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PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

OF THE

CORPS OF ROYAL ENGINEERS,

CONTRIBUTED BY

OFFICERS OF THE ROYAL ENGINEERS.

NEW SERIES.

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PREFACE.

THE Publication of the present volume has been unavoidably delayed from the impossibility of obtaining some of the papers in time for issuing it before the end of last year. As it is, it has to be published without one or two promised articles which the writers have not yet been able to supply.

Only one occasional meeting for discussion has been held since the publication of the last volume. The paper then read was contributed by Field Marshal Sir J. F. Burgoyne, Bart., and forms the first article of the present volume. Other meetings would have been held, but for the absence from England of the author of one paper, and for the want of others suitable for discussion.

The Editor is confident that he is only expressing the general feeling of the Corps in taking this opportunity of thanking Field Marshal Sir John Burgoyne for the efficient manner in which he has for many years acted as President of the Committee of the Royal Engineer Professional Papers, for the active interest he has taken in the welfare of the publication, and for the many valuable contributions he has made to its contents.

The interesting subject of the relative values of civil, military, and convict labour will be found very fully discussed in Papers Nos. IX and X. Paper No. II on wire gabions, was in type before the report of the Chatham committee had been published. Captain P. Smith hopes to be able to remedy the defect pointed out in the report.

C. S. HUTCHINSON,
Lieut. Colonel, R.E.

Railway Department,
Board of Trade,
January, 1868.

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LIST OF PLATES.

ERRATUM.

Page 79, 5th line from bottom, for " Wilson" read " Nelson."

MEMOIR

OF

LIEUTENANT GENERAL SIR HARRY D. JONES, G.C.B., R.E.

By LIEUT. GENERAL H. SANDHAM, R.E.

Although the apothegm advanced by Sir Thomas Larcom, at the opening of his Memoir on the late Major General Portlock, of the Royal Engineers, that "the individual is nothing, the aggregate everything," is undoubtedly true, yet it is equally true that the aggregate is made up of individuals; and of such an individual as the late Sir Harry David Jones, whose services, Military and Civil, have been so varied, so brilliant, and so successful, well may the aggregate be proud; for all the honours and distinctions he obtained, in the services upon which he was employed, reflect on the corps to which he was so devotedly attached, and of which he was so distinguished a member.

Lieut. General Sir Harry David Jones, G.C.B., was one of five sons, who all served with distinction in various branches of the Military and Naval service, amongst them was that distinguished officer, Lieut. General Sir John Jones, Bart., K.C.B., R.E., the author of "The Sieges and War in Spain" (which works Sir Harry edited in a 2nd edition), who enjoyed the confidence of the Duke of Wellington, and whose career stimulated Sir Harry to the attainment of a reputation and of rewards very closely approaching to those of his brother. The family is a Norfolk family, and the father of the subject of this Memoir held the appointment of General Superintendent at Landguard Fort, under the Marquis of Townsend, Master General of the Ordnance; he died in 1806. The grandfather was John Jones, Esq., of Fakenham, from whose descendants a large property is now vested in the present Baronet of Cranmer Hall, in that neighbourhood.

Sir Harry was born at Landguard Fort on the 14th of March, 1791; he entered the Cadet Company at the Royal Military Academy, Woolwich, on the 10th April, 1805, under a warrant of the Earl of Chatham, then Master General of the Ordnance, when it was mustered on the Rolls of the Royal Artillery as the 1st Company of the 1st Battalion; he passed through the Academy with credit, and received the appointment of "Candidate for the Corps of Royal Engineers," in which a probation of six months was passed on the Ordnance Survey of England; at the end of that period, on the 17th September, 1808, at the age of $17\frac{1}{2}$, he was *gazetted* 2nd Lieutenant of Royal Engineers, and was ordered to Dover, where he was employed in the superintendence of the extensive works of fortifications that were then in progress; his employment on home service was of short duration, for in 1809 he joined the Expeditionary Army, under Lord Chatham, destined for the Scheldt, and landed with it in the island of Walcheren; he there took an active part in the attack and reduction of the Fortress and large Naval Arsenal of Flushing, in which nearly the whole army was prostrated by a fever that more than decimated it, and was known to many a sufferer for years afterwards, as the "Walcheren Fever;" although he suffered in common with others, yet in the latter end of that year, 1809, or early in 1810, he took part in the defence of Cadiz, under Lieut. General Sir Thomas Graham, as a 1st Lieutenant, to which rank he was promoted on the 24th June, 1809. From Cadiz he embarked with a British force under Colonel Stewart, destined for the relief of the Spanish garrison of Tarragona, at that time besieged by the French.

From Tarragona he joined the army under the Earl of Wellington, then occupied in the Siege of Badajos (1812), in which he took an active part, and he also served with that army in the campaign of that year, and subsequently without interruption until the termination of the Peninsular War, in 1814. He was at the Battle of Vittoria on the 21st June, 1813, with the 5th Division, commanded by General Oswald, by whom he was recommended for promotion for his conduct in that battle; this, however, he could not receive, as he was then a subaltern

He was appointed Adjutant of the right attack at the Siege of St. Sebastian, carried on by Sir Thomas Graham, which was continued from the 11th July to the 8th September (1813), when the place capitulated; throughout this Siege he took a conspicuous part in it; at the unsuccessful assault on the 25th July, he led the storming party, and by his personal gallantry and example he held a certain possession of the breach with a few determined men, in the hope that renewed efforts would be made, until he and all his party were either killed or wounded, and carried from the breach by the garrison as prisoners, he himself being severely wounded; from that time until the 8th of September, when the castle surrendered, he was a prisoner; the town had been carried by assault on the 31st August, but yet the castle held out until the 8th September; during this period the prisoners were equally exposed with the garrison to the overwhelming vertical fire of the besiegers, which induced the governor to surrender.

Lieut. Harry Jones was sufficiently recovered from his wounds to again take his place with the 5th Division in the Battle of Nivelle, on the 10th of November, 1813, and in the operations before Bayonne. He also took part in the bridge operations for the passage of the Bidasoa and Nive, under the command of Sir Thomas Graham. He was again recommended for promotion for his conduct in these operations by General Hay, who commanded the Division, and the thanks of the Master General of the Ordnance were expressed to him by a Circular to the Corps, through the Inspector General of Fortifications.

On the 12th November, 1813, he was promoted to the rank of 2nd Captain.

The Operations before Bayonne were amongst the last of the war with France, but the Americans had declared war against Great Britain at that time, and an Expeditionary Force from Lord Wellington's army was embarked, under the command of Sir John Lambert, for New Orleans, which Captain Harry D. Jones joined in February, 1814, at Dauphine Island; he was immediately sent on a special mission to New Orleans under a return flag of truce. This American war was of short duration, and the British force returned to Europe to take part in the brilliant struggle of the European Powers brought again into war with France by the escape of Napoleon from Elba. Although Captain Jones was late for the Battle of Waterloo, he joined the Duke of Wellington's army before the capture of Paris, and was in command of the Engineers at Montmartre; he remained in France with the Army of Occupation until 1818. In 1816 he was appointed a Commissioner with the Prussian army under General Zietin.

From 1818 until the breaking out of the war with Russia in 1854, the services of the subject of this Memoir were most varied and onerous, but they were equally honourable to him; on his return to England he was employed in the professional duties of the Engineers at Plymouth; in 1823 he was removed to Jersey; in 1824 he was selected as a 2nd Captain to fill the important position of Adjutant of the Royal Engineer Establishment for Field Instruction at Chatham; and on his promotion to 1st Captain, in the summer of 1826, he was appointed to Malta; from whence he was employed on various important services. In 1830 he was sent to the Coast of Africa to superintend the embarkation of certain antique classic columns for His Majesty George the Fourth. In 1833-1834 he was ordered from Malta to Constantinople to report on the defences of the Dardanelles and Bosphorus; on this occasion he made the journey from Constantinople to England overland, collecting much information as to the means of travelling, and of the nature of the countries through which he passed; and he again received the thanks of the Master General for the very satisfactory manner in which these delicate services were performed, and for the fulness of his reports. On his return to Malta, in 1834, he was again ordered to Constantinople, on the ostensible plea of preparing plans and estimates for the Ambassador's residence, which he completed; the opportunity was not lost to him of making further reports with which he returned to England overland, and having deposited them with the Government, with Reports of his journey, he returned to Malta. In May, 1835, he was ordered home on being appointed Commissioner for Municipal Boundaries in England, and in November of that year (1835), he was employed on the Improvement of the Navigation of the River Shannon; on this commission he was engaged for several years, but his services were not confined alone to that object; in 1836 he was appointed First Commissioner for fixing the Municipal Boundaries in Ireland, and in October of that year Secretary to the Irish Railway Commission; and he was also especially directed to report on the state of distress in the County of Donegal.

His promotion to Brevet Major took place on the 10th January, 1837.

In 1839 he resumed the duties of the corps under the revised regulations relating to officers of Engineers seconded from the Corps to civil duties under the Government, which limited the period of the absence of seconded officers from the duties of the Corps to 10 years, and he was appointed Commanding Royal Engineer at Jersey; but his military employment was of short duration; in the same year he was made a Commissioner for the Improvement of the Navigation of the Shannon, and was again seconded from the Corps. As a proof of how much his services were appreciated and sought after, in 1842 he was appointed to the office of the Inspector General of Fortifications, but at the urgent request of the Lords of the Treasury, that appointment was cancelled that he might continue under their Lordships' orders in Ireland, and in 1845 he became Chairman of the Board of Public Works in Ireland. In the midst of the varied duties and services that he was called upon to execute, he consented in 1843 to edit a third edition of the "Journal of Sieges carried on by the Army under the Duke of Wellington in Spain, during the years 1811 to 1814," a work written by his distinguished brother, the late Major General Sir John Thomas Jones, Bart., K.C.B., R.E., which had gained an historical reputation throughout Europe; to this, however, his energy and experience enabled him to add much matter of information and instruction in the body of the work, including very minute details and plans of the celebrated Lines of Torres Vedras, thrown up to cover Lisbon in 1810, on which the French Army, with a very superior force, could make no impression; (to their influence on the war may be attributed the turn of the fortunes of the 1st Napoleon, and his eventual fall); instructive memoranda on demolitions, and a correspondence between Lieut. Colonel Fletcher, the then Commanding Royal Engineer, and Captain John Thomas Jones, R.E., who was charged with the completion of the Lines of Torres Vedras; and an appendix abounding with extracts from the Duke of Wellington's despatches, and from French documents bearing on the Peninsular War, full of interest and instruction; this work was brought out in 1846, in which year he was a Member of the Relief Committee under Sir John Burgoyne; and in 1847 he received the thanks of the Lords of the Treasury, and of Lord John Russell, who was at the head of the Government. He continued these duties in Ireland until 1850, when by Treasury Minute dated 2nd March, he was relieved from the office of Chairman of the Board of Works in Ireland that he might return to the duties of the Corps in conformity with the revised regulations above referred to, and he assumed the command of the Royal Engineers in Edinburgh as a Lieutenant Colonel, which rank he had attained on the 7th Sept., 1840. In 1851 he was selected to fill the important position of Director of the Royal Engineer Establishment for Field Instruction at Chatham; he there introduced a system by which officers and men of the Line were to take part in the Siege Operations carried on for the Instruction of the Royal Engineers, and the value of the pick-axe and shovel were to become more practically known to the Army. In 1853, at a Review and Sham Fight of the Troops at the Camp at Chobham, he personally directed the Pontoon Bridge operations on the Virginia Water, over which the troops of all arms passed in presence of Her Majesty the Queen, who was pleased to express to him her approbation, in a general order issued by Lord Hardinge, the Commander-in-Chief. In the course of this year he was selected to be one of a deputation under Lord Lucan sent by Her Majesty to Paris to congratulate the Emperor of the French, on the effect of his visit to the Northern parts of his dominions; again, in 1854, he was ordered to Paris by Lord Raglan, the Master General of the Ordnance, to report on a new pontoon adopted by the French; in this year (1854) war was declared by France and England against Russia, in alliance with Turkey, their combined forces were collected for operations in the Baltic, and on the side of Turkey in the Principalities in July; he (having attained the rank of Colonel in the Corps on the 7th July, 1853,) was appointed Brigadier General, and placed in command of the Forces to be employed in the Baltic in land operations; he accordingly embarked in Her Majesty's ship, *Duke of Wellington*, on which Admiral Sir Charles Napier had hoisted his flag; in August he landed on the fortified Island of Bomarsund, in command of the British portion of the combined French and English force, consisting of two battalions of French, with Seamen and Marines from both fleets, and a detachment (or company) of the Royal Sappers and Miners. The fortifications were extensive—defensible casemates and detached towers—against which guns were placed in battery, and breaches having been made, the garrison of the Island surrendered and were made prisoners of war; afterwards the whole of the works were demolished and the Island was abandoned; no other land operations of importance were undertaken. In September (the next month) the Brigadier returned to England, and in December he was promoted to Major General, and was ordered to proceed to Constantinople as Commandant of that city; on his arrival, however, in January, 1855, he found orders awaiting him, for him to join the army in the Crimea, then before Sebastopol, without delay; and on the 10th February he was put in orders as Commanding Royal Engineer of that army. He entered upon the arduous duties of the Siege with the same indefatigable energy and devotion that he had exhibited throughout his life in whatever service he had ever been engaged—Civil or Military; not a day passed that he did not visit the trenches himself, furthering, by his example, the devoted exertions of every member of the Corps who was employed in that memorable but lingering siege. He was present in the trenches at the unsuccessful assault on the Redan, on the 18th June, and was severely wounded in the forehead by a grape shot, and on that occasion, he was especially noticed by Lord Raglan, the Commander-in-Chief of the Forces, in his public despatches. Although not recovered from his wound, and in an extreme state of weakness, his lion spirit was not impaired, and at the general assault of the place on the 8th September, he was carried on a stretcher to the trenches, that he might witness what seemed to promise to be the last effort of resistance on the part of the Russian Army within the intrenchments, and happily so it proved, for in the night the garrison was withdrawn to the North side of the harbour, and negociations for capitulation and for peace were at once entered into. On this occasion too Sir Harry was especially noticed in public despatches by Sir James Simpson, G.C.B., the then Commander-in-Chief of the Army. In the course of this year he received the following distinctions and decorations, viz.:—K.C.B.;

1st Class Military Order of Savoy; 2nd Class Medjidie; Baltic Medal; Medal and Clasp, Siege of Sebastopol; Sardinian Medal; Turkish Medal for services in the East.

In consequence of his wound and the incessant fatigue he had undergone, his general health for the first time in his life (for he had an iron constitution) gave way; in September he was removed, in a state of extreme illness, to Scutari, and thence in October to England, in charge of a confidential servant, being totally unable to move or to assist himself in any way; however, in January, 1856, he was sufficiently recovered to take part in the Council of War in Paris, as a Member of the Council, under His Royal Highness the Duke of Cambridge, the Emperor of the French being President, by whom he was invested with the Order of the Legion of Honour. In the course of this year he was appointed a Member of the Commission on the System of Purchase in the Army, of which the Duke of Somerset was President. In 1856, he was placed on the list of officers receiving rewards for "Distinguished or Meritorious Services," a recognition of his devotion to the varied and important duties he had been called upon to perform for 48 years. In May of this year he was appointed Governor of the Royal Military College, and of the Staff College at Sandhurst, but he was repeatedly called upon for other duties, amongst which the most onerous and important was that of President of the Defence Commission, from which has emanated the extensive works of defence in front of our dockyards and harbours; these duties were not calculated to restore him to the health he lost in the Crimea. He required perfect relaxation and quiet, which he never could obtain, for his experience and ability were known and appreciated by every department of the Government; of these all were desirous to reap advantage, and he himself was nothing loth to spend his last efforts in the service of his country. On the 6th of July, 1860, Sir Harry became a Lieut. General, and on the 2nd of the next month he became a Colonel Commandant in the Corps of Royal Engineers.

After a critical yet fluctuating state of health, for more than a year, he at last sank from sheer exhaustion, on the morning of the 2nd August, 1866, esteemed, admired, and regretted, by all who had the happiness to know him; he was buried in the Cemetery of the Royal Military College, in a vault which had been prepared by himself for the reception of the remains of his son Montague, who died shortly after having obtained a Commission in the 34th Regiment, in 1859.

H. S.

Remarks on a passage in the "Notes on the Career of the late Captain Fowke," published in volume XV R. E. Professional Papers.

BY LIEUT. COLONEL STOKES, R E.

In the "Notes on the career of the late Captain Fowke, R.E.," published in Vol. XV of the Professional Papers, is the following paragraph:—

"In 1858, he was named . . . . a Commissioner of the International Technical Commission for rendering the St. George's branch of the Danube navigable, and his scheme was unanimously adopted; but from various causes, diplomatic and otherwise, his plan has only been partially carried into effect."

Captain Fowke's great merit and varied achievements in works of art render it unnecessary to add to his reputation by attributing to him the credit of what has been done by others, and he would assuredly have been the first person to correct the above statement, had he lived.

The object of the following remarks is to remove the erroneous impression which the paragraph quoted above is calculated to convey.

The Paris Technical Commission was simply charged to give an opinion upon the plans proposed for improving the Danube, concerning which differences existed amongst the members of the European Commission of the Danube. The Paris Commission, composed of Engineers from England, France, Prussia, and Sardinia, concurred in the opinion of the majority of the European Commission, namely, the delegates of England, Austria, Sardinia, and Turkey, who declared themselves in favour of the improvement of the St. George's branch.

The Paris Technical Commission, however, whilst adopting this branch of the river, proposed a mode of entering it from the sea, which according to Mr. Cole, originated with Captain Fowke, and supported their recommendations by examples drawn from the Rhone, Ebro, Oder, and Vistula. The writer of these remarks has shewn, in a paper on the improvement of non-tidal rivers, published in Vol. XIII of the Corps Papers (Paper No. 5), how inapplicable these examples were to the solution of the Danube problem. A man of Captain Fowke's practical mind would never have suggested his scheme for this solution had he visited the locality, but, unfortunately, not one member of the Paris Technical commission had ever visited the Danube mouths.

The works which have succeeded at the Sulina mouth of the river were emphatically condemned by the Paris Commission, and especially by Captain

Fowke; they have, however, been carried out with most satisfactory results in spite of their recommendations. Captain Fowke's proposed plan has not even been "*partially carried into effect*," nor from the beginning was there much probability of its being so, for every practical man who had ever visited the Danube, declared against it.

It is true that the principle of it was officially adopted by order of the Governments, but political reasons led to the postponement of any works at the St. George's mouth for a time; and from the moment that the completion of the Sulina works showed the sufficiency of the principle on which they were planned for attaining the end sought, all idea of applying Captain Fowke's scheme was abandoned.

If political and financial reasons did not now prevail to prevent altogether the opening of the St. George's channel, it is certain that this branch would be rendered accessible, *not* by Captain Fowke's plan, but by the application of the principles on which the works at the Sulina mouth have been so successfully carried out, and which might, undoubtedly, be adopted under still more favourable conditions at the mouth of the St. George.

J. S.

Galtz,
March, 1867.

PROFESSIONAL PAPERS.

PAPER I.

ON THE SIEGE AND CAPTURE OF BORGOFORTE,

ON THE PO.—JUNE, 1866.*

BY GENERAL SIR J. F. BURGOYNE, BART., G.C.B.,

INSPECTOR GENERAL OF ENGINEERS, &c.

Borgoforte, on the left bank of the Po, was fortified for the protection of the communication over the river at that place.

On the left bank it was covered by three detached Forts of permanent construction, of which one, *Rochetta*, abutted on the river above; one, *Bocca di Ganda*, below; and one, *Magnagatti*, was on the advanced apex of a triangle between them. (See Plan.)

The passage across the river was by a flying bridge, between the town and *Moltegiana*, on the right bank, where there was a Fort as a Tête-de-pont, which being on a point of a bend in the river would receive support on its front, flanks and gorge, from the two Forts which were immediately on the left bank.

The country on both sides was low, flat, and covered with vegetation, and was protected by substantial river and interior banks from winter inundations.

The works had a command of from 25 to 30 feet over the country, and their escarps and interior, and all the buildings in them, were thoroughly covered from *view*.

The Tête-de-pont, which was the object of attack, had a deep wet ditch and caponier-flanks; the gorge was closed by a massive loopholed wall; and parallel to it, in the interior, for nearly its entire length, was a very substantial bomb-proof defensible barrack.

The attack by the Italian force, under General Nunziante Duke of Mignons, was limited to that of the Tête-de-pont, and to operating on the right bank only, and was carried out by a heavy cannonading from batteries established along the dykes bordering each side of a rivulet (the Colatore Zara), that formed

* A Paper read at a Meeting at the War Office on the 12th of June, 1867.

a parallel round great part of the Fort at a distance of from about 1,500 to 2,000 yards, with some detached batteries for keeping down the fire of the two flanking Forts that were on the left bank.

The artillery allotted for the siege consisted of 74 pieces, of which 24 were of 17 centimètres (6·693 English inches), probably about 74 or 75-pdrs.; and 50 of 12 centimètres (4·724 inches), probably about 40-pdrs.

After every preparation, the construction of the batteries was commenced on the 10th June, and at daybreak on the 17th they were completed, and opened fire.

Under the most ordinary precautions, works constructed at such a distance could not be molested by sorties, to any useful purpose, from the small body that would form the garrison of such an insulated fort.

The sketch will shew the positions of the batteries, and the accompanying table the armaments, the Forts against which they were destined to act, and the distances from them.

