whole width of the ditch.

It may be considered objectionable, that the small ditches of the faces are not seen from the body of the place, and also that in a work of this size they should depend for a flank on their small caponières; but it is probable that these bastions would be countermined in the course of their construction, and also that this tracing arose from the ground falling too much in front of the main ditch, to allow of ravelins being constructed, as in the other parts, as given in *plate* 17, *fig.* 1.

The ravelins covering the caponières in *plate* 17 are considered to be an improvement on the advanced ravelins of Chasseloup and Bousmard, as they may be made nearly as salient on the glacis, and also prevent the body of the place being breached from the counterscarp of their salient angles; while they form a more efficient flank to their ditches, are more under the fire of the enceinte, contain a larger interior space, and there is a great saving of masonry at the gorge, as also of troops to secure it from assault.

In the attack of these fronts, the approaches are opposed, on the capital of the ravelin, by three mortars, under the parapet, cutting off the salient angle of the first part, and by guns behind it. The glacis on each side is protected by the fire of ninety yards of the enceinte, and by eighty yards of the second part of the ravelin, which (being covered by the first part) it is very difficult to enfilade.

The establishment of batteries on the counterscarp of the salient angle is also rendered exceedingly difficult by countermines, and by a double tier of fire the whole width of the ditch, from the enceinte, and from the caponière, which also, after their establishment, would prevent their making a serious breach in the body of the place. The attempts of the enemy to lodge himself on the first part of the ravelin are opposed by countermines prepared in the work during its construction, and by the intrenchment covering the second part, which allows of sorties; also the formation of batteries in the narrow part of the angle, sufficient to silence the defence of the second part, would be opposed by the fire of the whole of the enceinte behind the ravelin, by that of the casemated keep, and by sorties having their flanks fully protected, which could be only opposed by a very insignificant force. The permanent possession of the second part of the ravelin can therefore only be obtained after the destruction of the keep (which commands every part of the interior, and is not seen from the exterior;) and this is absolutely necessary for the enemy, before he could make his approaches on the glacis to the enceinte for his breaching batteries on its counterscarp, as they would be either taken in flank or reverse. The caponière flanking the ditch of the enceinte is independent of the keep, (which after being taken, would have its gorge open to the fire of the parapet of the enceinte, and of its detached escarp,) and its flanks, having a double tier of fire the whole width of the ditch, can only be opposed by batteries directly in front and of little more than the same width. The establishment of these batteries, and of others for breaching the escarp at one salient angle, would of course require the previous capture of two ravelins; between which the approaches would be sheltered from the collateral works, but they would be diminished in extent on advancing near the place, and consequently expose the troops (concentrated in larger numbers) to a more destructive vertical fire.

From the great projection of the ravelin, and the obtuseness of the angles of the enceinte, the effect of ricochet on the latter is prevented in an octagon, the prolongation of the side of the polygon being intercepted by the ravelin; which might even be made to project further, so as to cover the ditch from enfilade by distant batteries, which would secure the flank from annoyance. The fire of musketry from the detached wall, and from the gorge of the ravelin, protects completely the angle of the flank of the caponière from any assault during the passage of the ditch, so that the flank might preserve its fire to the last.

The salient angle of the enceinte may also be intrenched by a detached wall, as shown to the left of the figure, which would give a great extent of fire on the breach, and would be well flanked by casemates in the rampart of the middle part, or by the casemated barracks, which might be advantageously placed for that purpose.

The following is a comparative view of the above system, as applied to a hexagon, with that approved by the French engineers, and those invented by Bousmard and Chasseloup.

Details.	Prussians.	French.	Bousmard.	Chasseloup.
Interior space within the ramparts, square metres ..	345,600	141,600	130,200	201,600
Length of front in metres	420	360	360	410
Lines of defence in do.	200	260	275	280
Length of upper flank	—	39	48	40
Do. of lower flank......................	—	—	22	14
Opening of the angle of rampart	120	82	110	84
Width of ditch at salient	30	26	16	24
Projection of ravelin beyond the salient of the enceinte in metres.......................	180	135	228	195
Flank to ravelin from the enceinte..............	90	80	30	70
Width of ditch to ravelin	24	20	14	20
Do. do. to redoubt	5	10	15	10
Work required.				
Main ditch one front } Excavation, yards superficial	13,100	16,700	13,250	19,700
Ravelin do. do. } Excavation, yards superficial	10,700	9,260	8,900	6,480
Escarp of enceinte one front .... metres	450	492	640	612
Do. of ravelin do. .... do.	510	460	560	340
Counterscarp of enceinte, 1 front	420	376	540	550
Do. of ravelin	520	600	620	480
Subterraneous communications to the works	120	190	330	350
Do. do. round the counterscarp, &c...	580	690	1080	1100
Number of fronts required for the salient of the ravelin to defilade the enceinte from the first ricochet batteries	8	40	8	11

Observations on the above Details.

The interior space of each system is calculated to the foot of the rampart of the curtain, continued across the half gorges of the bastion. The upper flanks, except in the Prussian system, are exposed to shells, but those, as well as the lower flanks of all, are casemated. Besides the flank to the ravelin from the enceinte, as stated, the Prussian system gives an additional fire in the ditch of four guns, while the French enceinte may be breached by batteries on the salient of the ravelin, and the ditches of the others proposed are too remote to be well flanked.

In the lengths of escarps as stated, a deduction of one third is made for the redoubt and tenaille of the French, and for the curtains of the other tenailles, to allow for the difference of profile.

The communications round the counterscarp are much more necessary in Bousmard's and Chasseloup's systems, than in the others, in which they are only used for countermines; and a much cheaper plan is shown on the salient of the ravelin, in the plate, which would not be above one-fifth of the expense.

The above statement refers to Chasseloup's small system, which, from its dimensions, could be most easily compared with the others; in the large, having fronts of 590 metres, the enceinte is better protected from ricochet fire than that of Bousmard, and the flanks are obtained from caponières; but the great length of this front would prevent the use of it being very generally adopted.

It appears from the details given of the Prussian system, that great means of resistance are obtained at a comparatively small expense, which means might be increased, when required, by cavaliers, by interior intrenchments, and by a covered-way with redoubts. The armament required would also be comparatively small, as in the flanks, which completely enfilade the main ditches at a short range, a few pieces only would be necessary, to prevent a coup-de-main, while a full supply to resist a serious attack might be brought, by easy and secure communications. A few guns, placed on the salients of the ravelins, would be sufficient to keep off an enemy until he had broken ground, when the whole disposable guns of the place might easily be brought upon the enceinte on that side, and the second part of the collateral ravelins. The fatigue attending the usual arrangements would be also greatly diminished by this easiness of access throughout: the garrison therefore need not be numerous, as they are not required to expose themselves in outworks beyond the main ditch; they are protected by casemates in the flank defences (which are sufficiently strong to allow of their concentrating nearly the whole force on the points of importance), and being generally moveable and concealed from the enemy, do not give known or fixed points to his vertical fire.

IX.—*On Contoured Plans and Defilade.* *By Lieutenant* HARNESS, *Royal Engineers.*

ALTHOUGH horizontal contours have been, for some time, very generally used by our officers in the representation of ground, the operations that can be performed on an accurately contoured plan were almost entirely unknown to us, until Captain Macauley, about three or four years ago, published some problems connected with the subject, in the Appendix to his work on Field Fortification.

The practice of designing works, by the use of such plans alone, has however been long common in France; instruction in this art forming one branch of the course at the school of application for her engineers at Metz. It would be presumption, therefore, to endeavour to give a new arrangement to the subject; and the only object of this paper being to make the methods invented and employed by the French more generally known, it is principally taken from a Memoir, by Captain F. Noizet, to be found in the sixth number of the "Memorial du Génie."

To describe an object by contours, is to trace on its plan, in their proper relative positions, a number of horizontal sections of such object, and these are generally taken at equal vertical intervals. In the drawings prepared for forming the design of a fortification, the ground is thus represented, the level of each contour, or of any particular isolated points, being given in figures, above or below some assumed plane of comparison; and, since the horizontal and vertical position of every point can then be at once discovered, ordinary sections are unnecessary. In the progress of the design, it becomes necessary to consider the different planes of fire, and planes of defilade; to represent each of these planes by contours also would create confusion; a line, for each plane to be considered, is therefore drawn in any convenient part of the paper, and generally in the direction of the slope of the plane: this line, being graduated, or marked at the points where the contours would intersect it, forms what is called the scale of the plane.

A right comprehension of these scales of slope, is the most essential point towards acquiring the power of using contoured plans; and taking it for granted, therefore, that there is no difficulty in understanding that, in designing a work, it is necessary to consider the different planes mentioned, a more minute description of the method employed for defining them shall be given.

In order to describe exactly the position of a plane, three elements should be given, viz.: the direction of its slope, its inclination to the horizon, and the level of some point on its surface. In expressing a plane by horizontal contours, which are evidently perpendicular to the line of greatest slope, the direction of the slope is indicated. If the contours be drawn at regular vertical intervals, and the same vertical unit be employed throughout the drawing, they will be nearer together in the steep than in the gentle slopes, their distance asunder being in fact the base due, with the slope represented, to the given vertical unit: thus, if that unit, or the difference of level between the contours, were 2 feet, and the slope 1 in 5, the distance between them in plan would be 10 feet; if the slope were 1 in 20, their horizontal distance asunder would be 40 feet: the degree of slope is therefore indicated. Lastly, the position of the plane in space is determined by giving, in figures, the level of one or more of the contours. Now the scale of a plane gives all the above elements without covering the paper with lines: the divisions on that scale, agreeing with the horizontal intervals between the contours, express, exactly as they would do, the inclination of the plane; the direction of the slope is shown, almost invariably, by that of the scale, or, if this be drawn obliquely to the slope, by the direction given to the graduating lines, which are in fact small portions of the contours of the plane; and the position of the plane is finally given by putting the numbers, corresponding to those contours of which the graduating lines are portions, to the scale.

In illustration of the above, *fig.* 1 represents by contours, at vertical intervals of $\frac{1}{16}$ of an inch, a triangular pyramid standing on a plane inclined at 15°; its sides, in the supposed position, having inclinations of 30°, 45°, and 60°: the scales of the several planes comprised in the figure are also given, and *a b* is an oblique scale of the plane to which it applies.