The fire from the batteries was continued throughout the day of the 17th and the succeeding night, during which the number of rounds fired was as follows:—

No. of Battery.	12 centimètres.	17 centimètres.
1.	......	420
2.	1180	......
3.	700	......
4.	*1320	......
5.	897	......
6.	......	1086
7.	580	......
8.	......	350
	4677	1856

It was remarked as creditable to the artillery that not more than one-tenth of the rounds were lost, and not more than one-tenth of the fuses failed to explode —that is that not more than one-fifth were more or less ineffective!

At first the fire was answered actively from the Forts, and well directed.

The sudden opening of battery No. 3, between two and three hours after the rest, seemed to make an impression on the garrison of the Tête-de-pont, the practice from which then became very imperfect, and at mid-day it ceased firing altogether; but the two other Forts continued their fire till the evening.

Early on the morning of the 18th two great explosions were heard at the two Forts Rochetta and Bocca di Ganda, on the left bank, and it became known that the whole place was abandoned by the garrison.

When entered by the besiegers, it was found that the two Forts on the left bank, Rochetta and Bocca di Ganda, were in ruins from the explosions of their magazines by the garrisons on evacuating them, so that it could not be ascertained to what degree they had suffered by the cannonading. The Magnagatti Fort was complete and uninjured. Its destruction, like that of the other two, had been prepared for, but was prevented, it was stated, by an inhabitant of Borgoforte cutting the train.

After this severe cannonading, however, the great subject of interest would naturally be, what was the condition of Mottegiana (the Tête-de-pont), the special object of attack, and it is shewn not to have suffered to the extent that might be supposed from the amount of fire directed on it.

Its ditches, escarps, counterscarps, and caponier-flanks were uninjured; the parapet was partially damaged and thrown out of shape, as exhibited particularly in many of the embrasures, but substantially was standing and capable of good service; some guns were dismounted, and many of the carriages of others more or less damaged.

The principal impression made, however, was on the defensible barrack that covered the gorge; this was said to have been in ruins, a statement, however, not borne out by the photographs taken of it after the event; they shewed indeed numerous shot holes in the walls of the upper story, some of them very large from the effect of the explosion of shells, or of several striking near to each other; but very few took effect on the lower story, and the body of the walls and the roof remained standing; there were also breaches in the parts of the gorge wall that were not covered by the barrack.

The most striking effect, however, exhibited, was in the large masses of fragments of the barrack wall thrown out by the shells and scattered over the whole interior of the work.

The Fort was abandoned manifestly in great haste and confusion: officers' baggage, and even the sword of one and men's knapsacks, besides interesting documents and good supplies of ammunition and provisions, were left in it.

The conclusions to be drawn from this operation are not, I think, in favour of it as a system, although it was successful in this instance.

After a large expenditure of ammunition, not generally very easy to bring up in a campaign, and no doubt a considerable amount of deterioration of guns and carriages, the main features of the defences of the Fort remained intact and perfectly serviceable.

The fire of its upper battery which commanded the country may have been in a great degree silenced, but that is usually considered as only the commencement of any siege, and even that operation was not perfect, for the state in which the parapet is described to have been left, shews that it might have been used perfectly for musketry, and even that spirited efforts might have brought up guns from time to time to be served from it, for the effect of direct plunging shot from a distance of not less than 1,500 yards is far from possessing that constantly impressive power of the old enfilading ricochet batteries.

The feeling appears to have been that the cause of the abandonment of the work was the quantity of broken up masonry thrown about the interior by the battering of the barrack.

There can be no reason why this should have been considered to have been so decisive; there must have been plenty of places of refuge from its effects, and indeed it is manifest that there were, and that the bulk of the garrison might have found shelter in them till called out to oppose an assault; therefore it does not appear at all clear why the garrison so hastily retreated from this Fort, still less why those on the left bank should all be abandoned at the same time; and it must be supposed that the Austrians had other reasons for withdrawing the garrison than the results of this attack.

As it could hardly have been contemplated to have reduced the Fort by the destruction alone of the barrack retrenchment of the gorge, the real aim of the batteries of attack, as of much more importance, must have been to destroy, as much as possible, the parapet, and silence the guns on its main front of defence; and if so, it only proves, so far as the practice on that occasion goes, how large a force, even of rifled artillery, and how large an amount of ammunition, are required to effect those objects, where the fall of the plunging fire has, from a distance of 1,500 yards or more, so short a limit of range as that of the width of the parapet and length of platform in longitudinal extent, that is of 50 or 60 feet at most.

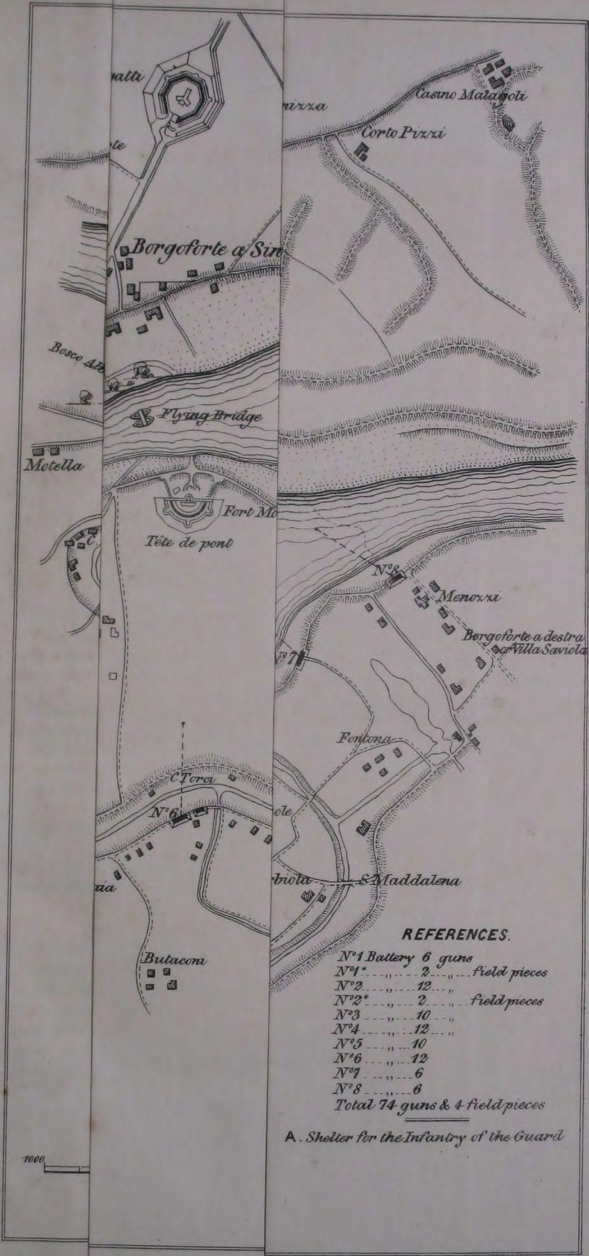
We have no reason to doubt but that those parts of the Forts of Rochetta and Bocca di Ganda, on the left bank, that were directed upon the front and flanks of the Tête-de-pont had casemated guns that would bear on them, and yet be very difficult to counter-batter, as such a construction was perfectly practicable; and if so, or even without it, had the garrison persevered, the entire reduction of that Tête-de-pont would have been still a work of considerable labour and loss.

The penetration of the shells into the masonry of the barrack in the Tête-de-pont, at from 1,500 to 1,600 yards distance, is stated to have been about 75 centimètres (nearly 2 ft. 6 in. English), with a radius of explosion of about 3 feet, while in the parapet, which was of particularly compact clay, they did not penetrate more than 4 or 5 feet; and it is mentioned incidentally that some that hit the defensible barrack in the distant Fort of Magnagatti, from a range of 4,000 yards, made impressions of from 4 to 4½ inches in the masonry, and about 20 inches in the earth.

The result of this operation, however, tends to confirm the present general understanding, that since the introduction of rifled cannon, it becomes expedient to avoid exposing masonry, even though unseen, to a plunging fire from long ranges; this is of particular importance with regard to caponier-flanks or other influential portions of the defence; wherever they must be in the possible prolongation of such fire from the front, as much of them as can be should be covered by a close screen; but a better method is to abut the casemated cover, whether for the troops, stores, or defences, on the back of the front line, and give the flanking caponiers a reverse fire, which would protect them altogether from such practice.

It may be observed on this point, that in proportion as a work is on more elevated ground than where the batteries of attack can be placed, will be the want of effect of this kind of fire; and it will be decidedly most effective, where it can be directed on the prolongation of a ditch for the ruin of an uncovered masonry caponier-flank.

J. F. B.



Lithographed at the Royal Artillery Institution

SIEGE BATTERIES.

No. of Battery.	No. of Guns.	Calibre of Guns in centimètres.	To act against	Range in Metres.	Range in Eng. yds.
1.	6	17	Rochetta	1900	2078
			Mottegiana	2500	2734
2.	12	12	Rochetta	1500	1640
			Mottegiana	1900	2078
3.	10	12	Mottegiana	1700	1859
4.	12	12	Ditto	1450	1585
5.	10	12	Ditto	1400	1531
			Bocca di Ganda..	2650	2898
6.	12	17	Mottegiana	1380	1509
			Bocca di Ganda..	2300	2515
			Rochetta	2450	2679
7.	6	12	Bocca di Ganda..	2400	2624
8.	6	17	Bocca di Ganda..	2500	2734
			Mottegiana	3000	3280

Nos. 1* and 2* were for field pieces to interrupt the communications across the river, or to oppose any guns the garrison might run out on the dykes of the left bank, but there was no occasion to use them.

Before the Paper was read, General Sir John Burgoyne made the following remarks:—

GENERAL SIR JOHN BURGOYNE: Before the paper is read I may state that it is taken from a manuscript account of the Siege of Borgoforte last year, in which the Italians thought they had great reason to triumph. What makes it of interest is that it is one of the first cases that has come to my cognizance of the application of the new force of rifled artillery to purposes of attack. I think the siege was conducted on fallacious principles altogether from its first commencement; and that the conclusions drawn from the result of the operation were also fallacious.

DISCUSSION.

COLONEL SIR W. DENISON, G.C.B., in the Chair.

GENERAL SIR JOHN BURGOYNE: The moral I would draw from this account is, that I do not think in places properly fortified, even under the old principle, if the scarps are well covered, they are subject to much more danger from rifled guns than they were before from smooth bores, or, at all events, to very little more. I do not see that rifled guns give much advantage in attack, excepting in this way: a distant fire may, in some cases, be brought at long ranges—800 or 1,000 yards—to destroy the parapet by direct fire rather earlier, though at a considerable expenditure of ammunition, than could be done by the old round shot. But in other respects, the idea that the rifled gun is to make our old fortifications of no value at all is, I think, an absurdity. I do not see that it will be of much use; on the contrary, I think rifled guns will be rather more useful in many ways in defence than in attack. In the first place their enfilading batteries are of less effect than the old ones, because the ricochet fire from the rifled guns is not so good; the shot always have a twist which makes their flight irregular; whereas the ricochet was the most powerful fire we had before, and I do not think it is compensated for by any advantage obtained from rifling.

COLONEL SIMMONS: I think with regard to this attack it is rather difficult to make out, as is well observed in the paper, why the Austrians evacuated the fortress. I can understand the evacuation of the fort *Mottegiana* being due in some measure to the imperfect communication across the river to the forts on the left bank which supported it; but the evacuation of the forts on the left bank seems perfectly unaccountable. The experience, therefore, that we gain from this attack on *Borgoforte*, is simply and solely that which we could gain from the ordinary first operations of a siege. I think it points out to us one or two things with regard to modern attack of very great consequence. First, that batteries can be opened at a very much greater distance from a fortress; they were opened in this case at distances varying from 1,500 yards to 2,000 yards. Within that distance the assailants were enabled to obtain the cover of some dykes, that had been erected for the protection from inundation of the great plains bordering on the Po. Similarly, I think it very probable that in front of almost all fortresses that are about to be attacked, a very large amount of cover could be got within 1,500 or 2,000 yards, and that probably the first batteries might be opened without experiencing much loss. From the original paper, of which this is a very full extract, it also appears that the Italians erected some of these batteries on the dykes—absolutely on the top of them—for they must be very broad dykes from the description given in the paper; others were made on the reverse slopes of the dykes by cutting, as it were, notches into them, the guns being fired *en barbette* over the top of the dyke. These positions were very favourable for the construction of a battery with its magazines, which would be completely under cover of these large dykes. I think it worthy of observation, with regard to these batteries, that they were seven days under construction without being discovered by the defenders. They were covered as the original accounts states, by high grass; and one battery, either No. 3 or No. 6 on the right bank of the *Colatore Zara*, was covered by a cherry orchard. The grass was sufficient in most cases to cover the batteries and in that particular case the orchard covered it completely. The first knowledge the defenders had of the works having been commenced for attack was the opening of the fire from the batteries. I think it is a very important point to have established, that there will be a great probability in future attacks, in consequence of the distance from the fortress at which guns are useful for attack being now so great, that in very many, if not in most cases, the first batteries will be opened with comparatively little loss, and that in many cases, they may be opened without their having been even discovered by the defenders.

I think this is a point gained for the attack. I think something is to be learned from the practice of the artillery against fort *Mottegiana* with reference to the employment of embrasures. We do not know what the thickness of the parapet was, but the account says that the parapet was somewhat damaged, that some guns were dismounted, and that many of the carriages were more or less injured. This brings me to a point which I once observed upon in this room before, namely, the desirability, if possible, of covering guns and carriages in position from direct fire. I believe that direct fire is much more dangerous now than vertical fire. Formerly, we had to guard against vertical fire to the utmost, and did so, apprehending very little damage from shells fired horizontally. Now, however, things are very much changed, and the horizontal fire of shells is infinitely more dangerous, and more to be guarded against than vertical fire. The fact that several of the guns firing through these embrasures were dismounted, shows the necessity of concealing the embrasures, and covering the guns from direct fire if possible. One of the most efficacious ways of doing this would be by iron turrets. But that is a very expensive arrangement, and one that is very difficult at all times to carry out, and there are other ways of accomplishing the same end. A paper was recently read at the United Service Institution on the subject, and I have lately submitted to the authorities the very great importance of trying an experiment with a gun carriage invented by the author of that paper, Captain Moncrieff, of the Edinboro' Militia Artillery. The object of this carriage is to permit of the gun being brought up to fire over the parapet; in its recoil it falls down behind the parapet, and is completely concealed; there is thus no weak point in the parapet or permanent object affording a constant target for the enemy to lay his gun upon. The whole parapet as seen from the exterior is one even line. The gun is loaded in comparative security, is brought up to the firing point, laid and fired over the parapet, and brought back again by the action of the recoil in a manner which seems simple, and gives every prospect of success. The machinery by which this is done is a very simple mechanical arrangement of counterpoises. But whether this particular gun-carriage is successful or not, I think, as I stated in this room two years ago, that it is of very great consequence that, if possible, some means should be devised by which guns can be kept in comparative safety, except for the actual moments when they are obliged to be brought up to deliver their fire. I am more desirous of pressing this point because, from having witnessed a good deal of artillery fire in experiments, I feel convinced that one of the most difficult problems you can give to an artilleryman is to lay a gun constantly upon a given point, where that point is not well defined by a particular object. I mean if you have a long line of parapet in a fortress, as it appears looking at it from the exterior, with no clearly defined angles (the difficulty of discovering an angle where the parapets are all green is well known) if you have no embrasures and no point in that parapet upon which the artilleryman can fix his eye in order to lay his gun, you present to him one of the most difficult problems that he has to deal with in practice. I think it is of very great consequence that particular attention should be paid to this subject, and that all elevated points, such as expense-magazines—which I have seen in some cases constructed in traverses, with the traverses raised above the level of the parapet

—that all excrescences of that sort, all elevated points above the line of the parapet should be most persistently avoided, as thereby causing a very great difficulty to the artilleryman in his practice. As regards the effect upon the buildings in rear, it is to be observed that artillery fire upon a line of parapet is rather uncertain, from the very great difficulty of judging range accurately. If a gun be laid upon a target at a given range, with a spirit level and with the greatest accuracy, it will be found that at 1,200 or 1,400 yards the shot strike at points which average two or three feet—and even more than that, with some artillery I have seen four or five feet—above or below the centre; the consequence is that a large proportion of the projectiles will pass over the parapet, and if these consist of the large heavy shells of the present day, I have not the slightest doubt that the defences in rear which stand up above the *terre-pleine* will be very seriously injured, and that these interior redoubts, that are supposed to be of such great value to works, will not add so much to their powers of resistance as is expected. In the defences which the Prussians threw up last year for the defence of Dresden, they erected a number of detached redoubts, and within those redoubts they placed defensible barracks. The entire defences were extemporised in a very ready way, only fifteen days having been required for their construction, for which, however, no doubt, preparations had been made long before. They went to great trouble and expense to make these defensible barracks bomb-proof or secure from vertical fire, but my belief is that the interior defences within the redoubts would have been utterly valueless after a few rounds of shell fired at the parapets themselves; the shells which would have passed over the parapets would have destroyed those interior defences, and at the moment when they were required they would have been utterly valueless. I think we shall have to pay much more attention to the fire of horizontal shells than we have hitherto done, and that their fire is of much greater consequence than vertical fire. As to the attack and the evacuation of Fort *Mottegiana* by the Austrians, I quite agree with Sir John Burgoyne, that it seems altogether unaccountable why they did not hold out longer, especially as the scarps and counter-scarps were intact, as well as the flank defences. I would observe, however, that we must resort to extraordinary means for attack, nowadays, to overcome the extraordinary means for defence which are employed; if the artillery fire of the work had been entirely subdued, but the defences in the ditch still intact, I think it quite possible to have assaulted a fort so circumstanced. Modern appliances permit of the construction of moveable bridges of steel which might take the place, in certain cases, of scaling ladders, and be thrown across a ditch 60 or 70 feet wide for the assault of a work, the fire from the parapet of which has been entirely subdued by the attacking artillery, and the flanking fire from which could not be opened until the attacking columns were close upon the counter-scarp. I have lately had a bridge of this sort designed by a young officer as an exercise, and up to a span of 60 feet it can be managed easily within one ton, and might be run along with almost as much facility as a fire-escape. Therefore, I think, if your attacking batteries have *entirely* subdued the fire from the parapet, you might, if you were well prepared for it, (I do not mean to say that the bridge to which I have alluded was perfect in its design) risk an assault with means specially prepared for the purpose.

THE CHAIRMAN: It appears to me that this subject is not brought before us sufficiently in detail to enable us to enter upon a discussion as to the effect, either on the attack or defence, of the improved projectiles, which have been brought into action of late years. I think the whole account is very loosely given. I do not imagine that the Austrians having their parapets only slightly damaged and their scarps untouched, can have been frightened out of the place by a shower of bricks produced by a few shells bursting in the rear of the work. And, again, there can be no imaginable reason why the forts on the other side of the river, which were merely fired at from ranges of from 1,500 to 2,000 yards, should have been blown up and deserted, unless there were some other political or strategic reasons why the garrison should have been withdrawn. With reference to some of the details that have been discussed by Colonel Simmons, I would observe that all experience goes to show that the more simple the weapon that is put into the hands of either soldier or sailor, the more effective it is. I take it from what I have heard, with reference to breechloaders and weapons of that kind, especially on board ship, that the sailors are, in fact, afraid of them. At one time the plug comes out; at another the tin cup at the end of the cartridge is put in the wrong way, and out comes the whole charge of powder into the ship, blows up the deck and destroys all the bulkhead. But changes are constantly being made and defects remedied; so that, I think, any discussion that we can go into at present, or any opinion that we may form as to the relative effect on the attack or defence of the place by the new projectiles would be merely matter of opinion—and of opinion based upon too narrow an induction to be of any value. My own opinion is that the defence has benefited more than the attack by this improvement in weapons of defence, if we assume that the place is armed with rifles and heavy guns of the same amount of precision as those brought to the attack. We must recollect that the parapets, &c., that are constructed for the attack of the place are of loose materials, easily penetrated, presenting but little resistance to shot, while the salients of the place, and those portions, the fire of which is most effective, can be cased with iron and made practically impregnable. Therefore, as far as my own opinion goes, and that is only an opinion deduced from reading, the defence has the best of it. With regard to Colonel Simmons' bridge, if it has to be moved over 1,500 yards, and if there be only one single rifleman, with parapet sufficient to cover him, it would be found very difficult, if not impossible, to bring it up to the edge of the counter-scarp.

COLONEL SIMMONS: I presume you would bring your trenches something nearer than 1,500 yards.

THE CHAIRMAN: There is the difficulty.

COLONEL SIMMONS: There is little or no more difficulty in bringing up the trench to within 600 yards than there used to be.

THE CHAIRMAN: I will give you half—take 750 yards—and supposing you have to drag your bridge over 750 yards with half a dozen riflemen steadily firing at you.

COLONEL SIMMONS: I should not try that experiment; I should get a little nearer first.

THE CHAIRMAN: I should be very sorry to be one of the men leading the bridge.

MAJOR HUTCHINSON: What distance do you propose to drag the bridge?

COLONEL SIMMONS: I have not decided in my own mind what distance, but what I mean to say is that if a fort be surrounded by a ditch which is entirely dependent for its defence upon works within it, unless that ditch is very broad, it is not a solid basis on which you can calculate for protection. If a place is to be taken, the trenches must generally be brought up to the counterscarp. The great claim that is made for all these defences within a ditch is that they are intact up to the period of the attack; that at the supreme moment of attack these defences are still intact; that they are completely concealed in the ditch, and at the moment of attack are so effective that you cannot cross the ditch. Now I do not think myself that this is a position which ought to be assumed, for I think with moderate breadths of ditches, up to 50 or 60 feet—quite 60 feet—it will be possible to give them the go-by by passing over them. I think this operation is not at all impossible. I do not mean to say it would not be a difficult operation; escalading is a very difficult operation in which a number of men must generally be sacrificed. No man has larger experience in escalades than Sir John Burgoyne, and he knows full well the danger of escalading with scaling ladders; but still it has been done, and we shall have to do it again if we go to war. I do not think it would be a more dangerous operation to run a bridge of that sort for a limited distance—I do not mean to say 1,500 yards—than it would be to carry a scaling ladder for the same distance.

THE CHAIRMAN: That was a difficulty that would have occurred under the old system of war, just the same, but we are discussing now the effect of the improvement of weapons, and your power of destroying from a distance all the defensive works, guns, and parapet, and everything, so that you may bring your trenches up to the counterscarp. That is, in point of fact, the very difficulty. I do not see how it is possible, with your present weapons, that you could get to the escarp so long as a gun or a parapet, or anything in the shape of a defence existed. If there is no fire emanating from the place you may walk into it of course.

COLONEL SIMMONS: I think in all attacks the first object is to subdue the fire of the place. The first problem to be solved is, Can you, or can you not, subdue the fire of the place? I believe that with appliances such as these turrets, and with others such as that I have described, a cheaper and more effective arrangement than the turret, viz., a rising and falling gun, (which, by the bye, is no new thing, but one, the importance of which was urged many years ago by the late General Blanshard, who endeavoured to invent some contrivance of the sort even long before the introduction of rifled artillery, but which is ten thousand times more important now,) you may get a good defence. But unless there is some means of keeping a gun or guns intact, ready to prevent the construction of the sap, I think we may presume that the fire of the place will be subdued, and that the sap will be continued. You bring many more guns to the attack than there are for the defence. It is evident in the present case that the fire of the place would have been subdued.

THE CHAIRMAN: That is the whole question which we have to consider. If the instruments which are now used in the attack are of such power that they can subdue the fire of the place in spite of any efforts that can be made to secure the works and to return the fire with similar implements within the fortification itself, why, the works are beaten down and the place is taken as a matter of course. If, however, by the use of iron or other arrangements, the guns can be preserved and half a dozen kept intact, then, looking to the present accuracy of fire, it would be perfectly hopeless to attempt to sap up to the place.

COLONEL SIMMONS: It would be a very long business, no doubt, but you must always bear in mind that the attacking force have a preponderance of artillery.

THE CHAIRMAN: I mean if you can keep the guns intact, and I do not see any reason why you should not, by the means of iron turrets or shields. If six inches of iron would not be thick enough put twelve, and if twelve be not thick enough put twenty-four; there is no limit to the amount of iron that may be used in a fixed turret. Though you cannot load a ship with a mass of iron of that kind, you may make an iron turret utterly impregnable against the effect of shot. Shot may hammer and hammer at it, but cannot penetrate it.

COLONEL SIMMONS: I suppose you will allow there has always been one very vulnerable part of a turret, and that is the embrasure; chance shot will go into an embrasure. If you have a number of guns round a certain circumference opposed to one gun in a turret, I think one might hope to keep down the fire of that turret, and to make it so very hot that that turret would not do much work.*

THE CHAIRMAN: I do not feel so certain of that. There is the old story you may recollect—I won't call it a story but a fact—that a single gun under cover, (I am not certain whether it was in a martello tower or a battery) beat off a seventy-four somewhere in the Mediterranean.

CAPTAIN STEWARD: It was a martello tower.

THE CHAIRMAN: There was a single gun firing steadily, hulling the ship at every shot. The seventy-four had thirty guns banging at it in every possible direction, but the gun went on steadily firing and the seventy-four was beaten off.

COLONEL SIMMONS: I think you can hardly compare that to a land attack, because the seventy-four was beaten off for this reason—It fired a certain number of rounds without chancing to upset the gun, it did not produce a breach in the tower, and therefore according to the ordinary course of events it was obliged to go off. The frigate did not open trenches, and had no solid base to work from. If, on the contrary, the guns of the frigate had been on shore in position round that one gun in the tower, we all feel that even in the old days of smooth bores that one gun would have been very soon silenced, and the battery destroyed. I do not think you can argue that because thirty guns in a frigate were beaten off, therefore the same number of guns on shore, or even a very far less number, would not have accomplished the desired object.

* During the American war, a monitor was completely silenced by several smaller ships around it keeping a steady fire on the embrasure as it was brought round to deliver its fire.

THE CHAIRMAN: Your accuracy of fire, of course, is limited, but if the one gun is dismounted another can be brought into its place. However, we are making a great number of hypothetical assumptions.

MAJOR LEAHY: It has, as pointed out by Colonel Simmons, been practically established in the case under discussion, that siege batteries can be opened with effect at longer distances than heretofore without being discovered, and with little or no loss of life in their construction.

THE CHAIRMAN: I do not see that you have any object in opening a battery at 1,500 yards. You used to open it at 600; you could do that, and you would now if you dared.

MAJOR LEAHY: The besieger is able to avail himself of accidental circumstances in the formation of the ground to open the battery without being discovered, and the siege guns are now as effective at 1,500 yards as they formerly were at 600 yards. I think it is a question whether, as ground favourable for a dispersion of the guns was found, the Italians were right in concentrating their guns in batteries at all. It is a question whether guns opened at that distance ought not to be still more dispersed, and I think we should look forward to the use which may be made of tramways in moving the siege guns from one position behind the trenches to another, the guns being mounted so as to be readily raised or depressed by an arrangement such as that proposed by Captain Moncrieff for guns mounted in permanent works.

COLONEL SIMMONS: It is quite contemplated to apply Captain Moncrieff's principle to guns for attack as well as defence.

MAJOR LEAHY: They are not yet adapted for the attack.

COLONEL SIMMONS: I think some of the designs I have seen are quite adapted for it.

MAJOR LEAHY: When speaking to him the other day he said he did not rely on his system, as at present developed, so much for siege batteries as for permanent works; but he contemplates, and I think we should contemplate, mounting guns on traversing platforms made to run on rails. As the provision of tramways in the trenches must enter into the plans of all future siege operations, the guns so mounted might be moved from place to place, and their fire thereby concentrated on turrets or embrasures from unexpected points. I think the power of concentrating fire from distant points gives great advantage to the attack on land defences, and more than compensates for the advantages likely to be derived from the use of turrets, which, being costly, are not likely to be provided to any large extent. A weapon that might be used with great effect is the small 1-cwt. Whitworth gun, which is accurate at ranges of from 1,700 to 2,000 yards, and throws an elongated projectile or shell weighing about 2 lbs. A number of these guns dispersed about the attack would, I think, tend very much to keep down the fire from forts. My opinion is that, on the whole, the advantage is at the present time with the attack rather than the defence.

THE CHAIRMAN: You seem to me to assume that it is an advantage that you are to begin at 1,500 yards instead of 600. With the power of artillery in the place you cannot venture now to come within your old range. Your old range was 600 yards, and at that distance you erected your ricochet batteries, &c. You are now compelled to begin at 1,500 yards. You say, very truly, the fire now is as effective at 1,500 yards as it used to be at 600, but the battery is put at that distance, not because it would not be more effective at the smaller distance, but because the fire from the place is so effective that it compels you to take up your position at the greater distance. Thus you have to work up from that 1,500 yards, about double the old distance.

MAJOR LEAHY: But it is a great advantage to begin without being observed. We opened our trenches at Sebastopol at 1,400 yards; we were not observed, and we did not lose a single man the first night.

COLONEL SIMMONS: I think with regard to the construction of the batteries at 1,500 yards, as compared with 600 yards, the facts are that you have such an accurate gun now-a-days, that if you had the power of making your first batteries at 600 yards you would prefer to make them at 1,500; for this reason, that you can bring up the guns and all the ammunition, and construct the works in comparative safety, whereas, by attempting to construct the batteries at 600 yards you would be subject to most severe losses. And as to opening the trenches, I do not consider that because the batteries are constructed at 1,500 yards you are therefore to compare that distance with the old distance of 600 yards, at which the first parallel used to be constructed; open your batteries at 1,500 yards, and still construct your first parallel at a range of about 800 yards from the place, when it will still be clear of the effective range of rifles fired from the shoulder. Therefore, I believe, at the same time that you make your battery at 1,500 yards, you can make your first parallel, probably at a distance not exceeding 800 yards.

THE CHAIRMAN: The old rule was based upon the range of musketry fire.

GENERAL SIR JOHN BURGOYNE: There is a fallacy I think in assuming the great advantage of establishing siege batteries at very great distances from the place; they are certainly constructed at little or no loss, but that is of no value unless it tends to expedite the siege, which I doubt to be a necessary consequence, for their effect is confined very much to silencing the fire of the place by opposing it direct, which is the least efficient mode; and that by a very great consumption of ammunition, which may be very difficult to supply, and with all the nearer approaches subsequently to be made, as of old. Nor do I see the difficulty of commencing approaches as near as before, notwithstanding the rifled guns in the place, particularly as the besieger will now bring the long range and the accuracy of the rifled musketry to bear on the artillery of the place; and after all it is the sorties, and not the fire from the place, that most essentially check the liberties the besieger may take in his approaches. To be sure, these distant batteries did reduce this place of Borgoforte, and that is precisely what I would criticize, for there appears to have been no real ground for its having been abandoned; the obstacles of ditch, escarp, and counterscarp, and the flanks, that is, all the real effective power of self-defence, remained intact, and had to be approached and overcome. The casemate or barrack in the gorge of the work being destroyed, even if it was so, did not prejudice these defences, though it was an error in construction not to have covered it, from which we may take a lesson. A remark has been made that the retreat of the garrison would have been cut off by the besieger's batteries.

COLONEL SIMMONS: All I suggested was, that one could suppose it possible that, with a feeble defence, Mottegiana might have been abandoned, because the garrison might have apprehended that the flying bridge across the Po would have been destroyed; but this does not account for the destruction of the other works.

GENERAL SIR JOHN BURGOYNE: No doubt the communication across the river would have been totally interrupted during the day, but not at night, and that at the worst is not sufficient grounds for abandoning a good work.

COLONEL SIMMONS: I take it that the Italians were as much surprised at the place being evacuated, as we are at reading it.

GENERAL SIR JOHN BURGOYNE: That may be, but they do not seem to treat it as a God-send, but boast of the great feats they performed, and among other things, even of having constructed batteries at 1,500 yards from the place without loss.

COLONEL SIMMONS: I think this attack was a most successful operation, although at the same time it cannot be denied that its success was a happy fluke. In my opinion the Italian engineers could not have calculated on taking Borgoforte in the way they did, but I think they may take great credit to themselves for the very trifling loss with which its capture was accomplished. The great object in all engineering works in war is that they should be accomplished with as little loss as possible, provided no undue delay be created to produce that saving of life. I take it that the attack of Borgoforte comprised only the first operation of a siege in which it was intended to construct parallels and approaches, and to bring up the works to the counterscarp,—that in fact it was the first operation preliminary to other intended operations incidental to a regular siege; and as the Austrians evacuated the place there was no opportunity for carrying on those further works. I think, therefore, the Italian engineers are quite right to claim credit to themselves for the very little loss.

GENERAL SIR JOHN BURGOYNE: Too much consequence may be attached to the constructing of batteries with little or no loss, that is, so far as giving up advantages to save casualties; the calculation must be on the consequences of the entire siege; losses in particular operations must be submitted to, when tending to expedite the great end.

COLONEL SIMMONS: Supposing that they had begun at 800 yards, and had been discovered, opposed as they were by rifled artillery, the batteries would never have been completed and never opened; because in the teeth of rifled artillery at that range, I maintain you can never erect a battery.

GENERAL SIR JOHN BURGOYNE: In that I differ altogether; a great extent of simple cover would be obtained the first night, with that protection the batteries would be progressively and irresistably established; if a single one were opened it would probably be overwhelmed by the fire of the place, but many are brought to bear at once, and concentrated upon distinct defences, and they will, aided by the rifled musketry, gain the ascendancy, as they have hitherto done.

COLONEL SIMMONS: The cover required now-a-days to oppose rifled artillery is very great; batteries have to be more than doubled in thickness to give the amount of security that they did formerly. If that thickness be not given to them, shells fired against them are so destructive in their effects that the battery would not long keep its fire open. The destructive effect of a very small shell, the 110-pounder, produces a crater of six feet seven inches in diameter by four feet in depth. The 70-pounder of the present day removes sixteen times the cubic content of earth by its explosion that the old 68-pounder used to, and unless parapets are very thick they will, as was shewn by the experiments at Newhaven, be cut away in a very short time by rifled artillery. That great thickness of parapet prevents, or almost prevents, its being thrown up in one night. Formerly you could throw up a battery in a single night, but directly you have to throw up a battery with this great thickness of parapet, it becomes the work of at least two nights, or unless you have very good workmen it would require three or four nights; in the attack under consideration they were seven nights in construction, and during the whole of those seven nights if the batteries had been within view of the fortress, their positions would have been well known to the Austrian artillery, and the probability is they would never have been completed. Therefore, if the artillery of the attack be sufficiently accurate in its fire to silence that of the place at 1,500 yards, I think it is a good system to construct the first batteries at 1,500 yards, especially when the probability is that that increased radius of 1,500 yards will permit of your taking advantage of the sinuosities of the ground to construct the batteries with comparative safety; and what is more, and which is just as difficult a matter as the construction of the batteries themselves, to construct the magazines for those batteries. The construction of field magazines is a most serious question, and one of extreme difficulty, which we have not yet solved. The magazines recommended by the committee of officers, who recorded the proceedings at Sebastopol, are, I believe, utterly unsafe to resist rifled artillery, and the chances are that magazines constructed according to those recommendations would be exploded within a very few hours after the batteries were opened, and that your guns would be all shut up. Therefore, I think it is of very great consequence to be able to take advantage of sinuosities and undulations of the ground, and make your batteries in comparative safety. The quantity of earth that has to be thrown up at night adds infinitely to the difficulties in the construction of siege batteries, requiring very large and comparatively closely compacted working parties, and my belief is that the great mass of earth that must be thrown up will discover the position of those batteries if they are within moderate range and view of the fortress; and I do not believe that if the position of a battery be once discovered, and if a single heavy gun be brought to bear upon it, that it will ever be completed. That is my belief after watching the effect of artillery practice.

THE CHAIRMAN: I think you are quite right; and, therefore, I think the defence has the best of it.

COLONEL SIMMONS: No doubt, defence and attack are much more difficult than they used to be.

LIEUTENANT ARDAGH: I suppose armour plates will always form part of the material of the attack?

COLONEL SIMMONS: There is the difficulty of carrying and placing them.

LIEUTENANT ARDAGH: Wherever you can carry a 32-pounder gun you can carry a two ton plate.

THE CHAIRMAN: If you are to suppose you have a railway to bring up all your materials you may bring up whatever you choose—you may bring up a 110-pounder. But where your roads are bad, and your country rough, you would have a difficulty.

COLONEL SIMMONS: I think both attack and defence become much more difficult, and that the operations of attack will be prolonged, but I think the attack will be equally certain in its ultimate results as heretofore. I think the old well established problem that "the attack must succeed" still holds good. I repeat that I think that the duration of the attack will be very much increased by the introduction of rifled artillery, but that the attack eventually will succeed just as certainly now as it used to.

GENERAL SIR JOHN BURGOYNE: You acknowledge, I suppose, that the besieger must come to very close approaches or he cannot breach.

COLONEL SIMMONS: Quite so, and he will have to adopt extraordinary means to meet the difficulties to be encountered in those approaches. It is only a question of time. It will take a long time to do it, but as certain as we are sitting here, the attack still has the preponderance over the defence. In my opinion it is only a question of time.

GENERAL SIR JOHN BURGOYNE: It will require greater time and greater means than formerly.

COLONEL SIMMONS: Yes, and we shall have far greater means than ever were dreamt of a few years ago, both for attack and defence. The progress of invention is so rapid that the means that we now consider wonderful will not be thought so a few years hence.

GENERAL SIR JOHN BURGOYNE: With reference to the opposition that may be made by the garrison to siege approaches, I have long thought that great advantage might be gained by the employment of a fire-arm of greater power than the musket, say a one-pounder, to be mounted either on wheels or on a swivel, which might be so portable and manageable as to be available for any temporary cover that could be obtained; it is well known that it can be made capable of great range, accuracy, and with considerable power of penetration, and would be very effective against saps and other light trenches.

COLONEL SIMMONS: That sort of fire was used very much by the Americans during their war, and I have not the slightest doubt it will be very much used again. I only wish we had it in our equipment, both for field service and permanent works. To shew the extent to which the Americans carried it, and how far we are behind them in that respect, I may mention that an officer of Engineers, who visited their works of attack at Richmond, told me that he himself watched a fellow who was called "California Joe," a well known shot in the American service; he stood behind him for nearly a quarter of an hour, and watched that man with his eye steadily fixed and looking along a telescopic sight upon a rifle laid upon a gun at a distance of about 600 yards, and as sure as a man shewed his hand at the gun he would hit him; and he thus entirely kept down the fire of the gun. If you apply these sights with this perfection of aim to these rifled one-pounder guns, I believe they would be of great use in defence, but I believe also they would be of great use in attack. You always have the advantage in the attack of working on a larger circle, and you always attack with a preponderating force. The old condition of the attack was to suppose that you had a larger number of guns than the defence, and you must still suppose that you have a like superiority. You would have a larger number of these one-pounder guns and a larger number of riflemen; and, therefore, if you work upon the same data as we used to work upon formerly, *mutatis mutandis*, we shall have the same ultimate result.

MAJOR LEAHY: If, as Colonel Simmons points out, the shell from the 70-pounder gun will act as a mine, and remove sixteen times the amount of earth that the old 68-pounder will, it gives an advantage to the attack over the defence; in the fortress the front attacked is necessarily limited in extent, and the besieger being supposed to have a preponderance of artillery fire and being able to use his guns with accuracy at 1,500 yards, would be able to reduce the limited extent of parapet to ruins, and although his subsequent operations might involve a good deal of engineering labour they would not entail a great loss of life.

THE CHAIRMAN: The 70-pounder is a heavy gun.

COLONEL SIMMONS: It is a light gun now-a-days.

THE CHAIRMAN: You will never make it easy to carry. If they put a 24-pounder on my shoulder instead of a rifle, I should succumb.

MAJOR LEAHY: The 65-cwt. or 70-pounder gun, that Colonel Simmons speaks of, is exhibited by us at Paris as a siege gun. The weight of the 68-pounder is 95 cwt.

COLONEL SIMMONS: There will be very few attacks undertaken in modern warfare without having a railway to bring up your gear.

MAJOR HUTCHINSON: I should like to ask Sir John Burgoyne one question. At the end of the paper he said that if possible caponier-flanks should be covered by some sort of screen. I want to know whether he alluded to the screen in use, I believe, at Diest in Belgium, a kind of tunnelled embrasure through which the guns fire?

GENERAL SIR JOHN BURGOYNE: I meant that instead of having your caponier exposed from top to bottom, I would cover it by an advanced embankment, leaving only what was necessary for the embrasures exposed, that is, so little as would render the blind fire against it very ineffective.

THE CHAIRMAN: With regard to the employment of guns throwing a shot of a pound weight, this would, as with the old wall pieces, be very useful in the defence of a place. No siege can be carried on without a great exposure of individuals. Officers must come within some proximity to the place to reconnoitre. Artillery must be carried backwards and forwards. According to the old system, and indeed at present, there are no weapons which can be used to fire at individuals at a long range but a 24 or 32-pounder. The one-pounder would probably answer every purpose.

COLONEL SIMMONS: I saw once the effect of a three-pounder—not much larger than the one pounder that is now proposed. It was a long rifled gun, 6 or 7 feet long, a breach-loader, that had been tinkered up from hoop iron by some mountaineers in the hills in Turkey. They brought it to Eupatoria, and wanted Omer Pacha to adopt it as part of his armament. He asked me what I thought of it, and I suggested that as the Russian videttes were within 500 yards of ours, and were supported by strong pickets in their rear at a considerable distance, we should try the effect upon one of the pickets. We took it out with a single horse to our line of videttes. The gun was loaded with a three pound leaden ball and laid at the Russian cavalry at a distance of about 2,000 yards; the first shot went about half way; we gave a little more elevation, and after firing two or three rounds—they did not understand what we were at, as they did not see this small projectile fall on the ground—we got up pretty near them, and at last we got a shot amongst them, whereupon they stood to their horses and mounted, and moved off some 200 or 300 yards further. We gave the gun a little more elevation and followed them, and got a shot amongst them again. They moved off 300 or 400 yards further and we followed them with the shot, the gun remaining stationary until they were about 4,000 yards distant, and we could get no further range. It shows what can be done with a small gun.

GENERAL SIR JOHN BURGOYNE: They could fire with as great accuracy as the largest guns we have.

MAJOR LEAHY: The range of the Whitworth one-cwt. gun at 5° is 1,700 yards—at 6°, 2,000 yards.

The discussion was then closed.

PAPER II.

NOTES ON A PROPOSED WIRE GABION.

BY CAPT. PERCY SMITH, R.E.

This gabion was proposed by the writer, then at the Cape, in 1860.

After some correspondence, the authorities at Chatham declined to sanction any expenditure for experiments upon it on account of its supposed cost.

In 1862 the Inspector General of Engineers personally directed that 50 wire gabions should be made and tried at Chatham.