The geometrical constructions that can be performed on contoured plans are numerous; the general principle of scales of slope being, however, once rendered familiar to the mind, these are so easy as hardly to deserve to be divided into problems; and it will be sufficient, before passing to their application, to mention a few of them only.

1. The inclination and direction of the slope of a plane passing through three given points A, B, C, *fig*, 2, which are not in the same straight line, may be found by so dividing the line A C, joining the highest and lowest of the given points,

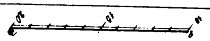


Fig. 1.

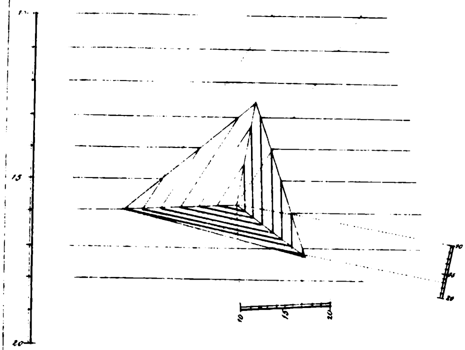


Fig. 2.

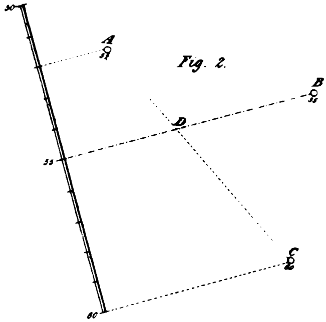


Fig. 3.

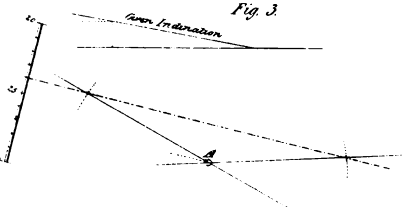


Fig. 4.

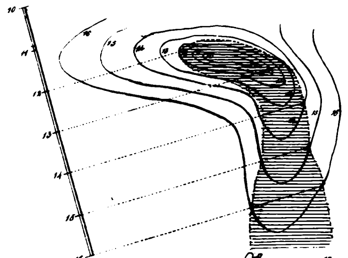


Fig. 5.

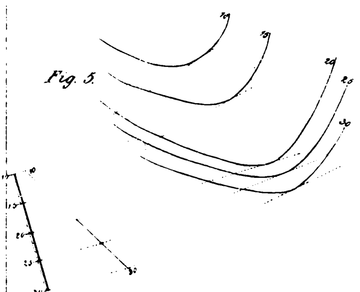
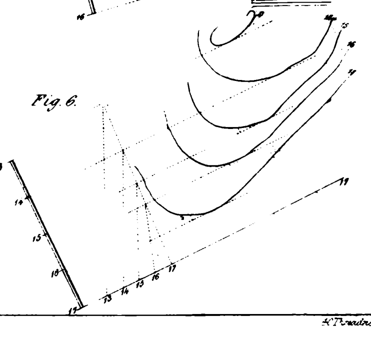


Fig. 6.



that the two parts may bear the same proportion to each other, as the numbers expressing the difference of level between the third, or intermediate point, and each of the other two: that is, making $AD : DC :: A \backsim B : B \backsim C$; the point of division D will then have the same level as B, and the line B D will be a horizontal of the plane required; lines parallel to it, drawn through A and C, will give two more horizontals of the plane; by dividing the spaces between these into as many parts as their differences of level may render necessary, and by continuing to trace them at the intervals thus ascertained, any number can be given; or by drawing a line in any convenient part of the paper, intersecting a few of these horizontals, and retaining just so much of each as may be sufficient to mark their direction as well as the points of intersection, adding their respective levels, a scale is substituted for these lines, and data preserved for employing the plane in succeeding operations.

If three points are in the same straight line, an infinite number of planes may be made to pass through them; but if their projections in plan are in one line, and the points themselves are not, only a vertical plane will do so.

2. If it be required to find the scale of a plane, which shall pass through two given points and have a given inclination, the inclination at once determines the interval, in plan, between two contours of which the difference of level is given; it therefore determines the interval, in plan, between the contours passing through the two given points; and the problem is completed by drawing, through the given points, two lines parallel to each other, and having that interval between them: having thus obtained two contours of the plane, the scale is readily made. If the distance between the points be less than the necessary interval between the contours passing through them, with the given inclination for the plane, the problem is impossible; and, when possible, it always admits of two solutions: for if, in order to draw the contour lines at the required distance asunder, an arc be described, with one of the given points as a centre and that distance as a radius, two tangents can be drawn to such arc from the other point, one on either side of that employed as the centre.

3. The scale of a plane which, passing through a given point, is parallel to a given plane, is easily found; for, in direction and in the length of its divisions, it would be the same as that of the given plane, differing only in the numbers applied to those divisions, which must be altered to correspond with the level of the given point.

4. If it be required to find in a plane, given by its scale of slope, as in *fig.* 3,

a straight line, which passing through a given point in that plane shall have a given inclination, but less than that of the plane; trace a contour of the plane, having any convenient difference of level above or below the given point; and then, with that point as a centre, and with the base due, with the required inclination of the line, to the assumed difference of level as a radius, describe an arc cutting that contour; the line, drawn through their intersection and the given point, will evidently have the required inclination. This also admits of two solutions, since the arc will cut the contour line in two places.

The difference of level between the point and the assumed contour is shown by the scale of slope, and being taken off from the scale of the drawing, is applied to the given angle of inclination. In order not to have to judge the value of small quantities on these scales, a point may be assumed on one of the contours, and a line having the required inclination be drawn through it; another, parallel to this, and passing through the given point, will be that sought. The vertical unit, or distance between the contours, in *fig.* 3, is $\frac{1}{16}$ of an inch.

By the above, a road up the side of a hill, represented by contours, could be so traced as not to exceed in any part a given inclination.

5. The intersection of two planes is found by producing, until they meet, two or more contours, having corresponding levels of each; the line joining the points of meeting must be that of their intersection; or if one of the planes be horizontal, their intersection will be that contour of the inclined plane which has the level of the horizontal one; or if the contours of the planes be parallel, the direction of their slopes being the same, their intersection, being a horizontal of each plane, will be known if one point in it be found; such point may be determined by making a vertical section through the planes; or by assuming a third plane, and marking its intersection with each of the others, the meeting of these two lines of intersection being the point required. Assuming a third plane is of course merely drawing two lines parallel to each other, in such direction, with such interval, and such levels assigned to them as may be convenient. When the contours are nearly parallel, two such planes can be employed to find the intersection, one point in the line required being obtained by each.

6. By the use of an auxiliary plane, as above, the intersection of a line with a plane is easily found: in this case the plane is assumed passing through the given line, and the line of intersection of the two planes cuts the given line in the point required.

7. Through two given lines, two planes may be described parallel to each

other; for, through a point in one of them, a line being drawn parallel to the other, the plane which passes through the lines that meet will be one of the two required; and a plane described parallel to this, passing through the other line, will complete the operation. If the two lines are parallel, there are evidently an infinite number of such planes; and if the lines intersect each other, or would do so if produced, the solution is impossible.

8. It may be required to draw, through a given point, a perpendicular to a given plane: now it is sufficiently obvious that the direction of such perpendicular must be at right-angles to the contours of the given plane, and also that its inclination to the horizon must be the complement to that of the plane; the base, due to a given rise on the one, will be equal therefore to the rise due to a given base on the other; and on this principle the line, after being drawn in the required direction, may have its levels determined; for if a second point be taken, by setting off upon it, from the given point, any convenient number of the vertical units employed, the horizontal distance due to the assumed number of vertical units on the given plane will be the difference of level between these two points.

9. A plane may be described perpendicular to a given line; the given line being considered the scale of a plane, another line is drawn perpendicular to it, as above; the latter will be the scale of the plane required.

10. A line may be drawn, through a given point, perpendicular to a given line, by describing, through the former, a plane perpendicular to the latter; the line joining the given point, and the intersection of the line and plane, will be the perpendicular required.

11. The angle made by two right lines may be measured by drawing, through any point in one of the lines, a perpendicular to the other; this will be the tangent of the angle, the distance between the foot of the perpendicular and the angular point being considered radius.

12. In like manner, if it be required to measure the angle at which a right line is inclined to a plane; a perpendicular to the plane, from any point in the line will be, as before, the tangent of the given angle.

13. The angle made by two planes may be measured by drawing in each plane a line perpendicular to their common intersection at the same point, and finding the angle made by those lines.

Constructions similar to the preceding, may be performed when the waving contours expressing the ground about the site of a work are a part of the elements employed. The surfaces they represent being considered to be made up of many planes, it may appear unnecessary to repeat them; but there are some too important to be left to the ingenuity of the officer who may wish to apply them.

14. The intersections of the horizontals of any plane, with the contours of a given surface, at corresponding levels, show, as in *fig.* 4, what part of such surface rises above that plane. By performing this operation with the planes of defilade of existing works, it is discovered from what places such works may be seen into: by it also may be determined the meeting of a glacis, or other artificial slope, with the natural ground.

15. But the problem principally required in perfecting the designs for works of defence upon irregular sites, is that by which their planes of defilade, or their imaginary planes of site, are determined. The conditions to be fulfilled in these cases are, generally, that the plane shall pass through a given point or line, and be either a tangent to a given surface, or pass at a certain height above it, which is the same thing, since it is only necessary to consider the surface raised by that quantity, increasing the given level of each contour by the required number of feet.

If then it be required to find the plane which, passing through a given line, shall be tangential to a given surface, it is only necessary, when the line is inclined, to mark, (producing it, if necessary,) the points having the same level as the contours of the given surface, as in *fig.* 5; and then to draw, from each of these points, a tangent to the contours on the same level with it; the tangent which makes the smallest angle with the lower part of the given line will be a horizontal of the plane. For it is sufficiently evident, that the planes, of which the lines thus drawn are the respective horizontals, would meet the surface at the points where these horizontals touch its contours, and that when the position of the given line and arrangement of the given surface are such that the required plane must rise from the given line, the steepest of these planes will leave the given surface below it everywhere, except at the point of contact; and that plane, of which the horizontals make the smallest angle with the given line, must be the steepest, for their distance asunder is then smallest: but when the disposition of the line and surface is such that the required plane must descend from the given line, it will be that of least inclination, and then the line which makes the greatest acute angle will be a horizontal of the plane required.