In 1864 the Deputy Adjutant General called for a description of the gabion and the following was forwarded:—

This gabion is formed of a sheet of galvanised iron-wire netting, 6-ft. 2-in. long, and 3-ft. wide, bent into a cylinder 3-ft. high, and 2-ft. diameter, secured with annealed iron-wire fastenings.

The mesh may be varied according to the nature of the soil, and the purpose for which the gabion is to be used.

For simply obtaining cover quickly, gabions of 1-in. mesh, and No. 18 wire gauge would probably be found sufficient.

In very light and sandy soils a smaller mesh might be used, or the gabion would have to be lined with a piece of rough sacking.

It is submitted that the gabion possesses the following advantages:—

1. *Simplicity*—It is all in one piece, requires no previous instruction, and only half-a minute to make it.

2. *Incombustibility*—An evident advantage.

3. *Facility of form for transport*—It can either be carried in rolls or flat sheets, and takes up less room than any other gabion.

4. *Lightness*—Its weight is $6\frac{1}{4}$lb.; that of the brushwood gabion, green, 60lb., dry, 40lb.; Tyler's, 28lb.; Jones', 30lb.

5. *Capability of being moved and placed with a sap fork*—This evidently prevents unnecessary exposure of the sapper.

6. *Noiselessness*—A necessary quality in a gabion to be used at night near an enemy.

7. *Capability of being easily strengthened*—This gabion may be strengthened to any extent required by increasing the number of folds in the netting. Thus, in an embrasure the netting would be doubled so as to overlap the exposed face.

In a revetment it might be doubled round twice, or even three times, if great strength were required.*

8. *Freedom from splinters*—If struck by shot it would afford no material for splinters.

9. *Capability of being easily repaired*—Any damage done to it by shot could be easily repaired by sewing a piece of netting over the hole, with a wire passing in and out of the meshes round the edges.

10. *Cheapness*—It would be cheaper, on the whole, than any gabion at present in use.

The cost of wire netting, 1-in. mesh, 18 wire gauge, is, retail, 1s. $8\frac{1}{2}$d. per square yard—the cost of a gabion would therefore be:—

$2\frac{1}{18}$ yards at 1s. $8\frac{1}{2}$d.	=	3s. $6\frac{1}{4}$d.
3 wire fastenings, at $\frac{1}{4}$d.	=	$0\frac{3}{4}$d.
Total		3s. 7d. retail price.

The per centage taken off by the manufacturer, from whom the above prices were obtained, is, if a quantity is purchased, 20 per cent., making the wholesale price of a wire gabion only 2s. 11d.

The prices of the other gabions at present introduced are given in the Corps Papers, Vol. VIII, p. 85, by the then Instructor of Field Works at Chatham, as follows:—

Brushwood, green	4s. 11d.
„ dry	6s. 2d.
Captain Tyler's, sheet iron	8s. 11d.
Quarter Master Jones', iron band	3s. 0d.

* This would, of course, increase the cost of the gabion 50 or 100 per cent. or more, according to the number of folds used.

The last mentioned in its improved form, costs 6s. 2d.† with pickets; and the cost of the most improved form of Captain Tyler's, is given by General Sir Charles Pasley as 15s. 6d. ‡

It is evident that as the wire gabion is far lighter and more portable than the others, the further the gabion has to be carried before use, the smaller becomes its comparative cost.

Of the advantages above enumerated, the following are shared by those gabions hitherto introduced :—

	Possesses.	Partly Possesses.	Does not Possess.
Brushwood......	No. 5, 6, 8.	....	No. 1, 2, 3, 4, 7, 9, 10.
Tyler's............	No. 1, 2, 3.	No. 4.	No. 5, 6, 7, 8, 9, 10.
Jones'	No. 3, 5.	No. 1, 2, 4, 6, 10.	No. 7, 8, 9.

It has been urged against this gabion.

1. *That it is expensive*—This is answered by the comparative prices given above.

2. *That it will not hold earth*—Lieutenant Clayton, Royal Engineers, Assistant Instructor of Field Works, reported, 15th December, 1862, that "one was filled with loose sand, nearly dry, as being the most unfavourable "description of soil to be found, and the other with a mixture of pieces of sod "and loose mud. The gabions held both very well, and from the two not "more than three shovelsful of sand escaped." He afterwards wrote that "some of the gabions had stood capitally all the winter in a parapet, and held "the earth very well."

After the above memorandum was forwarded, the gabion was tried at Chatham; but the report of the committee upon it has been lost.

The last edition of the Chatham Field Book states that the wire gabions "hold earth well, and are durable, but are so light that they are very liable "to be knocked over as they are being filled. In the revetment of a parapet "of a redoubt or battery they stood well."

It is submitted that wire gabions are well adapted for many situations, such as in cheeks of embrasures, &c., when their lightness, the only fault urged against them, would not signify; and that for nearly every purpose they would, by the exercise of a little care in filling, be useful in spite of this objection.

† Quarter Master Jones' pamphlet, page 5.

‡ Corps Papers, Vol. VIII., page 104.

P. S.

Weymouth, 10th February, 1867.

PAPER III.

DESCRIPTION

OF

HOWLETT'S PATENT ANEMOGRAPH, No. 2,

FOR RECORDING, IN THE FORM OF A DIAGRAM, THE DIRECTION AND PRESSURE OF WIND.

BY S. B. HOWLETT, ESQ.

The patent included two forms of the anemograph. A description of No. 1 will be found in volume XV of the Royal Engineer Papers. Since the publication of that volume, I have completed No. 2, of which a description is now submitted.

No. 1 records upon paper, and is suitable for an observatory; while No. 2 is a more portable construction, suitable for any position, and may be made at a low price. The stand packs in a canvass case like a fishing rod; the rest of the instrument goes into a carpet bag. Owing to its peculiar construction, even a hurricane would have no power to shake the instrument, which would go on recording the direction and force of every current passing across the station.

Fig. 1, shows the instrument as it appears when set up, the height from the ground to the apex being about 9 feet.

a. b. c. are slight iron rods, which drop into screw eyes inserted into the wooden part of the legs *d. e. f.*, the whole forming a tripod, fixed at the top by the cap *g.*, and firmly braced by six stout wires which hook into the legs.

h. is a triangular table of wood; through plates at the angles of which the the wires *a. b. c.* are inserted when the instrument is being put together.

i. is a heavy weight, the general form of which is a kind of spheroid having eight ribs, so contrived that, in every position, a circle 6·1 inches diameter is presented to the wind; and the area of this circle will be found to be the fifth part of a square foot.

The weight is fixed to a brass tube *k*, which is suspended by links of wire from the apex *g*; and, in order to vary the scale of diagrams, the point of suspension of the weight may be lowered by an arrangement at *l*.

In the tube *k* a common slate pencil is inserted, which, when the wind blows, works under pressure on the slate. The markings thus made are not obliterated by rain, though sometimes they may be blurred.

At *m* a piece of canvass is suspended from the angles of the table, just clear of the ground, and when this is loaded with stones, the whole instrument is rendered immovable during a gale.

Now suppose, for example, that the wind blows against the weight with a force of one pound, that force will be equivalent to five pounds on a square foot; and the deflection marked by the pencil on the slate will supply a scale to the diagram.

Fig. 2 is a plan of the table *h*, on which a slate 14 inches diameter, finely ground, is fixed by a pivot and screw in the centre; thus leaving it free to be turned round. Working on the pivot, and running on three small wheels, the vane *n*, in the form of a spur, constantly points to the wind, and prevents the pencil from passing the centre of the slate. On the edge of the slate a circle is graduated to 10 degrees. When the instrument is set up, the side of a common square box compass is placed against the meridian on the slate, which is turned until that meridian coincides either with the magnetic meridian or with the true meridian of the station.

Fig. 3 is a diagram section of the tube *k*, shewing the pencil and the pressure weight *o*, which rests upon the top of the pencil *p*. The pencil works freely in an inner tube *q*; and when it is used up, the weight *o* rests upon the top of the inner tube, ready to act upon a new pencil.

This weight *o* should be just heavy enough to make the pencil mark plainly, and to maintain a friction of the pencil on the slate sufficient to check the oscillation of the heavy spheroid on its return to the centre of the slate, and prevent it from striking the pivot of the vane too heavily.

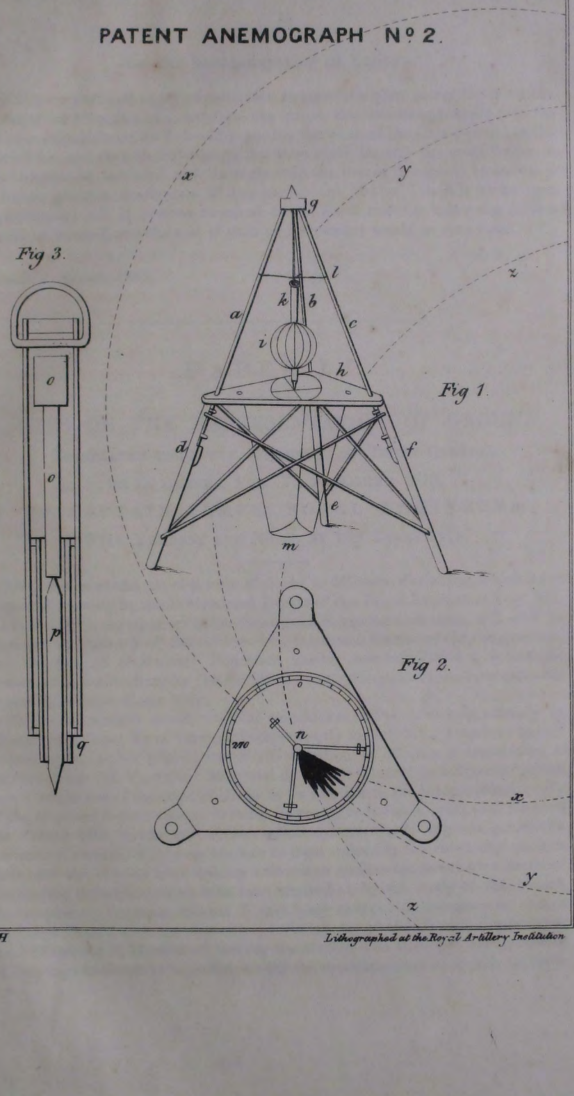
The part shaded black, in Fig. 2, is supposed to represent a diagram drawn by the pencil after having been set in action by the wind for a few hours. The pencil records one current after another; and as there are numerous currents, in a short time, a shaded diagram is the result, on the edges or salient points of which the forces and directions of the several principal currents may be found by applying the scale belonging to the instrument.

Having obtained such a diagram as this, it appears to be a legitimate use of the imagination to try to account for the curious facts which it offers for consideration.

We see that all these currents, having a lull between each, crossed the meridian of the slate at angles varying from 120° to 160°. Now such a diagram would be produced, if we imagine that the wind was passing, not in straight lines, like the flow of a river, but in circles, of which *xx*, *yy*, *zz* are arcs.

Having, now, a proper instrument for the purpose, this question could be easily settled, by a few observers placed a mile or two apart, when the wind is blowing about 3lbs. on the foot, on spots known on a map, each observer noting the direction, force, and time of each principal current. These observations being plotted on the map, in the manner of ordinary surveying, would show the courses of the currents. We know that great storms move in circles; and if it should be found that light winds move in the same manner, it might be possible to measure their diameters, and to find the ratio between the force and the radius, which might possibly tend to improve our knowledge of the law of storms.

PATENT ANEMOGRAPH Nº 2.



S. B. H.

Lithographed at the Royal Artillery Institution

If it were required to try experiments to ascertain what power the wind has to cause the deflection of a shot from the target, this instrument would give the data for calculations; for I should place the meridian of the slate parallel to the line of fire, and then if the order to fire were given directly the pencil began to act, the force of the wind and its angle with the line of fire would be shown.

I have given a description of the instrument just as I used it for my own experiments; but if it were required to be fixed, nothing below the table *n* would be wanted, and the cost of such an instrument would be very little.

S. B. H.

Bromley, August, 1867.

PAPER IV.

NOTES ON THE REPRESENTATION OF GROUND,

TRANSLATED FROM THE MÉMORIAL DU DÉPÔT GÉNÉRAL DE LA GUERRE, VOL. V., PUBLISHED 1853.

BY CAPTAIN JAMES, ROYAL ENGINEERS,

WITH REMARKS AND NOTES BY THE TRANSLATOR.

The articles on the use of a scale of shade in Military Sketching, which have appeared recently in the Professional Papers of the Royal Engineers (Vols. XII, XIV, and XV), together with the discussions consequent on them, will still be fresh in the memory of the officers who interested themselves in the question, and the Council of Military Education having now introduced a mechanical system of field sketching for the staff of the army, the interest has been extended beyond the limits of our body.

Having been much struck with the coincidence of the views held officially in France with those I put forward independently in Vol. XV., I venture to contribute to the further elucidation of the question by offering a translation of extracts from Vol. V. of the "Mêmorial du Dépôt Général de la Guerre," which treats on the use of the scale of shade in its relation to the topographical works of the Imperial Government. It must, however, be borne in mind that whereas the French lean to the use of the vertical system, we, in England, prefer the horizontal, and this difference hinders us from endorsing the views expressed in their entirety, or even from making a thorough application to our own needs of the leading principles which have been arrived at by the study of the French topographers. For these reasons I have only thought it necessary to charge the Corps Papers with the cost of re-producing one of the French illustrations, the "Diapasons de Hachures," leaving the student who wishes to see specimens of drawings executed in accordance with the established scales to seek for them elsewhere. And as it must be admitted that the mechanical rules are qualified by the French to a certain extent to satisfy artistic requirements, (a course which no advocate of a scale of shade will oppose being followed in moderation) we shall do well to leave the subject at that point where we should have to enter into technical details depending on the system of shading adopted. In comparing our case with that of the French, the consideration of the question must stop at general principles, or we shall find that what we intend to be an assistance to us has become an obstacle. But it is desirable to point out to those officers, who maintained that artistic effect could not be produced mechanically, the fact that a nation like the French, justly reputed as it is for its artistic talent, should have found this not only possible as regards the *effect*, but necessary to perfect *topographical success.*

I propose, then, to insert here a general summary of the French method of working, as an introduction to the chapter on "diapasons" or scales of shade, interposing a few remarks between the paragraphs.

In Vol. V, page 360, the text of the French work is as follows :—

"The commission, of which Laplace was president, which was appointed to fix the principles on which the new map of France should be executed, decided that the surveys should be made on the $\frac{1}{10000}$ scale, and that the map should be engraved on the $\frac{1}{50000}$ scale. During the first years, from 1818 to 1823 inclusive, the surveys were executed in conformity with this decision. In the districts where the cadastral survey was finished, a reduction from it to the $\frac{1}{10000}$ scale, assimilated to numerous geodesical points, was placed in the hands of the officers of the corps of geographical engineers, who were solely charged at that time with all work connected with the map of France. They completed the details of the plan, on the ground, surveying the new constructions and principal roads, as well as the other details which were not on the cadastre ; they represented the various features of the ground, either by portions of contours or with hachures," (i.e. sketching horizontally or vertically) "and they fixed a great number of altitudes by aid of which, and the form of the ground, they traced contours at intervals of $2\frac{1}{2}$ metres, which served as directing lines for the hachures in the final representation of the ground.*"

Page 361, translation continued.

"The following is a description of the manner in which the work, on the $\frac{1}{10000}$ scale, is executed. Each officer is supplied with a reduction to this scale, made from the cadastral plans of all the parishes *(communes)* comprised in the work assigned to him, as well as a sheet on which are traced the meridians and parallels, graduated to centesimal minutes, on a modified Flamstead projection, &c. . . ."

* It does not appear that these contours, at $2\frac{1}{2}$ metres, were fixed instrumentally, but sketched merely, the levelled points serving as a basis.

The sheets of Paris, &c., done on the $\frac{1}{10000}$ scale and engraved on the $\frac{1}{50000}$ scale, were found too expensive and took too much time, and in 1824 it was decided to make the new surveys, for sheets of the map of France, on the $\frac{1}{40000}$ scale, and to engrave it on the $\frac{1}{80000}$.

By the aid of these, the plan details are completed as formerly, and
Page 361.

"The officers represent at the same time, upon the cadastral maps, the different features of the ground, either by hachures or by parts of contours *traced by the eye*; they fix in addition a great number of altitudes (10 or 15 at least in every space of 4,000 metres square,)* using a surveying compass (boussole à'éclimètre†) reading to a centesimal minute."

"When the officers have plotted the details of the plan, on the sheet of projection destined for the fair copy of their work, they trace in pencil, with the aid of the numbered altitudes and the representation of the ground indicated on the cadastral maps, contours at vertical intervals of 10 metres, to be used as directing lines for the hachures, for the final representation on the fair plan is made by the vertical system, i.e., by hachures subject to these contours, and whose intensity (which is in proportion to the slope) is regulated by a scale of shade adopted by the Dépôt de la Guerre to establish uniformity in the work, the construction of which will be explained at the end of this article."

"Independently of the fair plan just spoken of, each officer has to produce a tracing of the contours; that at every 40 metres of elevation being marked in a distinguishing colour, to enable the number to be counted more easily, and to judge of the relative heights of the different parts of the ground. This tracing gives, in addition, the directions of water courses, the positions of the trigonometrical points which have been used in the survey, and the positions and altitudes, in metres, of all levelled points. In high mountains, and, in general, on steep slopes where contours cannot be traced at vertical intervals of 10 metres, they are shewn at every 40 metres, or, where possible, at every 20 metres; in like manner, in very gentle slopes, in order to show the form of the ground better, dotted auxiliary contours at vertical intervals of 5 metres are traced between those at 10 metres."

"The officers then execute three works which act as checks upon each other; 1st, the rough study formed by the joining of the cadastral maps, on which the ground is represented either by hachures or with portions of contours; 2nd, the fair plan, drawn on a modified Flamstead projection, on which the ground is represented by hachures, subject to contours at vertical intervals of 10 metres; and 3rd, the tracing of these contours, &c."

Page 367.

Notes on Scales of Shade (Diapasons) by M. Hossard.

"At the time when the Dépôt de la Guerre was about to commence the engraving of the first sheets of the map of France, the Minister of War, on the proposal of the Director of the Survey Establishment, nominated, in 1826, a commission chosen from the different public services, for the purpose of es-

* In England at present in a corresponding space, about $2\frac{1}{2}$ square miles, the minimum number of levels established on the 6-inch scale is about sixty, ten of these being permanent marks; the height of every trigonometrical station is also found.—E.R.J.

† The term "éclimètre" appears to apply to the mast of a barge, which is lowered at will, to pass under a bridge, and in this place seems to mean the sights attached to a surveying compass?—E.R.J.

tablishing uniformity in the manner of representing the relief of ground. The first decisions of this commission not having been adopted, it was re-assembled in 1828, and its advice, which may be found recorded in Vol. V. of the memoir of the Dépôt de la Guerre, commencing page 458, was approved by authority."

"Two articles treat specially of the thickness of the strokes (hachures), and of the distances between them (l'écartement), as follows :—"

"ART. 3.—The space between hachures (l'espacement) will be in inverse proportion to the inclination of slopes, and equal to a quarter of the plan distance between two adjacent contours, (courbes consécutives), &c."*

"ART. 4.—When the plan distance between adjacent contours shall be less than 2 millimetres (·0787 inch), the law for the thickness of the hachures will be substituted for that of their intervals. This thickness will increase in proportion to the inclination."†

*Any plan distance between contours exceeding 2 millimetres would apply to Art. 3. Let us consider what effect this would have upon the $\frac{1}{10000}$ scale, the nearest approach made by any of the French scales to the English, 6 inches to the mile.

Supposing contours at 10 metres, the ordinary vertical interval used in the French sketching, (see preceding pages), the plan distance between adjacent contours

Being 2 millimetres the slope	would	be	$\frac{1}{2}$ or $26\frac{1}{2}°$
3	"	"	"	$\frac{1}{3}$ or $18\frac{1}{2}°$
5	"	"	"	$\frac{1}{5}$ or $11\frac{1}{4}°$
10	"	"	"	$\frac{1}{10}$ or $5\frac{3}{4}°$

At $\frac{1}{2}$, there would be 0·5 millimetres from centre to centre of hachure, or about 50 fine strokes to the inch ; at $\frac{1}{3}$, 0·75 mm. from centre to centre, or about 33 strokes to the inch ; at $\frac{1}{5}$, 20 strokes ; and at $\frac{1}{10}$, 10 strokes. E. R. J.

† This rule applies when the plan distance between contours is equal to or less than 2 millimetres, but here the thickness of the strokes, and not the number of strokes, is the primary consideration. The rule applies to any slope steeper than $26\frac{1}{2}°$ on the $\frac{1}{10000}$ scale ; any slope steeper than $13\frac{1}{4}°$ on the $\frac{1}{20000}$ scale ; any slope steeper than 6° on the $\frac{1}{40000}$ scale ; and any slope steeper than 3° on the $\frac{1}{80000}$ scale. Therefore, with such a method of showing ground any expression at all, of any but the very highest and steepest ground, would be simply impossible on our English one-inch scale ($\frac{1}{63360}$). On our 6-inch scale, the labour of showing 50 strokes in an inch at $26\frac{1}{2}°$ would be immense. Such strokes, allowing an interval between them, of say, twice their thickness for light, (the smallest suitable to the inclination), would be $\frac{1}{150}$th inch broad. As the thickness increases in proportion to the inclination, this would give a breadth of $\frac{1}{75}$th at 45° or $\frac{1}{1}$. The strokes at that inclination, it is to be presumed from the French text, are intended to be as close together as possible ; say, then, the tint is to be in the proportion of 5 of shade to 1 of light ; the white spaces would be $\frac{1}{375}$ inch ; there would therefore be 62 strokes to the inch nearly. We should have 10 strokes to the inch at the lowest angles, and 60 strokes at the highest ; the labour entailed by such a scale would be quite impracticable in fieldwork. If the rules laid down in Arts. 3 and 4 were to be applied in their integrity with contours at other vertical intervals for steep or low ground, according to the system employed in France described in the preceding text, most contradictory results would be obtained. Nothing more then is needed to show, in addition to the arguments used in the French text (as follows translated), that these rules should be considered merely in a general sense. E. R. J.

Translation continued, page 367.

"It must be understood, however, that the reading of these articles should be in the most general sense, as is shewn by the approval which the Minister of War gives at the same period to the scales of shade (diapasons de hachures) proposed by Colonel Bonne for the use of the Dépôt de la Guerre, as a complement to the processes determined on for the expression of the relief of ground in topographical maps. It is evident, in fact, that the principle of *the quarter of the space between two contours for the distance of the strokes from centre to centre* has no object but that of a general application to mean slopes, and should be modified at the extremes of the scale, to which the principle is not admissible. In M. Bonne's scale the principle is applicable at inclinations of about 12 grades (10°48′) for the $\frac{1}{10000}$ scale, and at about 7 grades (6°18′) for the $\frac{1}{80000}$ scale, but as the mean slopes are gradually departed from, so the intervals given by this scale differ considerably from the proportion of one quarter. Thus on the $\frac{1}{10000}$ scale, the distance from centre to centre of stroke would be about $\frac{1}{12}$ of the distance from contour to contour at two grades (1°48′), and at half the distance only for thirty grades (27°) of inclination."

"The principle that the thickness of stroke should be in proportion to the inclination, combined with that of the number of strokes being in inverse proportion to the same, would lead (if these principles were adopted rigorously) to an amount of black in the tint which would increase as the squares of the inclination, so that, in obedience to this law, low country would be wanting in expression, while high mountains would be represented almost by entire black. Therefore the second principle, like the first, is only applicable to a very small portion of the scale of tints (as is shewn elsewhere in the report of the Commission), and it equally can only be understood in a general sense."

"The scale of Colonel Bonne adopted at the Dépôt de la Guerre and consulted in all the topographical establishments, has rendered great service to the science of Topography, and has powerfully contributed to give uniformity to the map of France. Although it is a little pale for gentle inclinations and rather too dark for steep slopes, yet, since its construction, the numerous topographical works which have been executed, on the most varied forms of ground, have permitted new comparisons to be made, and means (chosen from a great number of the best surveys of officers, reductions to the $\frac{1}{80000}$ scale, and engravings) to be taken as types; and taking these, individually and collectively, as a basis, the Dépôt de la Guerre has had a new scale of shade engraved, which appears to answer equally well in plains, moderately undulating ground, and mountains." (See plate).

"In order to make this scale as much subject to rule as necessary, the thicknesses of hachures and the distances between them were first calculated, numerically, with the adopted formulæ; and the engraving was executed with the point of a diamond, moved by a micrometrical screw and subject to a fixed pressure. A series of lines being drawn, without moving the copper plate, the thickness and separation of hachures could be measured microscopically on the proofs thus obtained, and consequently the continual regularity of the work be assured. The thickness was obtained, for fine and average hachures, from a succession of fine strokes, placed close together; for the thickest, by putting a stronger pressure on the diamond, which pressure was determined after making preliminary trials on the margin, and measuring, microscopically, the proofs obtained from them."

"In the new scale of shade, instead of expressing the slopes in degrees *(grades)* it appeared more in accordance with the intentions of the Commission of 1828, and with the practice of all the public services, to represent them by the relation of the height to the base. It may be remarked, in addition, that the denominator of the *slope* is simply the *cotangent* of the angular inclination, the height being taken as unity."

"It was thought, also, that the *tint*, that is to say, the relation of black to white, was the quantity for immediate determination, and consequently, that to which the most simple law ought to be applied; 1st—because in changing the plan-scale, the tint ought to remain constant for the same slope, whilst the thickness of the hachure is naturally variable*; 2nd—because the relation of the consecutive black and white intervals, formed by the hachures, is more easy to appreciate than the absolute thickness of one line in linear measure."

"In the new scale of shade, the slope being $\frac{1}{D}$, the tint is represented by the expression $\frac{1}{D}$ (1·5) or $\frac{3}{2D}$. As the interval between hachures could not be represented in *inverse ratio to the slope*, which is not suitable at once to all inclinations, as has been shewn also as regards the rule of *one quarter*, it was natural to try the expression,

$$i = \frac{D}{m} + n,$$

in which m and n are two constants, which may be fixed in such a manner as to satisfy exactly any two slopes in the scale of shade. A scale constructed by this law, by M. Livet, Captain of Engineers, professor of the school *(l'école d'application)* at Metz, served for some time as a guide to the pupils in their topographical studies. At the Dépôt de la Guerre, the preference was given to the following formula, which is, perhaps, as simple, and satisfies all degrees of the scale, better."

"Interval between hachures from centre to centre $= i = \frac{\sqrt{D}}{m} + n$, in which i is expressed in millimetres, m and n being two constants determined by experience."

"In the topographical works of the Dépôt de la Guerre, the plan distance adopted is as follows:—

2·5 metres	for the	$\frac{1}{10000}$ scale	= ·0098	or $\frac{1}{100}$th	inch	nearly.
5·0	"	" $\frac{1}{20000}$	" = ·0098	"	"	
10·0	"	" $\frac{1}{40000}$	" = ·0098	"	"	
20·0	"	" $\frac{1}{80000}$	" = ·0098	"	"	

* This is questionable. Does it not seem, on the contrary, that as the plan scale decreases, so does the minimum inclination, capable of being expressed, increase? On the $\frac{1}{10000}$ scale, it is easy to show slopes below 5°, whereas on the $\frac{1}{60000}$ scale, it would be almost impossible to appreciate any slope less steep than 10°, or to define any steeper slope to within 5° of its true inclination. E. R. J.

From which it results that this quantity increases in inverse proportion to the scale of the map, and that the plan distance is constant and equal to a quarter of a millimetre, (or $\frac{1}{100}$th inch nearly), for all scales."

"In practice, the alternate contours must always be suppressed in steep slopes, whilst in gentle inclinations other contours must be interpolated; but the separation and thickness of strokes will remain as they would have been, had the contours not been so added or suppressed."

"If we represent the distance in millimetres, between two consecutive contours, by d, we shall have $D=4d$, and consequently the tint$=\frac{3}{8d}$, and the interval $= i = 2\frac{\sqrt{d}}{m} + \overset{\text{mill.}}{n}$"

"The expression for the thickness of the hachure would be more complicated;

$$\text{thickness}=\frac{3\sqrt{D} + 3mn}{3m + 2mD}."$$

"The interval of the hachures between two given contours, might be obtained geometrically. It would suffice to make a construction from the expression

$$\frac{\sqrt{4d} + m.\,\overset{\text{mill.}}{n}}{m}"$$

"For the $\frac{1}{10000}$ scale, this would be as follows:—

$$\frac{1}{6}(\sqrt{4d} + \overset{\text{mill.}}{1\cdot68.})"$$

"Experience, resulting from the examination of a great number of drawings and engraved sheets, led to the adoption of the following values for m and n:—

$\frac{1}{10000}$ scale . . . . . $i = \frac{\sqrt{D}}{6} + \overset{\text{mill.}}{0\cdot28}$

$\frac{1}{20000}$ scale . . . . . $i = \frac{\sqrt{D}}{7} + \overset{\text{mill.}}{0\cdot24}$

$\frac{1}{40000}$ scale . . . . . $i = \frac{\sqrt{D}}{8} + \overset{\text{mill.}}{0\cdot20}$

$\frac{1}{80000}$ scale . . . . . $i = \frac{\sqrt{D}}{9} + \overset{\text{mill.}}{0\cdot16}$

m and n vary in arithmetic progression as the scale diminishes in geometric progression."

"This law, which would enable intermediate scales of scale to be constructed, might range from the $\frac{1}{5000}$ scale to the $\frac{1}{100000}$ scale, and the two extreme scales of shade so constructed might be made applicable for all maps, either on larger scales on the one hand, or smaller on the other."

"If the use of the law were continued beyond the $\frac{1}{100000}$ scale, the strokes would be so extremely fine, and so near together, that with ordinary materials the execution of the sketch would be very difficult, and the map, gaining somewhat the effect of being done with the brush, would entirely lose its brilliancy."

"It might not be useless, perhaps, to adopt a scale of tints as a guide to indian-ink brush-work maps. Types would thus be established by which the uniformity of brush-work would be assured, and certain fixed tones reproduced at will."

"With this object, the Dépôt de la Guerre has had a series of graduated tints added at the foot of the plate; but it was difficult to give them exactly the same tones as the tints made by strokes."

"The fraction written below each of them, and by which they are designated, indicates approximately the relative thickness of the alternate black and white spaces; although this relation is far from giving the real value of the tint, which is much darker than the figure appears to indicate. In order to explain this anomaly, we must suppose that on the copper-plate impression of those lines which are very fine and close together, the paper is impregnated with a small quantity of oil, which stains it, and tends to take something from the brightness of the proof."

"By the following experiment, (which furnishes a very precise and simple means of determining the tones produced by indian-ink shades, in which the exact proportion of black to white is known), this disagreement was proved."

"The effect of a turning disc or tee-totum, one-half of its surface being covered with paper similar to that on which the scales of shade were drawn,* and the other half blackened with opaque printers' ink, should evidently have been a tone represented by $\frac{1}{2}$; nevertheless by making the experiment, it was shewn that a tone much weaker than the tint marked $\frac{4}{10}$, and only a little above that corresponding to the fraction $\frac{3}{10}$, was constantly produced. By varying the arrangement of the black and white, so as to decompose the surface of the disc into alternate sections of each, analogous results were always arrived at; that is to say, the tint of the division of the scale of shade is always darker than that represented by the fraction by which it is designated. But as it is well known that indian-ink shades destroy the transparency of drawings, and that they obliterate the detail, much less than the same tints in hachures, tints marked by a figure corresponding to the tints produced by hachures may be employed without inconvenience in brush drawings."

"Colonel Bonne's scale of shade is marked by degrees (grades) and is constructed in such a manner that the quantities of black contained in each tint increase as the sines of the angles of inclination represented, the sine of 90° (100 grades) being absolutely black. It is to be regretted that no explanation of the law by which he regulated the distances between the hachures has been found."

"The object of this law of sines was evidently to increase the tint in feeble inclinations, but in reality this increase is scarcely sensible, and does not appear important enough to justify the preference which this law obtained over such a simple one as that of geometric proportions. Colonel Bonne having remarked that his scale of shade was a little too dark for slopes of about 45° (50 grades) had a second one engraved which is inserted in Vol. iv of the Mémorial of the Dépôt de la Guerre, plate 24. It is based on the same principles as that constructed in 1828, of which the original is at the Dépôt de la Guerre. The shade is expressed by $\frac{5}{7}$ths only of the sine of the angle of inclination; from which it results that the representation of mountains by this scale will be less dark than

* The experiment with the tee-totum would seem to prove that the discordance between the actual and the apparent relation of shade to light in tints is an optical delusion, and is not due to the reason assigned in this article.—E.R.J.

by the first, but that feebly undulating country, which was already too pale, will lose still more of its value."

"The Germans have made use of geometric relations, but wishing to give a sufficient expression to low country, they have adopted absolute black slopes of 45°, which they regard as a limit which cannot be reached in topography." *

"At the staff-school, (l'école d' application de l'Etat-Major) in order to increase the tints on weak slopes, the law of $\frac{14}{15}$ths of the sine of twice the angle of inclination was at one time adopted. This would answer perfectly for maps which only took in plains or moderately undulating ground, but it would lead to tones much too black in the representation of mountains. This law was besides incompatible with that of *the quarter of the separating distance*, equally admitted at this school, if the latter were followed out in the entire range of the scale. In fact, if, (starting from these two laws and the plan distance $\frac{1}{2}$, being also adopted), it is proposed to find by calculation the exact thickness of hachure for a given inclination a, the following expression is obtained:

$$\text{thickness} = \frac{14}{15} \sin 2a.\ \frac{1}{2}\ \frac{\cot a}{4} = \frac{7}{30} \cos^2 a.$$

according to which the hachure would increase in thickness as *the inclination decreased!*"

"M. Goulier, Captain of Engineers, and present Professor of Topography at the Artillery and Engineer School (l'école d'application, &c.), had a scale of shade constructed according to principles having the greatest analogy to those on which the last scale of shade of the Dépôt de la Guerre are based, drawn on stone. As in the scale actually in use at the school at Metz, the proportion of black to white is equal to one and a half times the tangent of the inclination. The constant quantities for the separation of the strokes differ from those of the Dépôt de la Guerre, but they were fixed with great skill, as being suitable to the topographical surveys executed at this school, in which the work being so much more rapidly done is not susceptible of the same finish as that of the map of France."

[Foot Note in Original]

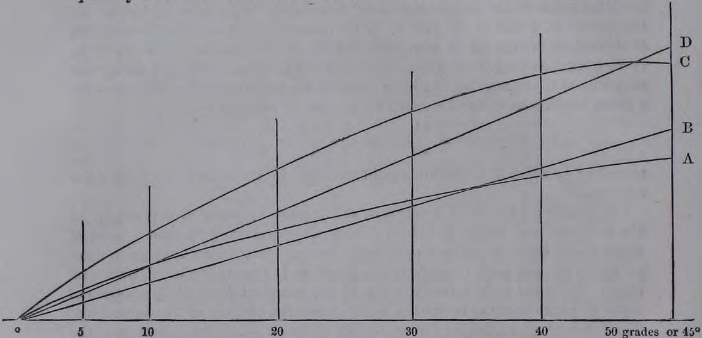
(Note.)—An extremely ingenious mathematical method, attributed generally to General Noizet of the Engineers, exists still, in which the representation of the ground is expressed vertically by lines *(lignes de plus grande pente)* whose length, thickness, and separating distance are variable. This method will not be explained here, because it has no reference to the methods followed at the Dépôt de la Guerre which are based entirely on the plan distance of contours. (It was explained at length in a very interesting memoir on topography by General Haxo, published in 1822).

"With reference to this subject, it is perhaps not useless to remark here, that if it is thought desirable that general principles should be established as a basis for topographical works in all public services, it need not be concluded that the same scale of shade should be used in every case. Evidently the constants should vary according to the end in view, and be determined accordingly. The officer who makes a reconnoissance in the field would sketch more roughly than if he were to execute the fair plan of this same reconnoissance in his quarters; and the latter drawing would itself be coarser and less finished than if it had been placed in the hands of a professional draughtsman who could devote considerable time to it, above all, if he had to furnish a study to engrave

* As asserted by me in Vol. XV. E.R.J.

from. As to the tints, although it may be well, as much as possible, to keep them at the same value for equal slopes, it will be seen notwithstanding, that when it is a question of producing a special plan, confined, as to the slopes, within certain limits, there will be an advantage in utilizing all the range of tones, or the majority of them, to express the slopes which exist on the plan."

"If we wish to compare the distribution of tints on the different scales of shade here mentioned, there is no better method of doing so than by representing these scales by curves in which the angle of inclination is the abscissa and the quantity of black in the tint the ordinate. We obtain thus the annexed figure



in which—A represents the new scale of the Dépôt de la Guerre.

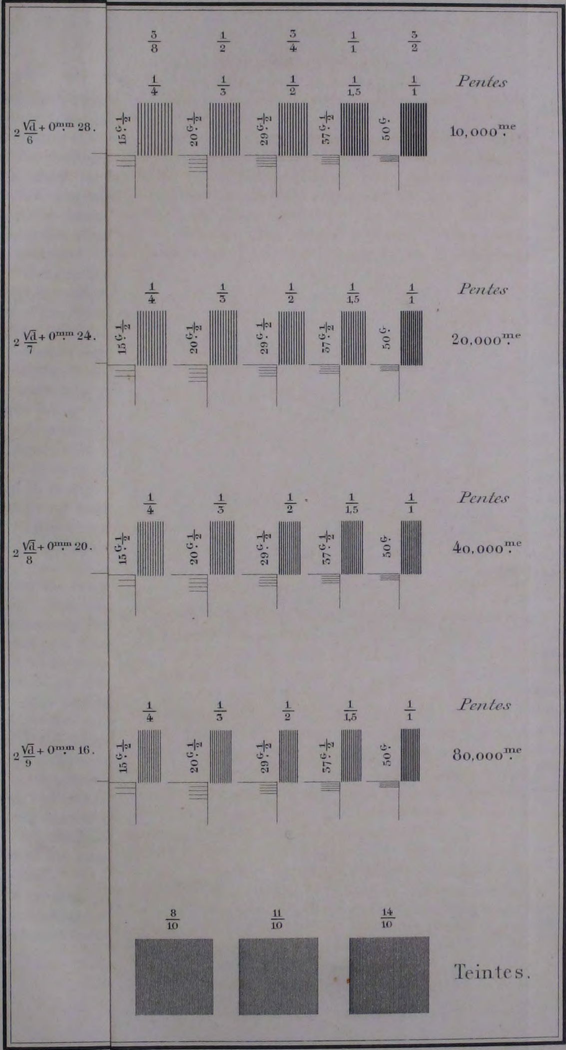
B .... the 1st of Colonel Bonne.

C .... that of the Staff-School.

D .... The German scale with dark tints."

"It may be seen that the new scale of the Dépôt de la Guerre differs but slightly from that of Colonel Bonne, and that it provides simply for slight defects in the latter, on the one hand in gentle slopes where it was too pale, and on the other in very steep slopes where it was too black."

"All attempts hitherto made to express the rapidity of slopes in the proportion of the intensity of the tints have contributed to prove how difficult it is with a single scale of hachures, to obtain a satisfactory model in flat and average country, without arriving at almost entire black in dealing with high mountains. In the new scale of the Dépôt de la Guerre, it is intended to distribute the tones conveniently from the most gentle slopes which can be expressed, up to the steepest inclinations, that of 50 grades (45°) being the limit; preserving always the transparency indispensable to the effect, and which would permit of the writing being clearly read. Yet if such a scale of shade were followed in all its rigour, there would be produced only a map without expression in every part; so it is well understood that the principal end in the scale is to assure uniformity in the various works, without excluding completely the artistic part of the design, which ought to contribute powerfully to give it expression. The



Kell, Bro.s Lith.rs Castle S.t Holborn.

e en millimètres entre deux courbes horizontales.

draftsman ought to take the whole scale as a type for all the slopes intermediate between the gentlest and the steepest of the district he is representing, reserving to himself the power of softening table lands a little, of giving more expression to the summits than to the lower parts of slopes, and especially of rendering the steep banks of valleys prominent, particularly when these banks are narrow, and cannot hide either the details of the plan or the writing. The length of hachures will contribute to rectify any inaccuracy caused by this exaggeration of some of the tints, but at the same time this exaggeration ought to be contained within very narrow limits."

"The maximum natural slope of unbroken ground in mountainous country never exceeds 37 or 38 grades (34°); this is the inclination of those long declivities of loose stones which are formed at the foot of mountains by the waste of the rocks. (Les talus d'eboulement qui se forment au pied des montagnes)."*

"Steeper slopes can only exist in very small heights, or where they are formed artificially in engineering works. The consequence is that on a plan, of which the scale is large enough to express the most minute breaks in the ground, only slopes below 38 grades would really have to be rendered by hachures; but this is not generally the case. The sides of high mountains are often formed by a series of little vertical steps, connected by natural slopes; these steps are too small to show topographically and it is the average slope which is expressed; that is to say, the surface which would be obtained by supposing that all the re-entering angles were filled up. Slopes of 50 grades (45°) are thus often reached in the most abrupt regions of mountains. In this case the broken nature of the surface should be indicated by small horizontal lines; but when an escarpment forms an inaccessible obstacle, it should be represented by a strong black stroke, the thickness of which should be in proportion to the elevation of the scarp. Nevertheless if the cliff has a wide enough base to admit of being expressed by the scale of the map, it will be shewn in an artistic manner, the higher part being the darkest, that is to say brought out by thicker black touches, relieved as necessary by intervals of bright light; the lower part, on the contrary, being of a light soft grey tint, so as to give depth by an effect analagous to aerial perspective. It will be well, also, in the representation of spurs and elevated points to give more expression to the higher parts of the ground, and more softness to the low parts and more particularly to the bottoms of valleys. Thus the scale of shade having served to fix the thickness and number of strokes towards the top of the slopes, those towards their feet will be finer, and rather closer together, care being taken nevertheless to preserve the proper intensity of the shades."

"The Staff-School is just having a new scale of shade engraved; † it will be like that of the Dépôt de la Guerre, and will be inserted in the text book used by the staff."

* In some parts of England such slopes are known as "screes;" but no one can understand what they are who has not studied mountains critically. I presume this is the meaning of the French phrase.—E. R. J.

† 1853. E. R. J.

PAPER V.

NOTES ON THE CAMPAIGN IN BOHEMIA IN 1866

BY CAPTAIN WEBBER, R.E.

INCLUDING

I. THE PRUSSIAN FIELD TELEGRAPH.

With Plates Nos. I and II.

The Prussian Field Telegraph Department, during the wars of 1866 with Austria, consisted of four sections, organized nearly alike, and under the control of the Director of the National Telegraph Department, Colonel von Chauven, of the Engineer Corps.