Now in the first case the tangent will make an acute angle with the lower, and in the second case with the upper part of the given line; it follows therefore that the tangent which makes the smallest angle with the lower part, as above stated, is always the horizontal sought.

Or, if the given line be horizontal, a tangent parallel to it should be drawn to each contour of the given surface; and then, by making a vertical section through these tangents and the given line, it will be seen through which the required plane must pass in order to leave below it all the others. This, however, may be ascertained without making a vertical section; for, as before, it is evident that it must, according to the arrangement of the levels of the line and surface, be either the most, or the least inclined of the several planes, passing through the given line and one of the tangents to the contours, that will leave the surface entirely below it; and that in the first case the tangent whose height above the given line is greatest, in proportion to its distance from it, must be a horizontal of that plane; while in the second case, when the given line is higher than those parts of the surface at which the contact is likely to take place, the plane of least inclination will fulfil the condition required, and the tangent whose difference of level below the given line is least, in comparison to its distance from it, will be a horizontal of that plane. A method for ascertaining which tangent should be adopted, without a vertical section, was first proposed by Captain Noizet, in the paper already referred to. He traces through any point in the given line, as in *fig.* 6, a line cutting the tangents drawn to the contours of the surface; he then sets off upon the given line, beginning from the same point, distances proportional to the several differences of level between the given line and each contour; which operation, when a constant vertical interval has been preserved between the contours, is merely setting of a number of equal parts along the line: to these points of division he applies the numbers of the several contours, beginning from the point first assumed, which retains the level of the given line, and joins each with the point where the line drawn cutting the several tangents, intersects that having the corresponding level. Then, similarly to the former case, the line making the smallest angle with the given horizontal, on the side where the numbers denoting the lowest levels are affixed, meets the tangent through which the required plane must pass.

If the plane be required to pass through a given point and to touch a given surface, it is obvious that there will always be several planes which may fulfil these conditions; in practice, however, it would generally be desirable to adopt, for a plane of site, or defilade, that which has the least inclination. To find this plane, draw through the given point, as in *fig.* 7, several lines cutting the contours of the given surface, and graduate them in such manner that they may be tangential to that surface; this may be done by making a vertical section on each line, and then determining its proper inclination; or by a method similar to that described above, for finding which tangent was the horizontal of a plane required to pass through a given line and touch a given surface. A line being assumed in the present case, on which to set off the divisions, each line to be graduated may represent in turn the secant to the several contours and tangents, and the points of intersection with the former, be joined to those of division on the assumed line, having corresponding levels: the line of junction making the least angle with the descending side of the assumed line will determine the point of contact with the surface, and consequently the level of a second point upon the line to be graduated.

The several lines having been so chosen that any plane passing through two, adjacent to each other, would not cut the intervening surface, having been in fact drawn in those situations where the contours, curving towards it, approach nearest to the given point, and being graduated by one of the foregoing methods, it only remains to find the plane of least inclination, which passing through one or more of these lines shall leave the others below it. For this purpose, join the points having any assumed level on each line, to those of corresponding level on the adjacent lines, and form in fact a horizontal section of the solid angle defined by them; of the tangents that can be drawn to that section, leaving every part of the latter on the opposite side to the given point, that which makes with the graduated line passing through the point of contact, an angle most nearly approaching to a right angle, will be a horizontal of the plane required.

By the foregoing processes, or others so closely resembling them as to be easily discovered when the mind has become familiar with the subject, the trace and relief of works may be arranged for the most complicated sites, from the data afforded by contoured plans alone. The engineer would not however confine himself to the use of constructions adapted only to a horizontal projection, but employ vertical sections, or for obtaining dimensions accurately, calculations, as his judgment might think fit.

It of course is not intended in this paper to discuss the principles which should be observed in occupying a given site. The first idea of such a project must be varied according to the object to be fulfilled, and it would vary yet more with the genius of its author.

The general arrangement of the trace however being decided, that of the reliefs may be completed almost by rule, so as to fulfil the different conditions required in the design of a fortress, viz.: that it shall defend the ground within reach of its arms; that every part of the ditches shall be defended; that all the works in advance shall be defended by those in rear; and that the whole shall be properly defiladed.

The steepest planes of the ground intended to be seen by any particular part of the work, being produced to their intersection with the vertical planes passing through its interior crest, at once point out the smallest command by which the first condition can be fulfilled; the two next require no comment, an ordinary section will at once determine the greatest admissible difference of level between the nearest point of a ditch or terre-plein to be defended, and the crest of the work defending it. The methods by which the last condition is complied with shall be more fully described.

Of Defilade.—When irregular ground has to be occupied, an imaginary plane of site is sometimes employed to facilitate the operations required in arranging the defilade; this plane is generally tangential to the most commanding points, leaving below it all the ground about a work, and at the same time reducing to an even surface the intended site, either of the whole work, or of the part under consideration, or so cutting it as to equalise the remblai and deblai required for the construction. The plane of defilade is that which, passing through the covering line of a work, leaves at a sufficient distance below it all the neighbouring ground. When these two planes are parallel, the different parts of a fortification may be said to have the same relation to each other and the surrounding country, as if constructed according to the usual supposition in elementary descriptions upon horizontal ground.

When the slopes about the site are very gentle, the points of command few, and but slightly raised above the intended work, an inclined plane as above may be adopted for the plane of site, and the reliefs and depths of ditches, which would have been suitable on a horizontal site, assigned to the different parts above and below it. But, when the slopes are steep, or the points of command elevated, it will become impossible to keep the two planes parallel, and the height at which the plane of defilade passes above the ground, must be less than the command of the work above the plane of site, in order to keep the relief within reasonable limits, and prevent inconvenient inclination in the terre-pleins; these considerations rendering it sometimes necessary to adopt in the same work, and even in the same face of a work, different planes of defilade. In this case, then, such planes should pass at least 8 feet above the highest but rather distant parts of the natural ground, or $3\frac{1}{2}$ feet above those parts which an enemy could not occupy without forming defences, including the parapets of advanced works within range of musquetry; the same considerations that fix the minimum command of parapets above a horizontal site, determining the vertical distance between planes of defilade and the points accessible to a besieger.

The first operation in defilading a work is to trace the limits within which an enemy can fire into it. If the work be isolated, or if the relief of other works with which it is combined be insufficient to cover it in any direction, arcs described with each salient as a centre, and the extreme effective range of the weapons likely to be used, generally 1500 or 1600 yards as a radius, will define these limits. But, if other works by their relief would intercept the view from a part of the surrounding ground, lines should be drawn through the most advanced points, both of the work to be defiladed and such protecting masses; and whatever portions are thus ascertained to be of no consequence, so far as direct fire is concerned, may be entirely disregarded in arranging the defilade; care being taken, however, to observe whether the protection afforded by another work is not merely partial, and whether from behind it, or over some part of it, that under consideration may not be exposed.

The whole of the exterior space, from which it is required to defilade a given work being marked out, the mode of proceeding will vary a little according to the conditions to be observed.

The trace and relief may be already determined; this would be the case when existing works were to be more perfectly defiladed: or the plane of defilade may be required to pass through a particular point or line, as when the position of some part of the crest cannot be varied; or when it is required to keep the plane of defilade a certain quantity below some works in rear; or when it is necessary that a communication, or the masonry of some part of the defences, should be covered: or, lastly, as must happen in cases where the greatest latitude is allowed, the form of the ground, and the adjustment of remblai and deblai, may fix a maximum and minimum command above the actual site, which must be attended to in choosing a plane of defilade.

Let it be supposed, then, that a work of two faces, forming a salient angle, has its crest finally determined. If the plane passing through that crest either cuts or leaves at less than the proper distance below it, any portion of the ground within the prescribed limits, the defilade must be arranged by sloping the terre-

Fig. 7.

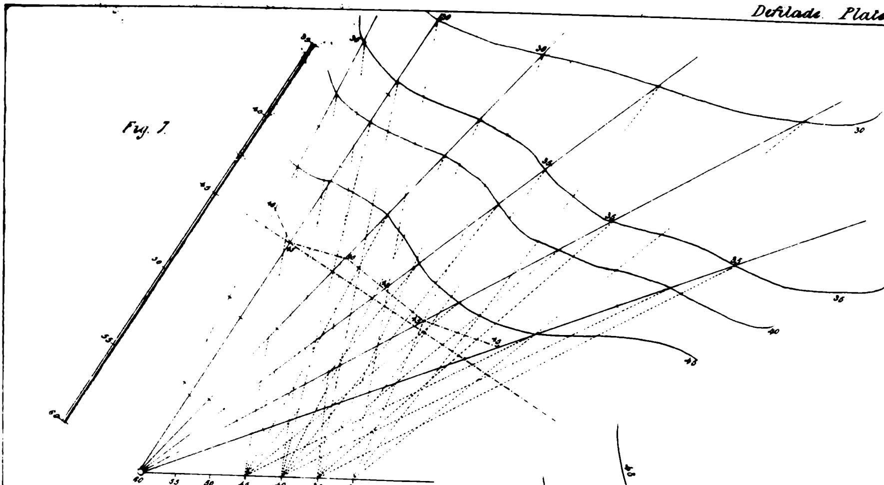
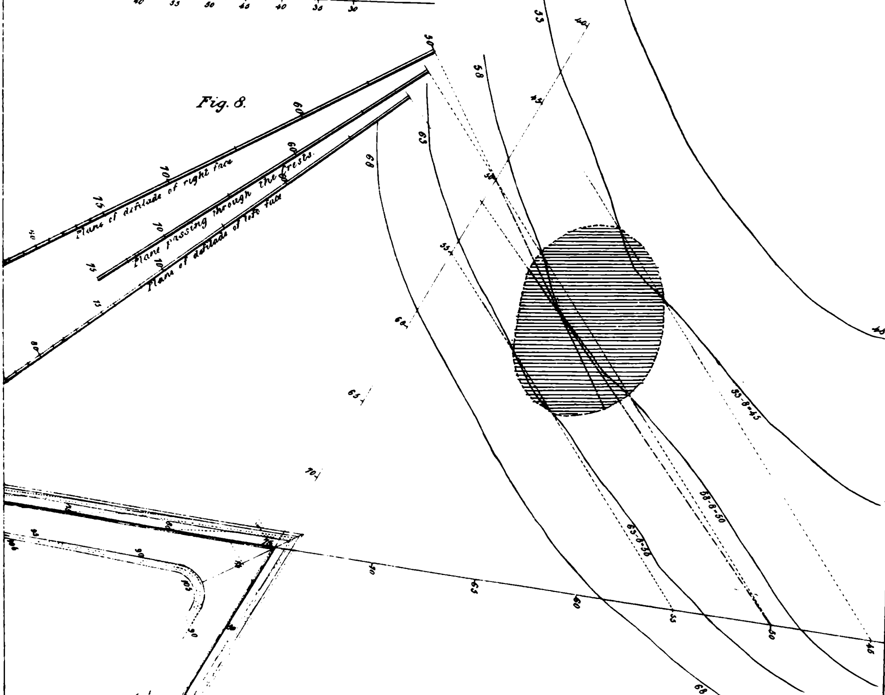


Fig. 8.



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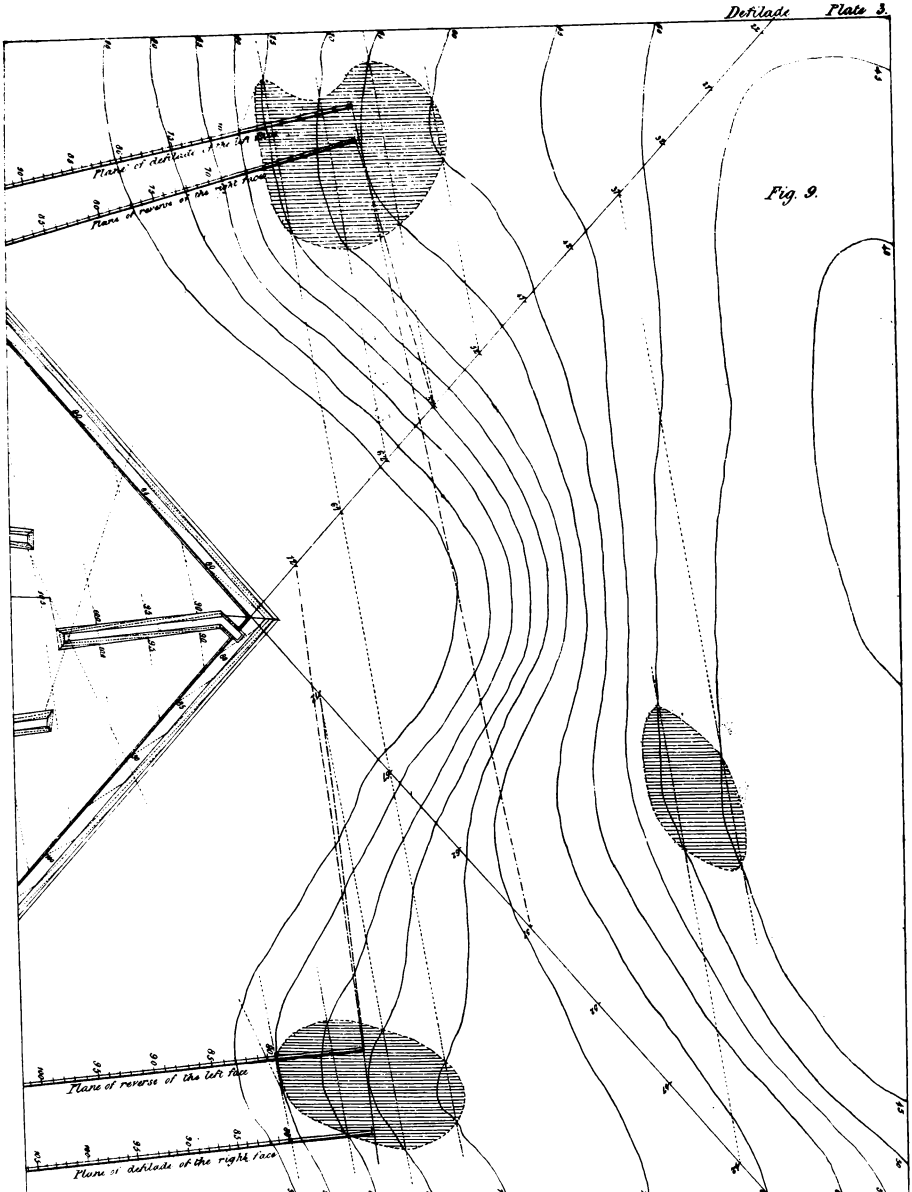

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pleins, or, if that be impossible, by traverses. If the points, which too nearly approach or rise above the plane of the crests, are all included between the produced faces of the work, as in *fig.* 8, neither face will be seen in reverse from such points, and by defilading each independently the whole interior of the work will be concealed: it will only be necessary to find, for each face, that plane which passing through its crest shall leave all the ground in front at a proper distance beneath, and then, by constructing the terre-pleins parallel to these planes, forming by their intersection a valley from the salient towards the gorge, the whole will be perfectly covered. Or if the terre-pleins would be thus rendered inconveniently steep, they must be lowered near the parapet, so as to obtain the same cover with diminished inclination.

If, however, the points from which shelter is required do not lie between the produced faces of the work, one of them at least, since the crest by the assumed conditions cannot be raised, will be exposed to reverse fire, and traverses must then be resorted to, as in *fig.* 9. Their positions should be so chosen as to cause the least inconvenience, and their heights determined by the plane which, passing through the crest of the face they are intended to protect, leaves at the required distance beneath, all the ground seeing it in reverse; if both faces are thus exposed, there will be two such planes of reverse, and if one traverse be constructed to cover both faces, it must of course be carried up to the highest of those planes.

A single traverse is generally sufficient, and when required only for the protection of one face, its height may obviously be made less in proportion as it is constructed near that face; leaving, therefore, sufficient space for the defenders, it may be traced parallel to the parapet until it approaches the salient, and then, in order not to impede the defence by filling up that angle, it may be turned, its height being increased, upon the second face: the traverse near the salient in *fig.* 9, shows this arrangement.

If both faces are thus exposed, the intersection of their planes of reverse marks the situation where the smallest single traverse would be sufficient, and the nearer it can be constructed to that line, the less will be the labour of its formation. But, when the faces of the work are long, and the interval between them becomes considerable at a distance from the salient, a single traverse would probably require to be raised so high, that more earth would be used in its construction than in making one for each face. In such cases, for the part near the salient, or as far as it is advantageous, a single traverse should be employed: for the remainder of the work, one for each face, as in *fig*. 9.

When the work is narrow, as a counterguard or covered way, it may be impossible to construct a single traverse capable of covering each face; several must then be employed, care being taken that any shot which would just pass one traverse shall be intercepted by another.

Lastly, when the commanding points of the ground fall on or nearly on the produced faces, a bonnette at the salient, or traverses across the terre-plein, a different plane of defilade being employed for the part in rear of each, must be resorted to; and when the work is exposed at its gorge, a parados must be constructed there, of such length as may be necessary, and of sufficient height to cover the whole terre-plein as far as the salient.

The directions of the different traverses should always be so chosen, that they may not afford shelter to an enemy from works in rear; and when these masses are intended to afford lines of fire, as with those in the covered-way, their crests must not rise above the plane of defilade of the work in which they are constructed.

The defilade of a work already constructed, leads easily to the methods to be adopted when the reliefs are undetermined, but certain conditions have to be fulfilled. It should first be seen whether a plane cannot be found which, fulfilling the requisite conditions, shall pass at the proper distance above all the surrounding ground; the work can then be defiladed without further difficulty. But, if this cannot be done, it should be ascertained whether a plane cannot be found, still fulfilling the required conditions, passing at a sufficient height above all the ground, except such parts of it as are included between the produced faces of the work, as in *fig*. 8, supposing a work of two faces to be under consideration, as before: adopting then such plane as that of defilade for the work, each face must be seperately defiladed by its terre-plein, from the commanding points included within the produced faces. If, however, a single plane cannot be found as above, or if such plane would be impracticable from its steepness, two planes of defilade must be employed, as in *fig*. 9, one for each face, the conditions being observed by both planes, if necessary, as when the relief of the salient is in question, or partly by each, as when some points of a work in rear are to be covered; and in this case traverses must be introduced, as before described, for completing the operation.

It may happen that a single plane cannot be found for one face even, without giving it so great an inclination in the direction of its length, that the relief at one extremity would be excessive, or that at the other inadmissibly small; in this case, each face must be defiladed by steps, the different portions rising above each other by such quantity as may be found convenient.

The above appear to be all the considerations required to be pointed out; they may be briefly recapitulated by saying, that the face of a work commanded by ground in front, in rear, or on its prolongation, can be defiladed from the first by its terre-plein, from the second by a traverse, or parados, or by giving it the same plane of defilade with some other face lying between it and the point of danger; in the last case, unless the commanding ground is but little elevated, or the face under consideration short, traverses must be resorted to, and the defilade completed in portions.

In defilading a fortress composed of several bastion fronts, it should first be seen whether a plane could not be found which, reducing to an even surface the intended site, would be tangential to, or at least would not cut by more than 2 or 3 feet, the surrounding ground. If such plane could be obtained, it should be considered as the plane of site, and the commands, &c. be regulated from it according to the proposed profiles. If such a plane could not be found, either for the whole or any very considerable portion of the work, the exterior sides might be considered two and two, as two faces of a work have been above, but it would generally be necessary to defilade each separately.

Until lately, the mode of proceeding in this case was by endeavouring to obtain a single plane of site for a whole front, or, if that proved impossible, from the existence of high ground upon its flanks, two planes of site, meeting on the capital of the ravelin, were employed: it is now, however, judged expedient, wherever two or more fronts of a fortress cannot be arranged upon a common plane of site, to consider each part separately. The limits of command for a bastion being chosen, from considering the ground to be seen by it, and the equalisation of remblai and deblai, the defilade of that bastion should be completed. So far as its faces are concerned, this operation would be similar to one of those already described; but its flanks might either have the same plane of defilade as the faces they respectively join, or have their crests determined by the plane passing through both faces, or have distinct planes of defilade; the principles already laid down being quite sufficient to determine in any case which of these arrangements should be preferred: but it may be mentioned here, that if protection from reverse fire be required for the flanks and faces of a bastion, the construction of a cavalier will generally prove the most advantageous mode of obtaining it.