The first and second sections, which had already served in the Schleswig-Holstein war, were the first to take the field with the two armies. They were speedily followed by the third, and the fourth left Berlin with the king of Prussia's head-quarters.

Each section is composed as follows :—

2 Officers of Engineers (the senior being in command).
6 Non-commissioned Officers } of Pioneers; (in some sections
73 Men . . . . . } of the landwehr.)
1 Officer of the Military Train.
4 Non-commissioned Officers, ditto.
44 Drivers and Foragers, ditto.
12 Officials from the National Telegraph Department, with the rank of commissioned officers.

Of the above, the Pioneers are especially charged with the construction of the line; the Military Train with the horses and waggon equipment; and the Telegraph officials perform the duties of signal men, and have the charge of the instruments and apparatus.

HORSES AND WAGGONS.

			Horses.
	Officers' horses	7	
	Signalmen's ditto . . .	12	
	Non-commissioned Officers' ditto	4	23
3	Station waggons	2 each	6
6	Store ditto	6 „	36
2	Baggage ditto	2 „	4
1	Forage ditto	2 „	2
	Spare horses		6
12	Total		77

The *station waggon* (Pl. I) is very lightly constructed, weighing when completed with stores, about 14 cwt., and is in every respect built with the strength and finish of a private carriage. The instruments are carried, when not in use, under the seats, where they are firmly kept in their places. On the outside of the carriage are two insulated conductors, which are connected with the instruments and batteries inside by means of insulated wires. To one of these conductors the cable is attached; from the other a wire is carried to an earth conductor, which is driven into the ground close to where the waggon may be standing. The recess under the footboard is used for small stores, or it enables any one sleeping on the seat, and putting his feet in it, to recline at full length. The rest of the space under the footboard is opened from the outside and also contains stores and tools.

The *store waggon* (Pl. I) is very strongly constructed, and carries 12 drums of wire or cable.

In sections 1 and 2, the waggon carries on the drums 5 English miles of uninsulated copper wire, 1 mile of the same covered with one coat of gutta percha, and 1,000 yards of ½-inch cable; 200 poles with insulators and 16 of the same fitted for making double lengths.

In sections 3 and 4, the waggon carries 11 drums of Sieman's cable, (Pl. I) and one drum of ordinary insulated wire, covered with tarred hemp; 16 poles with insulators, 1 ditto for double length. Each waggon carries a box of tools and small stores, with a proportion of shovels and picks. The cover of each waggon is of tarpaulin buttoned over the sides. The former waggons, carrying more, are higher than the latter and something over their weight, viz., 40 cwt.

The *baggage and forage waggons* are of the same construction as the ordinary German country cart.

The *hand barrow* (Pl. II), is a light iron frame with wooden handles and legs which fold up. When used, one man carries it in front and two behind, one at each handle, the cable passing between them.

The *wheel barrow*, (Pl. II), is formed by attaching a pair of light iron wheels, and a pair of iron handles to the step ladder, the drum being supported as on the hand-barrows. When used, one man draws it after him, and another follows to watch the paying out of the cable.

By means of these two barrows which are used as circumstances may require, the cables can be paid out at the rate of about 2½ English miles an hour.

The *cable*, used in sections 3 and 4, (Pl. II), is constructed at their works, near Charlton, by Messrs. Siemans, at the price of about £45 per mile. The copper wires, three in number, are covered with two thin coatings of gutta percha, having a hemp covering of 16 strands, steeped in tar, outside of which are three tapes of thin copper. There is a good deal that is original in this cable, especially in the copper tape, which by overlapping prevents the cable being stripped, unless all the tapes are cut through.

Each section carries at least one Prussian mile. In sections 1 and 2 the uninsulated wire is used on 200 poles, 50 Prussian paces apart, the insulated is kept for use when passing through woods, and the large cable through water.

In sections 3 and 4, the small cable is laid on the ground, being buried, or raised on poles, &c., where much exposed to injury. By the use of the latter, some saving in expense and weight is effected in the store waggons.

The *poles* (Pl. II) are about 12 feet long and 1¼ inches thick, of straight grained red deal, having an iron point at one end and a socket with a ferrule screw at the other. The arrangement for using a double length of pole is shewn in the sketch.

The *insulators* are of two forms, one of gutta percha with an iron spindle and male screw; the other consisting of a metal bell with an earthenware cup inside to insulate it from the spindle. Each has a corkscrew joint to catch the wire.

The *connector*, (Pl. II), used to cover and secure the ends of wires when they have to be spliced in a hurry, consists of two pieces of hard wood, semi-cylindrical in shape, having a groove on the flat face of each, and a double layer of india-rubber to receive and embed the wire, the segments being kept together and compressed by a brass collar and screw.

The *supports*, of which examples are sketched in Pl. II, can be screwed into trees or driven into walls. When the insulated wire is used they have merely the corkscrew point, otherwise they can have insulators attached.

The construction of the line with uninsulating wire is thus carried on. The men carrying the drum of wire on the hand or wheel barrow, walk first at a quick pace without halting; at every 50 paces two others halt and drive the crowbar; another, taking a pole from a man who carries several, inserts it into the hole made by the crow-bar after hooking the wire with the corkscrew top of the insulator; the wire is stretched by a man holding it tight on his shoulder, who does not let it go until the pole in front of him is placed, and another man beyond it is ready to draw it quickly through.

Thus, to construct a line, there are required—

With Barrow	3 men
„ Crow-bar	1 „
„ Mallet	1 „
Carrying poles	1 „
Placing ditto	1 „
Stretching wire	2 „
Spare	3 „
Total	12

The latter three being employed to carry additional poles from the store waggon, and to stay the poles with wire guys and pickets, where the line curves or takes a new direction.

The total length of wire with the Prussian army was 110 English miles, exclusive of the short lengths of thick cable, being in the proportion of six Prussian, or 27½ English, miles to each section.

There are two *batteries* of 10 cells each in every station waggon. The element, (Pl. II.), is that of Marie Davy, charged with sulphate of mercury, moistened with water to the consistency of paste. It is of a portable size, the action is not disturbed by motion, and the india rubber vessel and cover prevent the solution leaking or being spilt.

The *instrument* used, as throughout Prussia, is an improved form of Morse's, which prints with ink. Each station waggon carries two, so that messages can be sent in two directions at the same time. Four more instruments are in reserve, giving a total of ten to each section.

Practice in the Field

Suggested many improvements in the equipment and organization just described.

It was found that two Engineer officers (per section), were insufficient, as the Pioneers had frequently to work in three or four places at once.

Similarly 73 pioneers might have been advantageously replaced by 100, including ineffectives, to lay 25 miles of wire; with a still greater increase, if the repair or replacement of a permanent existing line formed part of the day's work.

The employment of first class officials from the National Telegraph Offices, proved a great advantage, but mounting them was a mistake. Carried on the waggons they would have been more efficient at the end of the day's march, having frequently been disabled by a long march on horseback; and with such an arrangement, 3 per waggon would have been sufficient.

In this case seats would have to be constructed on the station waggons. These waggons were very much lighter and smaller in sections 3 and 4, than in the other two. In practice they were only used when no building was conveniently situated; when such was the case it was always used as a station.

The store waggons proved too heavy; waggons to carry half the length of wire, drawn by 4 horses, thus doubling the number per section, would have been much more convenient; a certain number of the heavy ones might have been retained as a reserve to keep to the roads, the light ones accompanying the working parties.

A light boat might with advantage have been carried on one of the store waggons for use on water.

The experience in the field never extended beyond setting up 10 miles of new line a day, as the head-quarters of each army were always within that distance of some permanent telegraph line, on road or railway.

An important part of the duty of the Field Telegraph Department in the war of 1866, was to repair the permanent lines destroyed by the enemy in its retreat. As much as 25 miles of line was thus repaired in one day, in addition to the construction of new line.

For this important service additional stores should form part of the equipment of each section.

The new line was generally constructed by commencing at the nearest point, and working in both directions towards the proposed termini.

If time permitted a line was frequently laid from the head-quarters of the army to those of the nearest corps; but during no part of the campaign was it attempted to unite the head-quarters with those of all the corps. No attempt was made to construct the line on the field of battle.

The use of the Siemans' cable was condemned by the officers who commanded sections 1 and 2, who had taken the field without it, and who had proved the thorough efficiency of the copper wire on poles.

The reasons of these officers, strongly expressed, for their condemnation, were founded on the practice they had witnessed with the other sections which had constructed very little line, and may, therefore, be received with some reservation.

Unless buried throughout its length, the danger of injury to the insulation, (they thought) was very great from wheels of vehicles, or from persons cutting it from curiosity. And supposing the insulation destroyed by a very slight bruise, the difficulty of discovering the point, even with a galvanometer, was almost insurmountable.

On the other hand, a mounted man riding along the line constructed with poles, could easily detect any point where the wire was completely cut.

The use of a uniform cable being very much to be preferred, the toughest form of protecting covering becomes an interesting matter of enquiry.

Mr. C. Siemans adheres to the form proposed by him. He states that the cable of the same construction furnished by him to the Austrian army, but a little stronger, is the best, and that the cable, supplied by the firm to the Prussians, was to order, and therefore lighter than he approved of.

He informed me also, that in the case of loss of insulation by a slight injury, the distance of the point from the station, *could* be ascertained by a galvanometer, from the fact that the return current is carried by the copper covering, a way of getting over a difficulty, which may not have struck the Prussian officers.

A further consideration of this subject will induce all to see the necessity of using an insulated wire for field purposes, the advantages being so great. Its use at once allows of a reduction of the skilled or trained labour accompanying the equipment. The precaution of burying it where it lies across roads and tracks, and laying it along lines where the most cover, for concealment, is to be met with, would probably render the probability of injury remote. Indeed it is a question whether guards and patrol along some lines might not be necessary in any case, especially in thickly populated countries.

The efficiency of its Field Telegraph Department having contributed to the successes of the Prussian army, it is a proof that its organization was well arranged, and that the lessons to be learnt from it should not be thrown away. We are told that the Austrian army was equally well provided, and the Universal Exhibition in Paris contains examples of its telegraph equipment. The probability is, that neither army had a superiority in this respect. Hence, may be inferred the vast difference that exists between the use of these means by an army in advance and one in retreat; and how important it is that a General should regard them only in the light of accessories, always unworthy of entire dependence.

II. The Field Railway Department of the Prussian Army,

With Plates Nos. III. and IV.,

Organization.—Under the immediate direction of the War Minister. The officials of the department are half military, half civil. The military are officers of Engineers and soldiers of the Pioneers. The civil are Engineers and Machinists taken for the time being from the State Railway Department. The latter are selected and their services placed at the disposal of the War Minister by the Minister of Commerce. When thus associated with the army they become subject to military law and discipline, and are wholly under the orders of the Commander-in-Chief of the army with which they are serving, and they dress in their usual official uniform.

The military officials are:—

- 1 Colonel of Engineers commanding, who at the same time may be 2nd Engineer on the Head Quarter Staff in the army (when he has an A.D.C.).
- 1 Lieutenant of Engineers.
- 50 Non-commissioned officers and men of the Pioneers.

The civil officials are:—

- 1 Head Railway Engineer, a Civil Engineer thoroughly acquainted with the construction and repair of permanent way, railway buildings, machinery, rolling stock, &c.
- 2 Under Railway Engineers occupying the position and performing the duties of Clerks of Works.
- 6 "Bahn Meisters" of the rank of Drivers, Head Plate-layers and Foremen of Trades, who are employed in charge of the Store-Depot, and superintendence of labour, two being locomotive drivers.
- 2 Machinists—For the repair of locomotives, rolling stock, water-pumps, and tanks.
- 1 Telegraph Official who is exclusively employed on the examination of the telegraph wires and posts along the line of railway, reporting on, and, if necessary, superintending their repairs.

2 Locomotives, and 30 waggons and trucks, are placed at the disposal of the department, with which it enters the country into which the army penetrates.

On this train are carried—

2 Trollies.

6 Light covered carts, into which is packed the baggage of the officials. They are told off as follows:—

1 For Colonel commanding.

1 For Lieutenant commanding Pioneers.

1 For Head Engineer.

1 For 2 Under Engineers.

2 for the 9 Subordinate Officials.

These carts are used, if it is necessary, to march by road from one line of rail to another, and are horsed by requisition on the country invaded.

The Pioneers, who are exclusively carpenters and smiths, are armed and equipped in the usual manner.*

Sets of tools are carried nearly in the following proportions:—

For Engine Fitters . . .	2 sets.
" Plate Layers . . .	4 "
" Carpenters . . .	4 "
" Smiths . . .	4 "
" Quarry men . . .	2 "

Blasting-powder or gun-cotton of which there should be a double supply, to remain at the first reserve depot.

Spades and Picks 50, in addition to those carried by the Pioneers, and a reserve of 200.

Rails, Sleepers, Bolts, Chairs, &c. for 250 yards of way, with a reserve of $\frac{1}{4}$ of a mile at every intermediate depot, and an unlimited supply at the base of operations.

500 *feet* of squared piling and baulks with which to bridge the smaller openings left by the enemy, and a proportion of ropes, nails, spikes, and scaffold clamps, with a reserve at the first depot.

Operations of the Field Railway Department attached to the 1st Prussian Army during the campaign in Northern Bohemia (See Plate III.)

This section of the department being at Gorlitz on the advance of the 1st army and capture of Dresden, proceeded to reconnoitre and repair the line between those places on the 17th of June.

At the intermediate stations of Lobau and Bautzen the sheds were burnt down, the water-crane destroyed, and the points disturbed. At Dresden a store of rails and materials was found.

From Dresden an advance on the direct line to Prague by the Elbe Valley was impracticable, as the fort of Königstein commanded the way in both directions for some distance, and was held by the Saxons.

* Vide description in account of the Engineer Equipment.

21st June.—The line was ready for use and open towards the Bohemian frontier as far as Zittau.

24th June,—At Grattau the points were destroyed, and the rails torn up in three places between it and Kratzau. At Kratzau the water-crane and pump had been destroyed.

Between Kratzau and Reichenberg the line was broken in two places; these were repaired and the line opened to Reichenberg. The same day the Head-Quarters reached that place.

25th & 26th June.—Repairing the line through the Reichenberg Station which had been entirely destroyed. Head Quarters at Sichrau. Actions of Liebenau and Podol, and occupation of Turnau.

27th June.—Depot formed at Reichenberg, leaving a detachment to complete repairs at Reichenberg and Kratzau stations. Advance to Reichenau, replacing the rails which had been torn up in three places.

28th June.—Army halted. Clearing away a mass of earth and rock which closed the line between Liebenau and Sichrau. The line passed through a very deep cutting, and mines had been exploded in each bank, detaching large masses of rock and earth which filled the cutting to a depth of about 6 or 8 feet over the rails, and for about 250 feet in length. The rocks had to be broken by blasting, and, with the earth, carried away in ballast trucks. With the extra assistance of 20 work people from the neighbourhood, and 50 pioneers of the 2nd battalion, the whole was cleared by a late hour in the night.

29th June.—Action at Jicin. By 10.30 a.m. the line was opened over the above mentioned portion, and an advance made to Turnau, replacing the rails in two places on the way. Turnau Station was found to have been placed in a state of defence, the points, turn-tables, and steam pump taken away, and pump made useless.

30th June.—Repairing the Turnau Station, and forming a depot there. The line was reconnoitred in both directions towards Eisenbrod and Podol.

2nd & 3rd July.—Battle of Königgrätz. The line by Eisenbrod and Semil was reconnoitred to Königinhof, and repaired in two places by Semil, 34 rails being replaced. Between Königinhof and Shurz (nearer to the latter) a viaduct of three arches had been blown up by the Austrians when they evacuated the strong position immediately above the railway on the night of the 30th of June, they having been compelled to do so by the loss of the action at Jicin.

The destruction of this viaduct made an opening in the way to a depth of 48 feet, and a length of about 130. Immediate orders were given for its repair, and the bridge, of which an illustration accompanies this report, (vide plate IV) was commenced on the 8th and finished on the 30th July. When completed it stood every test of strength.

At Podol (on the other line) the road crosses the Iser on an iron lattice bridge, constructed on Schiffkhorn's system in two lengths, together measuring 155 feet. From this the Austrians had carried away the cross bearers upon which the rails had rested, but they had not blown up the pier in the middle of the river. Repairs to this with timber bearers were commenced, and completed by the *9th July*.

In the meantime the line was examined to beyond Backau, where a similar bridge to that at Podol was found injured in the same manner; and thence to Jung Bunzlau, where the station was found uninjured, and only the pump-rod deficient.

10th July.—The train advanced with material to the bridge at Backau, where the repairs were at once commenced, and completed on the

12th July.—When an advance was made to Zamost, where ten wooden sleepers of another lattice bridge, which had been burnt, were replaced.

13th July.—The above completed, and reconnoisance made of the line as far as the bridge over the Elbe at Lobkowitz. From the intermediate stations of Kuttenthal, Wratitz and Bisic, the points and turn-tables had been removed, and at Bisic all the moveable portions of the steam-pump destroyed.

At Lobkowitz the line crosses the Elbe on a fine lattice bridge of Schiffkhorn's system, having four spans of 125 feet each. The Austrians had removed the rails and bearers from only one of these spans, and had not exploded their mine in the 3rd pier.

16th July.—The line repaired over the bridge in a similar manner to the preceding cases. I cannot ascertain if the Prussians were aware of the existence of the mine.

18th July.—Completion of repairs and the line opened to Prague, where the department was moved, after completing the work at Kuttenthal and Bisic.

From the 20th to the end of July, the greater portion of this section of the Field Railway Department was employed in repairing the line between Hof and Münchberg in Bavaria, where the Bavarians had torn up a considerable portion of their railroad, in one place as much as 90 rails.

27th July. — An Austrian Engineer Officer sent by the Governor of Theresianstadt who was ignorant of the armistice, succeeded in reaching the railway bridge over the Elbe during the night, and fired the mine which the Austrians had left in one of the stone piers. The result was the subsidence and fracture of the lattice girders, rendering the line impassable for trains.

Mode of Reconnoitring a Line of Railroad.

The reconnoisance starts with, and until interrupted, keeps up with the advanced guard, the movement being covered by cavalry scouts on each side of the line.

The greater portion of the train in charge of the department, with one engine in front and another behind, advances slowly, preceded at a distance of about 500 paces by a trolly, carrying one of the officers, four men to work it, and a bugler. On arriving at any obstruction the trolly signals to the train by bugle, and extra caution is used in advancing towards it. If in presence of the enemy the scouts give warning to the officer in the trolly, who returns to the train and the whole retires. The second engine can be detached from the rear to send messages or bring up fresh supplies.

The Elbe Railway Bridge near Lobkowitz.

The facts connected with the destruction of this bridge had not been collected when I left Bohemia; I am therefore unable to give any information as to the charge of the mine (or mines) employed.

Apparently in calculating it, considerable addition was made on account of the superincumbent weight of the girders, so as to ensure the complete demolition of the pier under them. One stone of not less than 4 cwt. was thrown a distance of more than 200 yards.

The construction of the bridge itself is interesting in a military point of view on account of the comparative facility with which large girders, on Schiffkhorn's principle, can be replaced. There is, I understand, no example of a similar construction in England. The whole of the bridge is composed of small castings jointed together, and bolted with wrought iron suspension rods, and cross bearers and wrought bars in the lower flange, without a single rivet throughout. The ties and tie-plates are of cast iron, and their connection with the suspension rods is ingenious. The segments being small, few were injured by the fall of the girders, and only a few of the wrought iron rods required repair before being used again. The chief objection to the system, as a girder, is its weight.

Remarks on the foregoing Operations.

In the account I have given I have selected as an example the work performed by the section attached to the 1st Army Corps, as the most interesting and instructive, being both largest in amount, and done during the early part of the campaign before the rapid retreat of the Austrians.

The section attached to the 2nd army commenced work at Prague, and taking charge of the rolling stock captured there, repaired the line from that place by Pardubitz to Brünn and on to Vienna. Beyond having to repair the line, and a few small bridges, it had no work of any great importance to perform.

Besides the energy displayed by the department, circumstances favoured the Prussians in making use of the railway communication in the enemy's country.

They succeeded in opening the line to Königinhof, within ten miles of the battle field, on the day following the battle of Königgrätz.

The destruction of the viaduct near Shurz was only serious in the event of a siege of Josephstadt being undertaken, as that fortress and Königgrätz closed the line against further progress to Pardubitz.

The neglect or disinclination on the part of the Austrians to destroy the latter bridge on the line between Turnau and Prague left that line comparatively open, and their hasty retreat after Königgrätz, gave them no time to do much between Prague and Pardubitz and further south.

Until the armistice commenced, the fortresses of Königstein and Theresienstadt closed all direct railway communication between Dresden and Prague.

On the 18th July the Prussians had succeeded in opening the line through Turnau, Prague, and Pardubitz, to Brünn.

On the 27th it was again closed by the act of the Governor of Theresienstadt in blowing up the Elbe bridge.*

But these nine days of open communication were invaluable to the Prussians.

Thus, two fortunate circumstances, the preservation of the Elbe Bridge, and the capture of rolling stock at Prague, enabled the Prussians to use the line *in the first instance*. Had the Austrians blown up the former and removed the latter, the whole line of railroad would have been useless, for a temporary bridge could not have been constructed in less than six weeks.

The Prussians were also fortunate in being able to preserve the line intact from injury by the inhabitants, partly by the number and strength of the guards posted along it, and partly from the terror of reprisals which they had inspired.

In the face of an active enemy, and in a country where the population was hostile, it would have been impossible to depend on the rail-road as a principal line of communication.