Beginning, generally, with the covered-way or most advanced line of defence, its different faces may be defiladed, two and two, as above described, assuming as conditions a maximum and minimum command. After this is completed, the defence of those in front must be attended to in defilading the works in rear, as they are taken in succession. Thus, the covered-way being determined, the ravelin would be considered, its command being nearly fixed by the necessity of defending certain portions of the ground, and also its own covered-way: next, each bastion may in like manner be separately defiladed, and then the curtain, the crest of which will have been decided by the preceding operations.

The foregoing principles of course apply to field-works also, but these would almost invariably be defiladed on the spot, by some such method as the following: erect a picket at each angle, and nail two slips or fingers across it, one at the maximum, the other at the minimum command that can be allowed to its parapet; with the assistance of a straight edge, or by stretching a cord between two or more of the pickets, and varying its position, it will be readily seen what plane or planes of defilade can be obtained within the prescribed limits. If these planes are likely to prove steep, and it be therefore desirable that they should not pass above the surrounding country more than is absolutely necessary, the height at which they are required to pass, should be deducted from the maximum and minimum command of the parapet, and the slips nailed across at this reduced level; a plane tangential to the ground should then be chosen, and the crest of the parapet will be everywhere higher than that plane, by the quantity previously deducted.

The limits of defilade for field-works are different to those assigned above for permanent constructions. It is generally considered sufficient if they afford cover within the distance of 700 or 800 yards, their planes of defilade passing about 4 feet, or the height of a field-piece above such points as are out of musquet shot, and 8 feet above the ground within range of the fire-arms of cavalry.

The defilade of a work, although it is absolutely necessary that it should be perfect, is nevertheless so completely secondary to the other considerations which determine the trace, that it can rarely, it may almost be said that it can never happen, that the trace most favourable for defilade can be given to the enceinte: the method proposed however for ascertaining the general arrangement of such trace is worth alluding to.

Assuming some point nearly in the centre of the space to be occupied by the works, and through which it appears convenient that the planes of defilade should pass, find the most advantageous plane or planes passing through it, and also at the due distance above the surrounding ground; these will represent nearly the easiest planes of defilade that can be obtained; and their intersections with two surfaces parallel to the site, but higher than it by the quantity assumed as the maximum and minimum command, will give two outlines enclosing a belt or zone, within which the trace should be confined.

The above rule is founded on the supposition that the best trace for a given site is that in which, when defiladed, the commands are most nearly uniform; and although it may be impossible to attend to it throughout the whole of a design, there will generally be some parts where its principle can be observed.

If a line of works were to be constructed on horizontal ground, in front of a commanding ridge also horizontal, it is evident that the intersection of a descending plane, resting on that ridge, with the ground, would be parallel to the ridge; and therefore, to obtain when defiladed a uniform command, the general direction of the works should be parallel to it. If the ridge were higher at one end than at the other, the horizontal of the descending plane, resting on it as before, would recede from the higher, approaching the lower extremity; its intersection with the supposed site would therefore do so, and such should be the direction of the trace. If the ground to be occupied had an inclination either from or towards the heights, but in such directions that its contours were parallel to those of the plane assumed as above, the trace would be the same as on horizontal ground; but if the contours of the ground were inclined to those of the plane, the trace should recede from the ridge as it descends upon the site.

This paper being written for the purpose of drawing attention to the advantages resulting from the use of contoured plans, rather than discussing fully a subject connected with fortification, might here be concluded; but as it may be said that there is great difficulty in preparing such plans, while in fact they are as easily executed as those now required, where numerous vertical sections are substituted for a single drawing, a brief description of a mode of obtaining them shall be added.

Trace, by placing a picket at each extremity, one at the upper another at the lower, those lines which best define the ground, or every sensible ridge and valley, and as many others as may be convenient when the surface is curved without any apparent angles. Fixing then a level in a good position, over one of the points in the contour to be traced, and where a tolerable length of it can be seen, send an assistant with a levelling-staff set to the height of the instrument, to stand between the pickets of the nearest line traced out, a second assistant keeping him in the line of those pickets, while the observer at the instrument moves him by signal up or down the slope, until they are on the same level: having marked this point, the first assistant places himself between two other pickets, and the operation is repeated until as many points have been marked as can be observed with one position of the instrument, when another is chosen.

The required number of contours being thus traced out, it is only necessary to fix the extremities of the different lines with reference to each other, and to measure them horizontally, noting the different marks laid down.

The general plan for forming a design may be made to a scale of about 200 yards to an inch, with contours at vertical intervals of about 5 feet; but it is not necessary that all the ground within the limits of defilade should be contoured; the whole of the immediate site of the work should be thus described, and any slopes in the vicinity which might affect the command independently of defilade: with respect to the heights around the work, it will be sufficient to give a few contours of each, beginning from their summits, and of course on the side towards the plane alone; the levels of a good many points of the remaining space should then be added.

Such a plan being employed for the general design, the details of each front may be completed on similar drawings, made to a scale of about 30 yards to an inch.

X.—*Report on the Manchester, Cheshire, Staffordshire, and the South Union Lines of Railway (by order of the Master-General and Board of Ordnance.) By Captain* ALDERSON, *Royal Engineers.*

London, 24th April, 1837.

SIR,

IN obedience to the orders of the Master-General and Board, dated 20th March, 1837, to report on the general nature, in an engineering point of view, of the two competing lines of Railway, the one promoted by a company called the Manchester, Cheshire, and Staffordshire Railway Company, and the other by a company called the South Union, I have the honour to report, for the information of the Master-General and Board, as follows:—

Both lines commence from the same terminus, nearly, in Store-street, Manchester.

The situation appears to me well chosen, it is central, and the part of the town through which the lines propose to pass consists of buildings of comparatively small value.

Each line commences with a viaduct, extending from the terminus to the end of the town, and crossing the river Medlock in its progress.

The Manchester, Cheshire, and Staffordshire line then crosses the turnpike-road to Sheffield, about $1\frac{1}{4}$ mile from the terminus, without altering its present surface, and passing the Gorton brook, leaving Longsight on its right, crosses the road to Stockport, which is to be lowered 9 feet 3 inches.

It thence, leaving Levenshulme to its right, comes to some considerable cutting, which can be employed in filling up the valley of the Mersey, which river it crosses by a viaduct, eight chains below Brinksway-bridge, being within the borough of Stockport.

The line then crosses the road from Stockport to Cheadle, which is to be lowered 22 feet, and comes into a considerable embankment for near two miles, which is followed by an equal portion of cutting, from which the embankment may be formed.

It then crosses the river Dean, and continues in cutting till it arrives at the river Bollin, which it crosses about ten chains above the town of Wilmslow: both these streams are inconsiderable, and have stone bridges across them near these places, of one arch each.

After crossing the Bollin at Wilmslow, the line runs on favourable ground till it arrives at the river Dane, at the town of Congleton; where a viaduct of considerable length will be required, on piers varying from 50 to 100 feet in height, passing over the river, valley, and main street of Congleton.

This work is the greatest, in an engineering point of view, on this half of the line; it presents, however, no difficulties, the banks of the river affording good foundations for the piers.

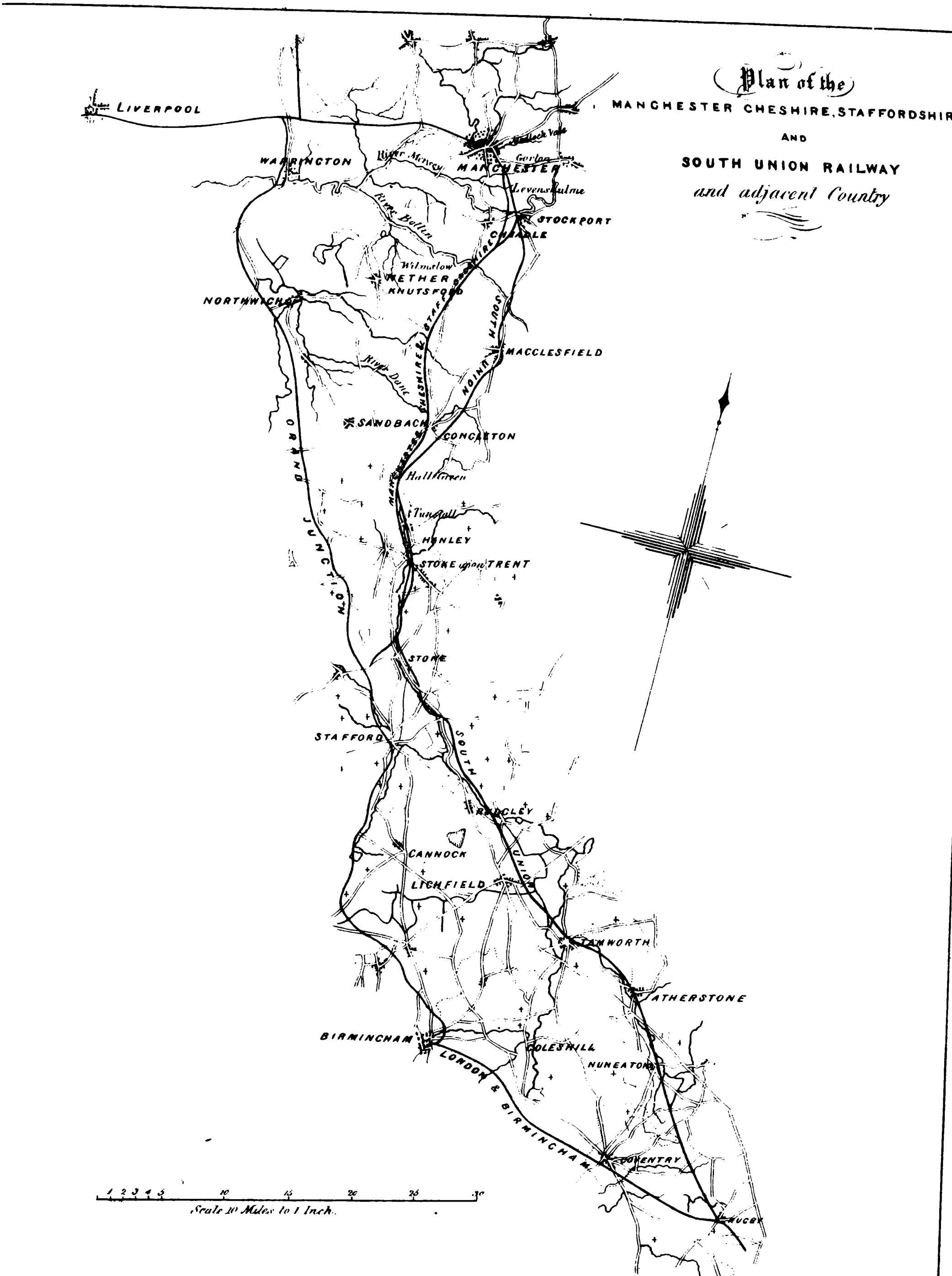
The line then continues in a straight line to Oak Farm, within about 300 yards of the Macclesfield Canal, to which it runs nearly parallel, till it arrives at Hall-green, when it crosses the canal at a considerable angle, taking a more direct course to its summit level at Harecastle Pass, when it again runs close to, and between the canal and New Church at Woolstanton, and commences its tunnel of 440 yards in length near to the lodge of Clough Hall, and arrives at its summit level 440 yards beyond the tunnel, in heavy cutting, averaging 35 feet in depth, in 29½ miles, having risen 290 feet; its greatest inclination being 1 in 378, or 14 feet to a mile.