Although naturally, railroads as a military means of communication should play a more important part in the defence than in the invasion of a country, it does not appear that General Benedek used the railroad for the movement of troops before the battle. But there can be no doubt that he depended greatly on it for the supplies of his army, and it was his desire to cover Pardubitz at the junction, that influenced in a degree his selection of the position in front of Königgrätz.

Conclusion.

In these operations two things have to be considered, viz., the creation of obstructions, and their removal.

The officer charged with the care of this service must be immediately in communication with the Commander-in-Chief.

He must be aware of the nature of the proposed operations in order to be prepared as far as possible for all emergencies.

In advance he must be prepared with means to remove all obstructions, and to make necessary repairs in the shortest possible time, obtaining beforehand as much information as possible of what the enemy is prepared to do, at the same time always providing for the contingency of having again to retreat.

In retreat he must take into consideration the nature of obstruction he proposes to create, the material and the time that its removal will occupy, with reference to the delay which will be caused as well to the enemy in his advance as to himself if the line should be regained.

In case of a hasty retreat or the evacuation of a province, the officer charged with the task of destroying a line of railway would only consider what nature of impediment he could create in the shortest space of time which would be the greatest hindrance to the enemy.

* On the night of the 27th July the Governor of Theresienstadt, unaware of the armistice just concluded, sent an Engineer officer across country, who safely carried out his orders to fire the mines in the bridge, and regained the shelter of the fortress. From this time until the repairs to the line between Prague and Dresden were completed on the 4th August, the through communication with Berlin was broken.

The abandonment of the first line of railway between Josephstadt and Turnau, and thence to the Saxon frontier, was a necessity to the Austrians as soon as the Prussian armies had passed the defiles, and their destruction of the viaduct at Shurz was justified as conducive to the safety of Josephstadt; but the impediment created by discharging a mass of earth into a cutting near Liebenau was slight and disproportionate to the importance of the object, though at the same time the covering up of the line was a better mode of closing it than blowing a hole in an embankment as is generally suggested, for in the former case only one truck could be loaded at a time in removing the rubbish, but in the latter any number could be loaded at once, and the ballast transported to re-fill the gap.

It is probable that the Austrian Engineer refrained from destroying the bridge over the Iser between Turnau and Prague, believing that the Prussian occupation of the line was only temporary, but after the defeat at Königgrätz he ought to have acted on his own responsibility, and have fired the mines on the Elbe bridge. For the same reason, knowing that the Prussians had occupied Pardubitz, and severed the communication with Vienna, he should have destroyed the rolling stock at Prague, all of which there was ample time for him to have done.

The tearing up of the rails at intervals, and the damage to the stations, &c., were probably only intended as, and proved to be, the cause of but short delays, and they answered the purpose if it was intended to prevent the Prussians from opening the line daily as far as their army advanced.

I could obtain no information on any special way of tearing up rails quickly, but was informed that it took about 30 minutes to replace each pair of rails with their sleepers, in a rough way, which is about the time required by railway plate-layers in England.

For the construction of bridges the Prussians met with ample supplies of timber; but in a country where this did not exist it would be very desirable to have iron trestles constructed with screw joints and screw pile ends, which could be rapidly put together, and more easily carried than timber. They might be on the same principle of construction as those used on the Indian railways in alluvial districts.

In considering the subject of a Field or Army Railway Department for service with a British army, it is of material importance to take into account the question of whether the theatre of war be at home, or in the colonies, or abroad.

At *Home*, in case of an invasion, the management of the traffic for military purposes, whether the line were partially or wholly closed to the public, should in no way be connected with the Department whose duties would be the destruction or repair of a railway.

Previous to an invasion a well-devised scheme should be worked out so that the preparations for the destruction of bridges and viaducts, and for other means of closing the line should be completed in time, with the view, if possible, of preventing any line in the country being used by the enemy. The points chosen for obstruction should be be very frequent, as it would be difficult to prevent some rolling stock from falling into the enemy's hands. It is evident that the direction, as well as the preparation, of these operations should be under the control of a single officer in direct communication with the Commander-in-Chief, that he should have complete knowledge and experience of railway engineering, and that he should be assisted by a competent staff.

The existing Railway Engineers would not be available in time as volunteers for this service; even supposing them to be in every way suitable, their civil duties would engage them as long as the line was open to the public, which would be till the last moment. Hence there appears to be a necessity for a military nucleus for an Army Railway Department. The association of military and civil officials would not be so easy as in Prussia where the civilians are the servants of the State. If the Civil Engineer is more competent in the construction or restoration of a line, it must be conceded that the Military Engineer would be more *au fait* at the demolition. Such a division of duties might be made, and under any circumstances the labour could only be obtained among the railway workmen, as but few soldiers would be disposable for the service.

It seems desirable therefore that Railway Engineers and workmen should be organized in companies only, on the same system as a company of Royal Engineers, in which way they would be most disposable for the duties likely to be required of them.

The same arrangement could be made in case of the invasion of any of the British colonies or possessions, except where a native population existed, as in India, whose allegiance was doubtful.

Abroad. In the event of a British army taking the field in any country where railways existed, an Army Railway Department would be necessary; first, for the repairs of the lines; secondly, for the working. And in *this* case it would be convenient to have them all under one head. In the former case the whole of the ordinary railway officials would be in their places, and there would be a positive loss in disturbing them, but in *this* case a complete railway staff would have to be supplied. Under certain circumstances, lines in military occupation might be worked by contract, but the expense would be very heavy, and in an active campaign, the chances of war might give rise to accidents, causing great inconvenience to a commander, who would have no real control over the officials.

In whatever way the railway communications of an army are managed, the first object should be to obtain the greatest efficiency; and for this it is evident that every individual connected with the railway department should be subject to military law, and that the whole management should be under one officer directly responsible to, and in communication with the Commander in-Chief; otherwise the joint control of any civil or other military department would be sure to tend to confusion at the moment when the greatest efficiency and promptitude of action were necessary.

At the same time it would be always the object of a commander in occupying a foreign country to reinstate the native officials in their posts as early as possible.

In the late war, the Prussian field railway department was employed only in the restoration of the lines, the working of them being immediately taken up by the State railway officials, the Austrian staff of under-employés remaining in their places, and the traffic at each station being managed by an officer of the Quartermaster General's Department. There were three departments engaged, but they were all under military discipline. If the state officials and the Austrian employés had not been available, the lines could not have been worked without a special staff.

Armies invading a foreign country might meet with none of these facilities, and it is therefore highly desirable that power of immediately repairing and working a line of railroad should be in the hands of a commander.

As military trains should rarely travel at a greater speed than 15 miles an hour, with great caution, and always in daylight, the want of experience of unpracticed officials would not be a very serious inconvenience. The whole strength of the department would be first directed to the repairs of the line. Plate laying is easily done after a little practice, the construction of wooden bridges is the task of any military as well as civil engineer, and the removal or supply of earth to repair the way is entirely a matter of time and labour.

The guarding, and, if necessary, the patrolling of the line, would be undertaken by the troops, for which purpose guards should be posted at every station.

The charge of the traffic, depots, &c., at each station, would have to be in the hands of an officer, with assistants and working parties at the large stations.

Signalmen would have to be dispensed with in most cases, as the guards of the line would have charge of the crossings. The trains would travel very slowly, and never enter a station without a signal by bugle from the officer in charge.

Locomotive drivers and guards, especially the former, must have experience, but experience really means more the knowledge of the line than of the charge of a locomotive; and in a new line of road this can be acquired only gradually.

It need hardly be added that the repair, maintenance, and working of the railway telegraph would play an important part in the working of the line.

On the above grounds I am led to make the following suggestions :—

That the simple details of the repair, maintenance, and working of a line of railway should form part of the course of instruction at the Royal Engineer Establishment at Chatham, in the following way.

That a contractor's locomotive, with trucks and a trolly, with one or two miles of rail, be supplied, the rails, chairs, &c., being of various patterns, and that part of the annual field work instruction be the taking up and laying down, on a permanent way, of portions of this line, a certain number of men being taught the duties of driver, stoker, and guard.

This line might be doubtless utilized in some way to pay its expenses.

That all the officers under instruction should be required to make projects for the demolition of railway bridges, creating obstructions on railways, and of temporary railway bridges and viaducts of all kinds, and that any officer desiring it should have the opportunity of going through a course, and obtaining a certificate of knowledge in the theory of railway construction.

In this manner, at the breaking out of a war, there would be a nucleus of an army railway department, ready to undertake the duties described above.

III. The Engineers of the Prussian Army.

With Plates V and VI.

The strength of the Engineers attached to one Prussian Army Corps is as follows:—

Colonel on the Staff		1
Adjutant to ditto (Lieut.)		1
Captain on the Staff		1
Total Officers on the Staff		3
One Battalion of Pioneers of 4 Companies:—		
Lieut. Col. Commanding (Engineers)	1	
Lieut. and Adjutant to do (do)	1	
Captain of Companies (do)	4	
Lieutenants do (do)	12	18
Total Officers of Engineers		21
Surgeon	1	
Assistant do	2	
Train Officers	4	7
Total other Officers		7
Men in each Company:—		
Under Officers	16	
Foremen of trades	18	
Privates	116	150
Total N.C.Os. and men of Pioneers		600
Train Soldiers:—		
With Pontoon and Light Bridge Train,		
Under Officers	10	
Drivers	150	160
Light Bridge,		
Under Officers	4	
Drivers	60	64
With Reserve Tool Train,		
Under Officers	2	
Drivers	30	32

With each Company of Pioneers,

Drivers of Tool Waggons	4		
Ditto Officers' Baggage Cart	1		
Ditto Officers' Batmen	4		
	9		
Total with 4 Companies		36	
Batmen of Colonel Commanding and his Adjutant		3	
Total N.C.Os. and drivers of Train		295	

Grand Total of 1 Battalion of Pioneers:—

Officers of Engineers	18
Ditto other Departments	7
N.C.Os and Soldier Pioneers	600
Ditto Train	295
Total	920

The four Companies of Pioneers are thus classified:—

1st	Pontooners	
2nd	Sappers	The Light Bridge Train accompanies one or other of these Companies.
3rd	Ditto	
4th	Miners	

The men are the first selection from the recruits of a province, being chosen for their strength and knowledge of trades.

In training them as Sappers, the intention is that each man should have a speciality, but that all should be sufficiently acquainted with the other duties of an Engineer soldier, to be able to take a part in them.

The whole battalion may be employed on the construction of works in a campaign; but during peace they perform no remunerative labour in their garrisons, being solely occupied in exercising as Sappers, Pontooners, &c. In each company are 30 men trained to a special knowledge of the exclusive duties of the other companies.

Thus, with the pontoon train are, 15 Sappers and 15 Miners.

The soldiers classified as "foremen of trades," are selected for their intelligence, and receive a trifle more pay monthly than the private.

The weight of the clothing, necessaries, &c., of each pioneer is as follows:—

Belts	$4\frac{1}{2}$	lbs.	
Cartouch box and cartridges ..	4	"	
Bread bag (full)	4	"	
Knapsack (ditto)	20	"	
Great Coat	5	"	
Rifle (short)	8	"	$45\frac{1}{2}$ lbs,
Clothes	9 to 12	"	
Tool and case	5 to 7	" ..	14 to 19 "
Total			$59\frac{1}{2}$ to $64\frac{1}{2}$ lbs.

The spade is carried in a leather case resting on the back of the left hip, the case being slung by two straps, one (supporting the chief weight) passing over the left shoulder with each end fastened to the case, the other over the right shoulder, attached to the waist-belt in front and to the case behind; both straps passing under the knapsack straps.

The pick-axe is reversed, the butt of the handle resting in a cup (like a lance) and the iron pointing over the shoulder.

They are kept in an upright position by a small strap at the end of the knapsack.

Pontoon or Heavy Bridge Train.

Equipment.	Waggons.	Horses.
Pontoon Waggons	32	192
Tool ditto	3	18
Reserve baulk ditto	2	12
Forage ditto	3	12
Officers' Baggage ditto	1	2
Total	41	236
Spare Horses		10
Non-commissioned Officers' ditto		10
Total Horses (Officers' excepted)		256

Each Pontoon Waggon contains—

Boats	1
21-feet Baulks	7
12-inch Boards	18
Oars (1 as rudder)	3
Boat Hook	1
Anchor and Rope	1

And the necessary lashings.

Weighing altogether, including waggon, 42 cwt, or 7 cwt. per horse.

The pontoons are described by Lieut. Colonel Lovell, R.E., in his "Paper on Pontoons," in the "Professional Papers of the Royal Engineers," Vol. XII., as "Prussian, old pattern, wood, open boat, both ends boat shaped; 23·69 feet long, 5·06 feet wide, and 2·49 feet deep, weight 1,134 lbs., or with one bay of superstructure, 2,390 lbs."

The boats are very similar in outline to a Norway yawl, but flat bottomed, constructed of oak varnished and caulked, but they are 3 feet 3 inches deep, instead of 2·49 feet, as in the above extract.

The superstructure consists of 5 baulks, supporting the boards forming the roadway, laid with double bearings on the gunwales of the boats, and lashed to belaying pins on both sides. Their scantling is $6\frac{1}{2}$ in. by 5 in.; and they project more than one foot over each boat, so that the latter are 14 feet from centre to centre when the bridge is constructed. The side pieces are of the same dimensions as the baulks, and are lashed in the usual way.

A bridge is constructed at the rate of about one bay in five minutes. There being 450 feet of bridge with each army corps, the two Prussian armies together had 1,200 yards.

The Prussian new pattern iron boat, which has a much higher power of support, has to a limited extent replaced the wooden one. Its superiority in every way over the latter is undoubted. I did not think it necessary to make a drawing of either of these boats, there being nothing in them specially worthy of notice.

I could not ascertain that at any time during the campaign it had been found necessary to make use of this pontoon train; but had the armies been obliged to attempt the passage of the Danube, there was sufficient material to have made two bridges across it; and the trains belonging to all the army corps had been brought together for that purpose, previous to the cessation of hostilities.

At the only place where a large bridge was necessary, over the Moldau, immediately below Prague, one was constructed of the large country boats, of which more than sufficient were forthcoming.

The Light Bridge Train (Pls. V and VI)

appears to me to be the most interesting portion of the field equipment of a battalion of Prussian Pioneers. The details are as follows:—

	Waggons.
Waggons carrying 1 trestle, or half a pontoon, in proportion of 6 of former to 4 of latter, with superstructure	10
Baggage waggon	1
Forage ditto	1
Total waggons	12

	Horses.
Horses to trestle and pontoon waggons	60
Ditto to baggage and forage ditto	4
Ditto for non-commissioned officers	4
Spare ditto	4
Total (exclusive of officers)	72

Each Bridge Waggon contains:

Trestle.		*Pontoon.*
Transom	1	Half pontoon of sheet iron on Birago's principle.
8-ft. legs	2	
13 ditto	4	
18 ditto	2	
Feet	2	

Baulks	5
Bank ditto	1
12-inch boards	24
6-inch ditto	2
Side pieces	4
Rack lashings and pins	50

Side lines	2
Small pickets	10
Large square ditto	2
Mallets	2
Pick-axe	1
Felling ditto	1
Spade	1
Box of small tools and stores under waggon	1

Thus loaded, a waggon weighs 30 cwt. giving a weight of 5 cwt. to each of the horses which draw it.

Lieut. Colonel Lovell in writing of Birago's pontoon, as used by the Austrians, with two bow pieces together, allows to a greater space a power of support of 18,000 lbs. and I find the trestle, when laterally supported, to be quite equal to it; so that it may safely be assumed that this bridge is fully equal to the passage of all the train of an army, heavy siege guns excepted.

When constructed for my inspection a detachment passed over at the double, 5 deep, with closed ranks.

Each army corps has 144 feet of bridgeway of the above description, and if for the passage of infantry only, the separate use of the half pontoons will extend this length to 180 feet.

The points most worthy of notice in this bridge appear to me to be—

1st—The principle contained in the adoption of a composite bridge, which is true to the actual requirements of military bridge construction. Few streams or narrow rivers are met with, too deep throughout to receive a trestle which may be immersed 15 feet. But where that depth is exceeded, in most rivers places are found where one side is deeper than the other, when the pontoons could be introduced in that portion of the bridge.

2nd—The supply of trestle legs of three different lengths, and the power of altering the length of the chains supporting the transom, allow of the bridge being adapted to the height of the banks, as well as to the depth of the water of a river.

3rd—The simplicity of construction of the trestles, which admits of one bay of the bridge being completed (lashings excepted) in four minutes; and the strength of the superstructure and all parts liable to fracture; this quality of strength being ascertained on examination of the bridge exhibited to me, which had just come off the wear and tear of a campaign, during which it had been repeatedly used.

4th—The mode of securing the baulks when packed as shewn in the sketch, Pl. V.

5th—The form of the waggon, which allows the front wheels to lock, although carrying a load of such great length, (Pl. V).

In common with the Prussian field gun carriages, the waggon possesses the great defect of having a pole which is dangerously close to the ground; the contact of its end with any considerable unevenness being solely prevented by the dexterity of the driver.

It will also be observed that the length of the baulks make it necessary to attach the draught at a point too distant from the work.

The defect in this form of bridge is, that the trestles being two-legged depend for lateral support on the continuity of the bridge, and its connection with either bank; but it is not a vital one.

This flying bridge equipment appears to be especially intended—

First—For use in the passage of small rivers and streams during an action, and,

Secondly—For the same purpose during an advance, while bridges of timber found in the neighbourhood are being constructed; being taken up and again advanced to the front when those of a more permanent nature are ready.

The Prussian Sappers are well drilled to its use, and exercised in its construction by word of command, frequently at the double.

It compares very favourably in weight and power of support with Blanshard's heavy pontoon bridge, to any given length, and is at least as simply put together.

Between it and Captain Fowke's no comparison can be drawn, his being only an infantry bridge; although not having seen it, I cannot say what may not be achieved by placing his pontoons close to one another.

And here it may be remarked, that light bridges ought to be able to bear the passage of field artillery; indeed since heavy metal has become of such importance in an action, it is a question if they ought not to admit of the passage of a 40-pounder without horses.

The passage of the Elbe on the morning of the 2nd of July, was effected by the second Prussian army, on three bridges thrown over it at Königinhof, Shurz, and Kukus, where the stone bridges had been destroyed by the Austrians, and these were immediately replaced by ordinary four-legged trestle bridges, made of timber from the neighbouring woods, and the light bridge sent again to the front.

Each company of a battalion of pioneers, independently of the bridge equipments is accompanied by two waggons containing as follows, in addition to the tools carried by the soldiers, which consist of—

	Carried by men.	In waggons.
Spades	72	68
Pick-axes	36	104
Felling ditto	18	12
Hatchets	14	6

Besides sets of carpenters', smiths', wheelers', and other small tools and stores, with an iron cylindrical field forge. Each waggon weighs 28 cwt. and is drawn by 4 horses. The company of miners carry a proportion of mining tools.

The Reserve Train of Engineer Tools is intended for the use of working parties when a position has to be strengthened or extensive field works to be thrown up, and it is quite separate from the Engineer stores accompanying a Siege Train.

Equipment—Waggons ...... 6, drawn by 4 horses each.

In each waggon—	Spades	270
	Pickaxes	70
	Felling axes	30
	Mallets	4

Crow bars	4
Tracing lines	2
Rammers................	8
Sets of Carpenters' Tools ..	1
Ditto Smith's	1
Small stores	various.

With 3 field forges in the Train.

Before concluding, I may state as one result of my observations, that the Prussian Engineer officers did not seem to be particularly wedded to either the mode of organizing their companies or any of the details of their equipment.

They thought well of their Light Bridge train, and I think that the pattern of their train waggon is very good, being as strong and lighter than ours in proportion to the weight carried.

From what I saw during my tour I am inclined to lay greater stress than is usual on the importance of abattis as a defence, believing that men will remain behind it longer than behind a breastwork, which offers little impediment.

To make use of this nature of obstacle to the full amount that the resources of a position will allow, a very large number of felling-axes may be required, and I venture to suggest that a greater proportion, than has been heretofore allowed, should be carried with the army in the field, and that every man in a regiment who is capable of using them should be known.

IV. On the Defences of Dresden. (Pls. VII, VIII, IX, & X.)

Immediately after the occupation of Dresden, in June, 1866, by the second Prussian Army, under His Royal Highness Prince Frederick Charles, steps were taken to fortify the town, so that a division, placed there to guard the important railway junction, should be able to defend the place against a superior attacking force.

Pl. VII.—The accompanying plan, on a small scale, shews the position of a circle of detached forts and batteries erected for that purpose.

Those on the south side were completed when I inspected them in August, 1866. Those on the north had only been marked out, but (I understand) have been since constructed.

Plates VIII, IX, & X.—The example herewith is a type of the form and profile of the forts, but each possesses trifling peculiarities incidental to the nature of the ground.

The batteries are of nearly the same dimensions, having two or three traverses, and places for four to six guns, the ditches being without flank defence, but having a thick Scotch fir abattis leaning against the counterscarp. They are closed in rear with a strong palisade, flanked by a projection in the line, and have a wooden barrack 30 feet long, similar to those in the forts, of which a section is given. Against surprise the batteries are very nearly as secure as the forts.

In the construction of the forts the following details appear worthy of notice.

The bombproof covering of the caponiers, magazines, and barracks, into the wooden construction of which is introduced the use of old railway irons as a support to concrete under the earth, producing a watertight roof of considerable strength and great cheapness (which I am told the Prussians had subjected to ample tests) as a resistant to the effects of vertical fire.