As both lines meet at this point, I propose to consider their relative merits to it in the first instance.

The South Union line, from the end of the viaduct at Manchester, runs on the east side of the turnpike-road to Stockport, about 12 chains distant, and nearly parallel to it for 3¼ miles, when it crosses the road, which has to be lowered 7 feet, and goes direct for Stockport, having been for the last mile in cutting averaging about 14 feet deep; it then crosses the river Mersey, about eight chains below the Wellington-bridge, by an extensive viaduct on piers, between 80 and 90 feet above the level of the river, and passing over some of the buildings in the town, situated on the sloping banks of the river; at the upper end of the town it goes into cutting for about 3 miles, followed by embankments and cuttings alternately.

Within 2½ miles of Macclesfield, there are some short steep hills to be cut through, and one tunnel of 200 yards in length; after which it crosses the river Bollin, which, 1½ mile back, has to be diverted or otherwise twice crossed; after cutting through another short steep hill, it enters the town of Macclesfield, again crossing the Bollin over Beach-bridge, which has to be raised 11 feet.

It then crosses eight streets, all of which have to be raised from 1 to 16 feet,


Plan of the
MANCHESTER CHESHIRE, STAFFORDSHIRE
AND
SOUTH UNION RAILWAY
and adjacent Country
LIVERPOOL
WARRINGTON
River Mersey
MANCHESTER
Gorton
Levenshulme
STOCKPORT
CHEADLE
River Bollin
Wilmslow
NETHER KNUTSFORD
NORTHWICH
MACCLESFIELD
River Dane
SANDBACH
CONGLETON
Hall Green
Tunstall
HANLEY
STOKE upon TRENT
STONE
STAFFORD
RUGELEY
CANNOCK
LICHFIELD
TAMWORTH
ATHERSTONE
BIRMINGHAM
COLESHILL
NUNEATON
COVENTRY
RUGBY
GRAND JUNCTION
SOUTH UNION
MANCHESTER CHESHIRE & STAFFORD
LONDON & BIRMINGHAM
1 2 3 4 5 10 15 20 25 30
Scale 10 Miles to 1 Inch.
Munday Lith.

and again crosses the Bollin frequently, or in some places follows its course, it being intended, I understand, to divert the river by tunnelling it under the adjoining street, the line being here from 12 to 16 feet below the level of its bed.

The line thus traced through the town of Macclesfield appears to be attended with considerable difficulties and great expense. On leaving the town it rapidly increases in the depth of its excavation; and, after destroying a large reservoir of water, and crossing the turnpike-road 62 feet below its surface, enters upon Dean's Moss.

The cutting through this moss is about $2\frac{1}{2}$ miles, its greatest depth 86 feet and averaging 55 feet throughout, giving upwards of 3,000,000 cubic yards; the whole of which must be run out on the adjoining land, not being required for embankment.

As this is a work of considerable magnitude, and about which much has been said, I shall endeavour to state my own impressions on examining it.

On crossing over this part of the line, which, in its present state, is attended with some inconvenience for the want of drainage, I observed that wherever surface-drains had been cut, and some of the turf removed, the remainder was perfectly dry, and showed a vertical section quite firm, the water having left it for the drains or excavations made by removing the turf; and I therefore think. by good surface-drains, and by running in drifts at both ends, so as to give vent to the water, the drainage may be effectually secured, and the work proceeded with, without any fear as to the result.

From the strata, as exhibited by borings shown me by one of Mr. Stevenson's assistants at Macclesfield, extending from 40 to nearly 100 feet in depth, and from which I understand a geological section has been made, I consider it may be compared to a pond filled with vegetable matter and water resting on gravel, sand, or marl, and when tapped at the level of the bottom of the pond, with the assistance of surface-drains, that the water will pass of.

Having heard of the difficulties that had arisen at the Kilsby tunnel, on the London and Birmingham line, by coming into a vein of quick-sand with water, and as this might guide my judgment with respect to those likely to occur in the above undertaking, I went to inspect it. On going down one of the working shafts, where they had met with the running sand, I found this vein giving out the water very freely, which they were collecting and pumping up with the steam-engine; at the same time they were working 40 feet below, in the blue shale perfectly dry.

It appears to me, therefore, if this had been an open cutting, or if time could have been allowed to work this tunnel from the ends only, that, had they come upon the stratum of sand, it might have been drained off, at a comparatively small inconvenience or expense; but it is necessary in a tunnel of this length to commence in several places at once, in order that one part may not delay the opening of the line; and the shafts, required afterwards for the ventilation of the tunnel, but sunk now for the above purpose, become so many wells, causing the difficulties encountered in the tunnel alluded to. The masterly and scientific manner in which they have been completely overcome, reflects great credit on the engineer employed.

I need scarcely add, that in an open cutting like Dean's Moss (if I am correct in my view of the case) these difficulties need not occur.

With respect to the foundation to be obtained for the rail-road at the required level, both from the borings and the geological features of this part of the country (being of the new red sand-stone formation nearly at the edge of the coal measures), I do not see any reasonable grounds for being under any apprehension as to the result.

That a work of such magnitude must be attended with very heavy expense is quite certain; and, when the immense surface of the slopes of this cutting is considered, and the quantity of water they must receive during a heavy fall of rain, it will be found that a large sum will be required to effect the drainage; and the difficulties of adopting arrangements for this purpose are the greater, from the inclination of the line through Dean's Moss being almost entirely in one direction, and that, too, towards the town of Macclesfield.

I am not aware how the engineer proposes to carry this work into effect, but from his knowledge, talent, and experience, there is no doubt of his adopting the most effectual means.

Still I cannot but consider the four miles, from the sixteenth to the twentieth, as presenting difficulties, in an engineering point of view, of no ordinary kind, and to be avoided, if practicable.

The line, after passing Dean's Moss, has nearly a mile of cutting, averaging 28 feet in depth, and then crosses the river and valley of the Dane by a viaduct, which, although considerable, is much less than the crossing of the same river on the other line; it then has about half a mile of cutting, averaging 25 feet in depth, and crosses two vallies, one upwards of 100 feet in depth, with a brook running through the bottom.

It again encounters some deep cutting, between the 28th and 30th mile, about $1\frac{1}{2}$ mile, averaging 26 feet in depth, when, after a short embankment, it arrives at the tunnel at Harecastle Pass, and thence to the Bath Pool, the summit level of the other line; having gone 31 miles 6 chains, and risen in the first 19 miles 48 chains to its summit level at Dean's Moss 312 feet; and from thence to Bath Pool fallen 22 feet, its greatest slope being one in 264, or 20 feet to a mile, and having for the last five miles been on a level.

On comparing these two routes from their common terminus at Manchester to the Bath Pool, I am of opinion, that the Manchester, Cheshire, and Staffordshire Company have taken the more direct, cheaper, and easier-constructed, as well as easier-working, line.

The greatest work on this line is the viaduct over the Dane, at Congleton; but I consider the crossing of the Mersey and the Dane on this line to be on a par with the crossings of both those rivers, including the heavy embankment across the valley and brook between the 24th and 25th mile, on the South Union line; and that the tunnel, before entering the town of Macclesfield, together with the difficulties in getting through that town, and the immense cutting through Dean's Moss, to be the additional work against the South Union line between these two points, viz. the terminus at Manchester and Harecastle Pass: and besides this important difference in the cost of construction, the additional 1 mile 46 chains of distance, the additional rise of 22 feet, the greater inclination of the steepest slope, and generally of this portion of the line, must be considered as disadvantages affecting, permanently and materially, the expense of conveyance upon it.

From the Bath Pool I will now trace the two lines to their respective junctions with the Grand Junction Railway.

The Cheshire and Staffordshire line having got through its heavy cutting in the Harecastle Pass, crosses the Grand Trunk Canal, in the parish of Tunstall, about a quarter of a mile from the mouth of the tunnel of the canal, and runs through the Potteries nearly parallel to the canal.

At the town of Shelton there are several engineering difficulties to be overcome; some heavy cutting between the 33rd and 34th mile; and in a little more than one mile, between the 33rd and 35th miles, six turnpike or tram-roads to be passed over or under the line, besides tunnelling under the canal.

The line then crosses the river Trent, and, running along the east side of the Grand Trunk Canal, and nearly parallel to it, passes, at the back of Stone, across a valley and brook requiring a viaduct; and, after encountering some cutting, crosses the turnpike-road to Rugeley, and re-crosses the canal and river Trent with its valley, requiring both a viaduct and considerable embankment; comes between the 45th and 48th miles to some heavy cutting about two miles in length, and averaging 32 feet in height throughout; when, after passing the river Sowe, it joins the Grand Junction Railroad at Rickerscote, in 21 miles 31 chains, having descended from its summit level at Harecastle Pass 191 feet 3 inches, with no inclination greater than 1 in 378, or 14 feet to a mile, having two miles on a level.

The South Union line, after getting through a similar cutting as the Cheshire line in the Harecastle Pass, keeps on the west side of the Grand Trunk Canal, passing close to Longport and Etruria, having nearly 4 miles of embankment, averaging 16 feet throughout, part of which will be performed by the deep cutting in the Harecastle Pass, and the remainder from side cutting.

It then crosses the Grand Trunk Canal about midway between Etruria and Stoke-upon-Trent, immediately in rear of this latter town; and crossing the river Trent, takes very nearly the same line as the Cheshire junction: a little past the 42nd mile it interferes with a bend in the canal, which it is proposed to divert, but which I think may easily be avoided.

The Cheshire line does the same, and they have re-surveyed it, and shown me a sketch, in which they propose to pass to the east of it.

At about the 43rd mile, close to Meaford Old Hall, it sends a branch into the Grand Junction Railroad, re-crossing for that purpose the Grand Trunk Canal, and river and valley of the Trent, which is much narrower at this point than where the other line crosses, after which it encounters about two miles of cutting, averaging 20 feet in depth, and enters the Grand Junction Railroad at Hamner Houses, 7¼ miles short of the Cheshire and Staffordshire line; having gone 15 miles 74 chains, and descended 159 feet, with no slope greater than 1 in 349, or about 15 feet to a mile, and having 2½ miles on a level.

On comparing these two routes from Harecastle Pass to their respective junctions with the Grand Junction Railroad, I am of opinion, the South Union line is the cheaper and more direct communication with the Grand Junction Railroad; it avoids the engineering difficulties in Shelton, as well as the uneven section behind Stone; crosses the valley of the Trent with a shorter viaduct and embankment, and has a much less heavy cutting between that and its junction, which is effected in 5 miles 38 chains less distance, in addition to its other advantages.

The Cheshire junction, in order to save 1 mile 63 chains, has to make 5 miles 38 chains additional railroad, under unfavourable circumstances, and without a corresponding advantage between Manchester and Birmingham.

At the same time it is right to state, though I decidedly give the preference to this half of the South Union line, I do not think there is that *amount of difference* in an engineering point of view between them, that I find in the first half on the opposite side.

The following is a comparative statement of the two competing lines in point of distance, together with that of the substitution of such portions of each as I have here considered as presenting the least difficulties in an engineering point of view :—

	Miles.	Chains.
From Manchester to Rickerscote, by the Cheshire and Staffordshire line,	50	71
From Manchester to Hamner Houses, by South Union line	47	0
From Hamner Houses and Rickerscote	7	20
	54	20
* From Manchester to Bath Pool, by the Cheshire and Staffordshire line, and thence to Hamner Houses, by the South Union line .	45	34
From Hamner Houses to Rickerscote	7	20
	52	54

Thus, by making 45 miles 34 chains of railroad, and joining the Grand Junction at Hamner Houses, the communication between Manchester, Birmingham, and London is completed.

In the opinions I have given relative to these two routes, I trust I shall not be considered as calling in question the skill and talent of the engineers employed, their high characters and reputation would cause such an imputation to recoil on myself; but I am well aware, that in laying out lines of railroad, in order to

* The Committee of the House of Commons having declared themselves in favour of this joint line, the two companies agreed to unite, each withdrawing the half of their line thus objected to; the new formed company to be called the Manchester and Birmingham Railway Company.

obtain support from towns on the line, as well as from influential individuals whose property is affected, an engineer is compelled to deviate from that route which (considered professionally only) he would otherwise recommend.

In compliance with further orders from the Master-General and Board, dated 5th April, 1837, I shall now proceed to report on the remaining portion of the South Union line, from where it sends its branch into the Grand Junction Railroad, to its terminus at Tamworth, as well as on a projected line of railroad between Tamworth and Rugby, where it joins the London and Birmingham Railroad; and then consider the respective merits of both lines, viz.:

The Manchester, Cheshire, and Staffordshire line, *via* Birmingham and the South Union line, *via* Tamworth and Rugby, from which latter place they both take the same route to London.

The branch near the 43rd mile leaves the main line, in cutting which continues for about a mile, taking the same line as the Cheshire and Staffordshire line, crosses between the 43rd and 44th mile the turnpike-road to Leek, which has to be raised 7 feet, and then crosses the brook and valley behind Stone; it then runs nearly on the surface, till it crosses the turnpike-road to Stafford 13 feet above it, requiring it to be lowered 6 feet; when it comes into embankment for 1½ mile averaging 16 feet, and after cutting through a short steep hill, and diverting two cross-roads, crosses the Grand Trunk Canal and the river Trent with a trifling embankment, just sufficient to pass the canal without difficulty; a short cutting follows from which this embankment may be formed.

The line then runs for five miles with slight embankment, and comes into two miles of heavy cutting through sand, stone, and marl, averaging 36 feet throughout, when about two miles of slight embankment brings the line to Colton Mill; it previously, however, opposite Bellamore, encounters a bend in the Grand Trunk Canal, which is to be diverted.

Leaving the town of Rugely on its right, it has a short steep hill to cut through, when it runs parallel to the river Trent, about twelve chains from its right bank.

Between the 59th and 60th mile it again crosses the Trent, and, in less than one mile further, the Grand Trunk Canal; it then passes to the left of Handsacre Hall, crossing two turnpike-roads from Litchfield to Rugely, and continues on favourable ground, with the exception of about half a mile of cutting about the 65th mile, until it arrives at the town of Whittington, through part of which it passes.

It soon after meets with a bend in the Coventry Canal, which it is proposed to divert by straightening it with embankment.

The line, then passing in front of Tamhorn House, crosses the river Tame, here about 35 yards wide, with a gravelly bottom and good banks; it then crosses Staffordshire Moor in slight embankment, and arrives close to Tamworth, crossing the road to Ashby-de-la-Zouch, at the outskirts of the town, in cutting from 20 to 25 feet in depth, and arrives at its terminus on the banks of the river Anker, 24 feet below the Derby and Birmingham Railroad, which crosses it nearly at right angles, in considerable embankment.

This line, from the point where it sends its branch into the Grand Junction Railroad to its terminus, has gone 28 miles 26 chains; its greatest inclination being 1 in 331, or 16 feet to a mile (which continues 1½ mile only), having descended 130 feet, and ascended between the 52d and 63d miles 26 feet, and having gone eleven miles on a level.

I will now trace the proposed line of railroad, commencing at the South Union terminus at Tamworth, to its junction with the London and Birmingham Railroad at Rugby.

This line crosses the river Anker immediately it leaves its terminus, and for three miles runs on favourable ground; it then re-crosses the Anker, and has to pass under the road from Poleworth to Warton, 64 feet below its level. As this hill is short, a tunnel might be found advisable.

For the succeeding thirteen miles it continues in the valley of the Anker, on very favourable ground, frequently crossing this small stream, and which I should suppose, in the four crossings between the 11th and 12th miles, would either be wholly diverted or converted into two crossings.

At the 13th mile it passes immediately at the back, and to the eastward of the town of Nuneaton, and one mile further that of Attleborough, crossing four roads which have to be raised considerably, and the Ashby Canal; and soon after the 15th mile passes through the back part of the town of Shilton to the westward of the church, being in cutting from 16 to 33 feet in depth.

The line now enters upon a more uneven section, having to cross over a number of short hills and vallies, round which the Oxford Canal used to run, but which has now been much shortened by cuttings and embankments.

The old Oxford Canal, here represented to be crossed so frequently, excepting in two places, does not exist.

At the 24th mile the line crosses the Oxford Canal, and one mile further the old canal (used as a branch,) where the road to Newbold-upon-Avon crosses, and leaving that town to the eastward, enters the valley of the Avon, which river it twice encounters, but which may be made into one crossing, and then joins the London and Birmingham Railroad between the 82nd and 83rd mile from London, near Rugby, in about 18 feet embankment; having gone about 26½ miles, and risen 137 feet to its summit level near the 18th mile, including a fall of 6 feet between the 4th and 8th miles, and from thence fallen 28 feet to its junction with the London and Birmingham Railroad, its greatest inclination being 1 in 396, or rather more than 13 feet to a mile, and having 2 miles on a level.

In reporting on this portion of the proposed communication between Manchester and Rugby, viz. from Meaford Old Hall to Tamworth, and thence to Rugby, through the vallies of the Trent, Tame, and Anker, I am of opinion that, both from its inclinations and the directness of its route, (the curves being all good, and a considerable portion of the line between Tamworth and Rugby nearly straight,) also from the absence of extensive and laborious engineering undertakings, it will be an easily and cheaply constructed, as well as good working line; and that the country through which it passes is well adapted for railroad communication.

The road, river, and canal crossings appear to be the greatest works on the line; the former, occasioned by the line being so near the surface, obliging the roads to be raised considerably; and the two latter, from their frequency, as well as occasionally requiring to be diverted.

It is apparent, too, that in one or two cases, in passing through the valley of the Trent, the ornamental property, which abounds here to a considerable extent, has obliged the engineer to deviate from that route which, considered profesionally, he would otherwise have adopted; and the most extensive cutting on the line, as well as one or two additional river and canal crossings, would appear to have been occasioned by these deviations; but in a valley of this kind, it is only extraordinary that this does not occur more frequently.

Having now reported on the projected lines of railroad of both companies, from their common terminus at Manchester to where they respectively avail themselves of railroad communication already formed; and having also examined that railroad between those respective points, viz. Rickerscote on the Grand Junction, and Rugby on the London and Birmingham Railroads; I will now proceed to show the advantage gained by the South Union Company, in point of distance between Manchester and Rugby, and the additional length of railroad to be constructed to obtain this advantage.

By the Manchester, Cheshire, and Staffordshire line:—

	Miles.	Chains.
From Manchester to Rickerscote	50	71
From Rickerscote to Birmingham...........	27	40
From Birmingham to Rugby	28	60
Total...........	107	11
By the Manchester South Union, &c.		
From Manchester to Tamworth	71	46
From Tamworth to Rugby................	26	36
Total...........	98	2
Leaving in favour of the latter route	9	9

In addition to which the difference of the inclinations on each route must be taken into calculation, as shown in the following table:—

Ascents and Descents on each Line of Railroad from their common terminus in Manchester to Rugby.

From Manchester to Rugby.	Ascents. Feet.	Descents. Ft.
Manchester to Rickerscote	290	191·3
Rickerscote to Birmingham................	216	117
Birmingham to Rugby	111	158
Total..	617	66·3
By the *Manchester South Union.*		
Manchester to Tamworth	348	304
Tamworth to Rugby	137	34
Total...........	485	338
Leaving in favour of the latter route	132	128·3

The descents going south become ascents going north; according, therefore, to Mr. Stevenson's calculation, in his Report on two proposed lines of railroad between Glasgow and Ayrshire, that 20 feet of rise is equal to a mile of horizontal distance, (which, though I do not quite subscribe to, may be considered a tolerable approximation to the truth,) we shall have (averaging both ways) about 6 miles 40 chains, which, added to the 9 miles 9 chains of actual distance, will give something more than $15\frac{1}{2}$ miles between Manchester and Rugby in favour of the South Union line.

To obtain therefore this advantage of $15\frac{1}{2}$ miles between Manchester and London, and to give also a communication to Birmingham, the South Union line proposes to make 101 miles 72 chains of railroad.*

The Cheshire and Staffordshire line, abandoning this advantage of $15\frac{1}{2}$ miles, completes the communication between Manchester, Birmingham, and London, in 50 miles 71 chains, by making use of the Grand Junction and London and Birmingham Railroads already formed, saving thereby the construction of 51 miles 1 chain of railroad.

In conclusion, I beg to state, the plans and sections from which I have taken the foregoing distances are constructed on small scales, and some allowance must therefore be made for trifling inaccuracies.

I have the honour to be, Sir,

Your most obedient humble servant,

R. ALDERSON,

Captain, Royal Engineers.

To the Inspector-General of Fortifications, &c.

Opinion upon the South Union and the Manchester and Cheshire Junction Railways. Captain ALDERSON, *Royal Engineers.*

SIR, London, 8th May, 1837.

IN obedience to the Master-General and Board's order, dated 3rd May, 1837, $\frac{C}{2232}$, calling for my opinion on the two Reports transmitted with the accompanying letter from Lord Francis Egerton, Chairman of the South Union and Manchester and Cheshire Railways, I have the honour to report, for the information of the Master-General and Board, as follows:

In my former Report on these two lines of railway, I did not express an opinion on the deviation line of the Manchester and Cheshire junction, commencing a little beyond the third mile, and crossing the river Mersey at Stock-

* The extension of the South Union line from Stone to Tamworth, and thence to Rugby, was thrown out by the Committee a day or two before this Report was sent in.

port, at the same place as the South Union line, but 20 feet below it, and rejoining the main line between the ninth and tenth mile from Manchester. I examined it, however, so as to enable me to do so at a future period, should it be required; and have now to state that, excepting the additional expense to be incurred in crossing the river at this place, and the purchase of the ground through the town, I see no objection to its becoming a portion of the main line, instead of the route by the Brinksway-bridge, particularly as, in the proposed branch from Stockport to Macclesfield, it is considered essential to pass by the Poynton and Adlington collieries; and, with this understanding, I will now examine the reports of the two engineers, in which this object is proposed to be obtained by different routes.

Both parties have adopted Mr. Stephenson's line between Stockport and Macclesfield, as the basis of their reports.

Mr. Stephenson also proposes his line from Manchester to Stockport, by which he crosses the river Mersey 20 feet above the required level for the main line, *via* Wilmslow and Congleton, which 20 feet he proposes to overcome by a descent of 1 in 377 south from Stockport, until it meets the main line, which, being an ascending slope, is accomplished in one mile.

Mr. Rastrick, on the other hand, proposes his line between Manchester and Stockport, which, being a portion of the main line, he avoids any alteration to it, but has to rise 20 feet at Stockport to join the branch from Stockport to Macclesfield, which he also accomplishes in one mile; but which, being on an ascending slope, obliges him to have an inclination of 1 in 150.

It appears to me, therefore, that the comparison between these two reports may be thus drawn.

Mr. Stephenson interferes with the main line to its disadvantage, by ascending 20 feet more than is required for it, in that portion of the line between Manchester and Stockport where the greatest traffic will occur; and again, by having to descend the 20 feet between Stockport and Harecastle (causing a corresponding rise in the opposite direction), excludes the coals from the Harecastle collieries, which, by having a descending slope along the whole line, might be enabled to compete, in the Stockport and Manchester markets, with those from the Poynton and Adlington collieries, and thus prevent monopoly.

By thus altering the main line, fresh assents from the proprietors and occupiers become necesssary, and the passing of the Bill of the Manchester and London Railroad this session is thereby rendered doubtful.

Mr. Rastrick, by not interfering with his main line, avoids these serious objections; but, in order to connect his branch with it, proposes an additional mile of railroad, at an inclination of 1 in 150, descending towards Stockport to within a quarter of a mile of the station on the left bank of the Mersey.

This is no doubt a considerable inclination; but when it is considered that the branch line falls from the collieries to Stockport, and that all the heavy traffic is in this direction, and that a considerable portion of this heavy traffic is not to descend this steep slope, but be delivered at what he calls the Coal Station; and further, that the passenger traffic is of a limited extent, being merely that between Macclesfield and the terminus at Manchester; I think there is no doubt that the line, as thus laid out, will be fully equal to the traffic it is likely to have upon it.

I am further induced to come to this conclusion, from the fact of the slopes of the two termini at Liverpool on the Manchester and Liverpool line, through the passenger, as well as the other, tunnel being considerably greater; the trains descend notwithstanding, with the use of the " brake" only, without accident.

In thus considering these two reports, I am induced to give the preference to Mr. Rastrick's;* it upholds a principle from which I think there should scarcely ever be a deviation; viz. that a main line should not be injured to benefit a branch..

Having given an opinion on these two Reports, I trust I shall not be considered as outstepping my duty in calling the attention of the Committee to the fact, that the line between Stockport and Macclesfield was laid out in its present form as a portion of the main line between Manchester and London; and for this important object, it became imperative on the engineer to select the best and most direct line for a first-class passenger-train in both directions, without reference to expense; and it is evident, when the nature of the ground is considered, this has been accomplished in a most judicious manner: but, as the present object of this portion of the line is much more limited, the heavy traffic being all in one direction, and the passenger traffic that of one town only; and, as in order to accommodate itself to the main line (if the Committee finally determine on

* The Committee adopted this opinion, and the Joint Company therefore withdrew the other Report. The different points in dispute being thus amicably arranged, the Manchester and Birmingham Railway Company obtained their Bill during the session.

that line as here recommended), it must commence at a 20 feet lower level; it becomes, I think, very possible that, on a re-survey of the ground, a more equal distribution of this additional 20 feet may be effected than is proposed in either of the present reports (still keeping in view the accommodation to the collieries), as well as a more economical line; particularly in the two miles immediately preceding its arrival at Macclesfield, where it enters the valley of the Bollin, and where, by continuing in it to its terminus, it may avoid the heavy cutting and the tunnel it now has to encounter. The delay thus occasioned to the branch need not, I think, necessarily prevent its opening as soon as the main line, should that now be carried.

I have the honour to be, Sir,

Your most obedient humble Servant,

R. ALDERSON.

Captain, Royal Engineers.

To the Inspector-General of Fortifications, &c.

Report on the several proposed Lines of Railway between London and Brighton. By Captain ALDERSON, *Royal Engineers.*

SIR, London, 27th June, 1837.

IN obedience to your orders of the 2nd and 9th June, 1837, directing me to report, in conformity with the instructions contained in two letters received from Her Majesty's Principal Secretary of State for the Home Department, on the following proposed lines of railway between London and Brighton, viz. Sir J. Rennie's, or the direct line; Mr. Stephenson's, Mr. Gibbs's, and the South Eastern—

I have the honour to state, that I have carefully read over the evidence given before the Committee, as well as their report, and attentively compared the several plans and sections submitted to me; that I have also taken a general survey of the sites of the different lines, examining more attentively those portions where works of importance are proposed, and have no hesitation in stating, that the line proposed by Mr. Stephenson, considered in an engineering point of view alone, is preferable to either of the others.

Availing himself of the vallies of the rivers Mole and Adur, he avoids the heavy cuttings necessarily consequent on forcing a passage through the chalk ridges, known as the North and South Downs; and, with the exception of two short tunnels, one at Epsom and the other at Dorking, arrives at Brighton, *viâ* Shoreham, having only such ordinary difficulties to contend against as are necessarily consequent on undertakings of a similar nature and extent.

As, however, this is but one point for consideration of a main line of railroad, I will now proceed to consider the respective merits of the several lines, with reference to the second resolution of the House of Commons.

On referring to the map and the population returns, it will be seen, that the country passed through, or approached by either of the lines, as well as that on the coast, within reach of railroad communication by branches, containing neither manufacturing nor mineral districts, the towns present only the usual traffic of an agricultural population, and are, as compared with Brighton, of minor importance.

It appears to me, therefore, that after attending to one principal point in the construction of any main line, viz. that its London terminus be central; that route between London and Brighton which best unites engineering facilities with convenient termini should be preferred.

I will then consider the termini of the various lines with reference to the accommodation they afford to the metropolis at one end, and the town of Brighton at the other.

Each of the proposed lines avails itself of a terminus already constructed, or for which an Act of the Legislature has been obtained. Mr. Stephenson adopts the terminus of the London and Southampton Railway at Nine Elms, a little above Vauxhall-bridge, with a depôt on the banks of the Thames, branching from this line at Wimbledon-common, $5\frac{1}{2}$ miles from the terminus.

The Direct line and Gibbs's adopt the Greenwich Railway terminus at London-bridge, and avail themselves of railway communication, already sanctioned and now constructing, as far as Croydon.

The South-Eastern has also its terminus at London-bridge, and, in addition to the Croydon, avails itself of 12 miles of the Dover Railroad, branching off at Oxted.

Taking the Middlesex side of the Blackfriars-bridge as a centre, and describing circles with the several radii of one, one and a half, and two miles, thus including within the last an area of upwards of 12 miles bearing the densest population in the world, it will be found, that, whilst the terminus of London-