The height of the interior slope of the parapet, over which the guns are fired "en barbette" affording a cover of 5 feet to the gunners, and doing away with the use of embrasures.

A profile only possible with gun carriages such as the Prussian, which raise the axes of the guns 5 feet 6 inches above the ground.

The use of large hurdles made on strong stakes to revet the interior slopes, forming when secured, a very stout and permanent support to the earth, much superior to any made with fascines.

The use of a non-bombproof, as well as a bomb-proof shelter, for the garrison, seems a proper arrangement in the case of forts, such as those round Dresden, which are not likely to have to sustain a continued bombardment.

The form of construction of the barrack or block-house, and caponiers, very similar to that in use at Metz, taught at the French school of field works.

The most interesting fact connected with the defences on the south side of Dresden is the time occupied in their construction, viz., 14 days, exclusive of reconnoitring the ground and tracing. The work was under the superintendence of a Colonel of Engineers, and the officers and men of three companies of pioneers, (the soldiers assisting in the labour), and done by about 6,000 labourers brought from Berlin, on wages of one thaler a day; worked in two reliefs of 9 hours each, commencing at 3 a.m. and closing at 9 p.m. Nothing could be more creditable than the result, which is estimated to have cost about £15,000, the principal portion of the material, which is timber, being obtainable on the spot.

The relative position of the forts and batteries on the south side appeared to me to be good, but instances of imperfect defilade frequently occur.

As regards the site, Nos. 2 and 3 seem to be most disadvantageously placed, being domineered by the ground in front.

Their value as tactical points might be thus estimated. As batteries they would prove formidable, and unless great perseverance was displayed in attacking them, and the defence at the same time was weak, they might be safe against a *coup de main*.

In the event of an enemy advancing on Dresden, it is presumed that the Prussians were prepared to level walls, fences, houses, and trees to a distance of not less than 1,500 paces in front of the southern forts; no small task considering the number and intricacy of the enclosures.

The army designed to hold Dresden in such an event, was a division numbering 30,000 infantry, 48 guns, with a small proportion of cavalry, besides garrison artillery to man the guns in the works. For these, the guns may be estimated at—

	160	for the Forts.
	35	„ Batteries.
Total	195	is the proportion of
	130	.. 24 pounders
	65	.. 12 ditto,

requiring 585 gunners, allowing gun detachments for one-third, without relief.

The accommodation in the whole line of works being estimated for 1,700 men, 1,115 infantry, in addition to the artillery, might be permanently lodged in them.

Dresden can in no way be classed under the head of fortified towns on account of the existence of these works, for the reason that they are neither individually nor collectively of sufficient importance to compel an attacking force to undertake siege operations against them, and that their armament and garrison are alone insufficient to prevent an enemy entering and taking possession of the city.

Supposing the possession of Dresden to be all-important, the question is, what assistance is rendered by the forts to an army defending it?

Theoretically it may be estimated, that, when on the defensive, a line of such forts, armed with 12 or 16 12 or 24 pounders in each, about a mile apart, enables a given number of battalions to hold a line twice as long as would be possible if the forts did not exist. For if 10,000 men are supposed to be necessary in order to hold a line of one mile in length, it may well be allowed that 5,000 would be sufficient, even without extending them, when a fort exists at each end of the mile.

If this is the case, after detaching 5,000 men for contingencies and guards on the north side, an army of 25,000 men and 48 guns, with cavalry, would have been disposable at Dresden, and under the circumstances, sufficient to hold the whole line of the south side, five miles in length.

An enemy acting on a circle of which the radius is larger (vide Pl. VII) would occupy a front of 8 miles, which, in the same proportion, without the aid of forts, would require 80,000 men.

The existence of such forts being material to the defence of the place, the Commander would be led to consider their value, as to the nature of the ground upon which they forced his enemy to fight, the position of his own line, whether in front, in line with, or in rear of them; the nature of the communications; in fact, treating them as tactical points in his battle field, he would dispose his troops so that all the advantages possible might be derived from their presence, and if they enabled him to extend his line in the proportion already estimated, it will be conceded that their advantages are considerable.

Ordinary tactical points in a battle field, such as buildings, villages, woods, eminences, hastily strengthened for defence, would do no more than give a preponderance to the side that held them. But in the case before us we have regular works, affording cover to their defenders against heavy fire, strong parapets armed with artillery, bomb-proof magazines, and ditches lined with strong palisades, well flanked with musquetry caponiers. And therefore for operations extending over perhaps three or four days, it would be found that these works possessed all the value that I have supposed

I have said that an enemy would not be likely to have to undertake siege operations against them; but at the same time they are far superior in value to the chain of defensible villages made by the Prussians round the town of Pardubitz, in Bohemia, which a well sustained artillery fire of a few hours would render untenable. In fact, they are works of just such a nature, that a timid general might consider it necessary to open trenches in front of them, and a bold one be led to attack heedlessly, and thus receive a severe repulse.

Looking at this particular case, it will be seen that a battery (D) is erected to prevent the advance of boats from the south east, and it will be evident that a bridge of boats, forming a third communication across the river, would be desirable.

The south-western part of the line is weakened by the existence of broken ground in its front, because from the form of the river, and the proximity of high ground above Plauen to Fort No. 2, guns at Briefsnitz could prevent the defenders annoying the flank of an attacking force from the northern bank. On the other hand No. 1 is very well placed on commanding ground, and the inundation on the Weisseritz stream, with the battery B behind, is a serious impediment.

In connection with Nos. 2 and 3, the railway in rear, which is in a deep cutting, would form an excellent position for reserves, and afford lateral communication, even so far as to using a locomotive and trucks to bring up ammunition.

The south-eastern front is stronger, both from the openness of the ground, and the cross-fire obtained from No. 6, on the opposite bank of the Elbe, which has a considerable command; but the larger portion of the trees around the Royal gardens would have to be laid as abattis.

To cover a retreat of the defenders to the north bank, the area of the ancient ramparts should be converted into a *tête-du-pont*, by cutting down the trees and barricading the entrances; the bridges also should be ruined; but when visited by me, I could see no evidence of such arrangements having been made. I found that there was little or no foundation for the newspaper reports of the ruthless destruction by the Prussians of the environs of the city. Doubtless much that was left untouched would have been demolished had events taken a different course, and the Prussian army been compelled to retire; those who were ready to complain at the slightest personal inconvenience, would then have had a very different tale to tell.

After reconnoitring these Dresden works from the point of view of an attacking force, it seemed to me that (having the choice) the south-west front was the most vulnerable point. A general might seek by bombardment of Forts 1 and 2 from the ground west of Plauen to disable them so as to permit of an assault; in case of success he should throw a bridge over the Elbe, near battery A (which would be untenable), detach a brigade by the north bank to Pieschen, to take Neudorf, and if possible No. 10, threatening the railway bridge, and preventing the enemy harrassing the left flank.

The railway station, suburb of Friederickstadt, line of the Weisseritz, and end of the railway bridge being gained, and artillery being brought to bear on the rear of No. 10, the retreat or capture of the garrison would be inevitable.

On the Defences of Pardubitz, Pl. XI.

This town is the largest in that part of Bohemia, containing a Schloss, a fine square, and some good houses. Its selection, as a strategical point for defence, was doubtless due to its containing a railway junction and covering an important point of passage over the Elbe; otherwise its neighbourhood to the fortresses of Königgrätz and Josephstadt, in which the Austrians left (as was said) 16,000 men, was a source of weakness.

It formed, during the advance of the Prussians, and through the whole period of their retirement, one of the principal depots for army supplies and hospitals.

It is capable of receiving 15,000 men on an emergency, but when thus crowded it proved a hot bed of cholera.

The country around is quite flat, excepting a few very gentle undulations, presenting no obstacle to the movement of all the arms; but the view is interrupted by frequent villages, farms, and fir plantations.

The Prussians took advantage of such places, to form a line of posts on the south side of the Elbe, at a radius of a little more than a mile from the Schloss which forms the enceinte of the position, and at the same time commands the bridges which lead to the northern bank of the stream.

This line might be estimated at about 3½ miles in length, and was destined to be held by one brigade of 7,500 infantry and 24 guns.

Assisted by the defences, this number was sufficient to have held the ground between any three of the points.

As a "tête-du-pont" it would have covered the retreat of the army, had that movement been necessary, but it was defective in that respect from the form of the bends of the river allowing an enemy to command some of the line of retreat from the south bank, east of the town.

The points may be noticed individually as follows:—

The Schloss.

A very old wall with circular bastions, having a slight ditch and a musketry wall at the foot of the rampart, in which the Prussians had enlarged the old eyelet loopholes. Places for two guns in each of the towers commanding the river were nearly finished, and an expense magazine was commenced.

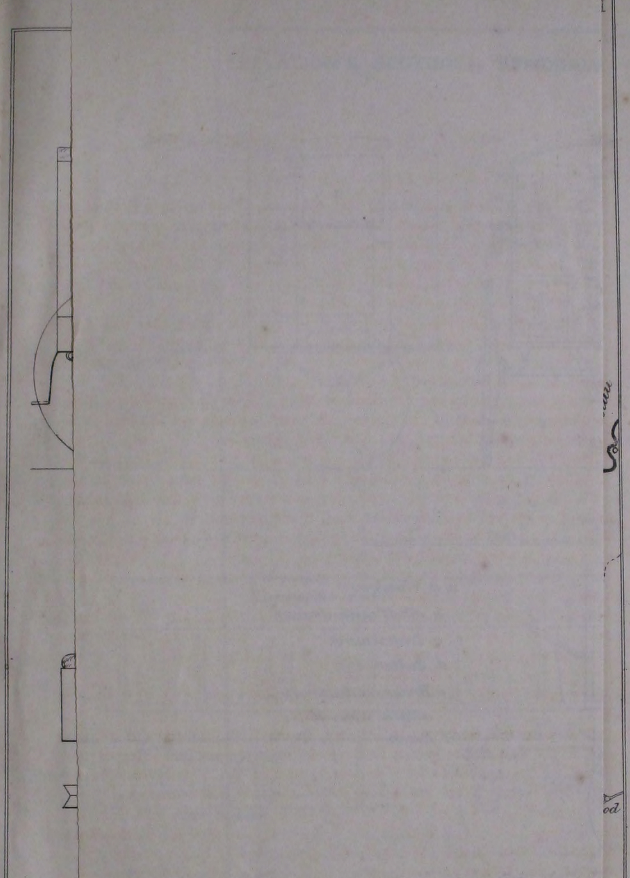
Israelitenhof.

Covering the main road to Sesenitz. The houses appeared to be insufficiently loopholed. The earthen battery and breastwork were neatly made. In contradistinction to any of the Austrian batteries, seen by me, the Prussian, here (as elsewhere), were constructed for guns en barbette, even with half sunken batteries.

Village of Studanka.

The abattis struck me as being extremely well made, of a large number of young Scotch fir trees, with their branches cut and pointed, forming a most formidable obstacle.

The garden palings were turned to good account, having brushwood woven into their tops to screen the defenders from the enemy's view. The earthen breastwork, connecting the villages, was very insignificant.



C E Webber

Village of Pardubiceh.

This example shews the *intention* of these defensible posts; apparently, that their defenders should only deliver a fire to their front, and not attempt to hold them after being turned, from the fact that they are all open to the rear, and in this case especially, with little flank defence. Here again I was struck with the apparent neglect to strengthen the houses, especially the church, which is a strong stone building.

The two farm-houses, near the railway station, complete the line, but have nothing, in connection with the work executed in placing them in a state of defence, particularly worthy of notice.

This placing a line of villages, houses, &c., in a state of defence, may become a more important feature than hitherto in strengthening a position, now that infantry fire has taken such a forward place in comparative importance. I have elsewhere shewn that its adoption along the line between Sadowa and Nechanitz might have proved of signal advantage to the Austrians.

It appears, however, that the circumstances of the defenders and the general position affect in the highest degree the nature and extent of the means used; and that (as in most things) a scientific consideration of these should take the place of a blind adherence to any theoretical data.

The defence of such posts forms a subject of study at the various military educational establishments, and I venture to suggest, that, as fortification has been developed, since the days when Colonel Macaulay wrote on the subject, in this, as in its other branches, the experience gained in late wars with examples from actual practice, be added, by some competent writer, to his admirable work on field fortification for the use of military students.

C. E. W.

PAPER VI.

PROJECT FOR A TWIN GUN BALANCE FOR FIRING "EN BARBETTE."

BY LIEUTENANT J. R. HOGG, R.E.

Preliminary Remarks.

The defects of embrasures in earthen parapets are too well known to need much comment, their cure is certainly not hopeful and they have become more and more glaring with the advance of military science in other respects. It is sufficient to sum them up under two heads :

1. Weakening of the parapet.
2. Marking out the latter into a range of targets for the enemy to aim at and speedily demolish.

The first of these may, by the judicious use of a certain amount of iron, be considerably reduced, without any ruinous expense being incurred, but the second is utterly irremediable. With this view, the design about to be described has been prepared, in the hope that it may be a step towards the solution of the problem of dispensing with embrasures altogether, and the substitution in their stead of a method of firing " en barbette," which shall reduce the exposure of the gunners to a minimum.

This design is far from perfect in the details which would fit it for practical application ; extended experiment, moreover, can alone decide upon the merits of some of the principles which it involves ; but such as it is, it may, with the improvements which friendly criticism will suggest, be turned to some account.

In order to raise a gun above a parapet, which has an unbroken crest line, with anything like rapidity, it is necessary either to employ an enormous excess of power, or else to mount it in balance with some compensating weight, and then to reduce as much as possible the friction retarding the action of such balance. For obvious reasons the latter system has been chosen for consideration, as being much more feasible with the mechanical appliances at present fitted for artillery purposes ; and similarly the kind of balance considered to possess advantages over others is that formed by coupling together a pair of guns, of equal weight, in such a way that the descent of one may be mainly instrumental in hoisting the other, they being fired alternately.

The " twin gun balance," illustrated by the drawings, may, with certain modifications of detail, be made applicable to works either of defence or attack, and will probably fulfil the following conditions :

1. The whole process of loading and running the gun up is done under cover.

2. The "laying" proceeds under cover also, as far as the gun detachment is concerned, excepting only the man who mounts in rear of the gun to direct the operation and clamp the elevating gear, and it can be performed with ease and rapidity.

3. The recoil of either gun starts the balance into action, and brings the two guns to the terreplein level, abreast of each other, and ready for either to be reloaded.

4. Unless great rapidity of fire be desired, two men at the winch handles suffice either for working the balance or adjusting the aim of the guns.

In the battery of a defensive work every gun requires a traversing arrangement, whereas for the purposes of attack this is necessary only within very narrow limits; the mechanism required for the latter is, consequently, more simple, and it is to them that the whole scheme would appear more applicable, since, in permanent works, which justify the cost, the use of shields will probably be preferable to any other arrangement. The project would, however, be very incomplete if the method of applying its principle to traversing guns were not worked out, and, therefore, the latter has been more fully considered, the siege battery arrangement becoming a simplified modification of it. Whether the principle can be made applicable to such pieces of ordnance as are destined to be used in coast defence, is another question: its study has been limited to the weight of the 64-pr. for the present. The drawings exhibit such details only as are necessary to show the general principles of the mechanism employed, several obvious requisites, which would unnecessarily complicate them, being omitted.

Application of principle to the battery of a defensive work.

The following is a general description of the method of mounting a pair of guns in balance on the rampart of a defensive work. A double traversing platform, 26 feet long, is mounted on a central pivot, and inclined to the horizon at an angle of 30°, each of its ends resting upon a set of short conical rollers grouped together in a curved rack. On this double platform, which is capable of traversing through a horizontal angle of 90°, two short ones, styled "travellers," ride up and down on sets of rollers, and balance each other by means of a wire rope running upon a wheel which is pivoted underneath the upper end of the platform. On these travellers, again, the two gun carriages slide, their recoil being checked by powerful compressors; when at rest, the travellers are abreast of each other half-way up the platform, and in this position the guns have about as much parapet cover as they would get on ground platforms with no embrasures in front of them. At this level each gun is loaded in its turn, and the balance then set in motion by a winch, one gun rising to fire "en barbette," whilst the other descends below the terreplein level; the winch is then thrown out of gear with the balance wheel and applied to the traversing arrangement of the double platform, whilst the gun about to fire is given the necessary elevation by means of a breech lever of special construction.

When the gun recoils from its fire, its breech, which bears upon an inclined slide fixed to the traveller, descends until the muzzle has an elevation of 12°, when it is checked by a bow-spring fixed between the cheeks of the carriage. The traveller allows the gun carriage to recoil upon it for a distance only of from 1 foot 6 inches to 2 feet, it being assumed that it is possible to construct a metal rope of sufficient strength to overcome, by means of the compressors, the inertia of the whole balance during the time spent in this short recoil, and at the same time of sufficient pliability to ride easily on the balance wheel shown in the drawings (3 feet 9 inches in diameter).

The force of the recoil is thus to be utilised in starting the balance into motion, and, although actual experiment can alone determine the extent of the latter, such data as exist seem to justify the belief that it will suffice to bring the gun down under cover of the parapet, if not as far down as the terreplein level, abreast of the ascending one. If the work of the recoil be expended before the two guns reach this position, a few turns of the winch handles will complete the adjustment, and then the descending gun can be sponged out and the ascending one loaded. A rotating stop is fixed at a short distance above the axis of the double platform to check the two travellers at the proper point, if the work of the recoil should not be expended before it is reached. The breech lever and recoil slide are proposed instead of the elevating screw for the following reasons :—

1. The steep inclination of the double platform necessitates the adoption either of a long traveller, which will allow the gun to recoil upon it far enough for its muzzle to clear the crest of the parapet when it begins to descend the slope, or else of some method of throwing the muzzle in the air simultaneously with the recoil.

2. To enable the gun to be loaded at the muzzle, when below the crest of the parapet it must have an elevation of about 12° to allow the rammer to be easily introduced.

3. The lever shewn in the drawings would enable two men to give the gun its proper elevation with great rapidity, a third man directing them from the tail end of the traveller, and clamping the lever when his aim is true.

The winch axle is attached to the platform, in such a manner as to enable it to act either in moving the balance or in traversing the whole machine about the centre pivot; the latter would be its ordinary gearing, it being only applied to the balance wheel when required to work it, and then immediately thrown back again, so as to reduce, as much as possible, the risk of the worm and pinion being injured by any shock that either of the guns may receive.

Each gun carriage would be run up on its traveller with side tackles when at the terreplein level, and the compressors then adjusted, so that when the muzzle peers over the crest of the parapet, nothing but the laying would remain to be done, an operation which the slewing-winch and breech-lever ought very considerably to simplify.

To meet the contingency of the wire rope being accidentally broken, a strong hempen one rides loosely in the balance independently of it, and acts moreover in preventing the recoil of the gun carriages from tending to overturn the travellers backwards, it being fastened to the upper ends of the latter.

The dimensions of the platform and travellers admit of pairs of guns being mounted within 40 feet of each other, from centre to centre, on the terreplein of any existing work, or at intervals of 66 feet, including a hollow traverse between every two platforms; the only novelties in the design of the battery are the fan-shaped pits, in which the platforms traverse, and the parapet indentations to admit the splay of 45° on either side of the central line of fire. This amount of splay has been arbitrarily assumed, but appears to be a convenient one in several respects. The carriage and breech levers admit of 12° of elevation, and 8° depression in the gun.

Plate I exhibits the general arrangement of a battery on the rampart of a fort in accordance with the above scheme, the elevation of the parapet shewing an unbroken crest line by the adoption of the sunken expense magazines, introduced by the late lamented Colonel Owen, R.E.; it also illustrates a method of employing the twin-gun balance in works of attack.

Application of the principle to siege batteries.

Taking it for granted that the platform and travellers can be transported piecemeal as easily as battering guns, and put together in or near an attacking battery, the same detail will apply to the purposes of a siege as to those of a defensive work, with this difference only, that, instead of the traversing arrangement necessary in the latter case, it will be sufficient to let the double platform run on three lines of bridge rail, spiked down to longitudinal sleepers laid parallel to the crest of the parapet, without furnishing it with other motive appliances than the gunners' handspikes. With flanged truck wheels, the bottom rail could be made the mainstay of resistance to the thrust of recoil, although the centre one could easily take its share of the strain. Any small deviation from the centre line of fire could be given by slightly slewing the gun carriages on their travellers, whilst the lateral rolling of the whole platform, if the rails be arranged for lengths of about 50 feet between the splinter-proof traverses, would answer the purposes both of changing the object of attack and of moving the guns away from any portion of the parapet which might be badly damaged, to a point at which better cover remained.

The transverse section through the permanent work shews the firing position of one of the guns with the other one at the bottom of the balance, that through the siege battery shews the two travellers abreast of each other, the left gun having been run up ready for hoisting "en barbette."

Details. Pls. II. III. IV.

The gun carriage shewn in the drawings is merely an imitation in wrought iron of an ordinary naval carriage, as adapted to a slide platform, with the necessary special appliances. The compressor, on the principle known as "American," consists of a plate-iron frame projecting downwards from the carriage between the sides of the traveller, and enclosing a set of four slabs of teak which rub against three interleaved wrought-iron strips, set longitudinally between these sides, but riding loosely on the two bolts which penetrate their ends, so as to approach or recede from each other with the motion of the driving spindle. The latter has a screw-thread cut right and left-handed upon it, so that, worked from one side of the carriage only, it can drive the two compressing levers contrariwise.

Breech lever.

The most important feature of the carriage is the breech lever; this is proposed, for reasons already given, instead of the ordinary elevating screw, and may be thus described. A bar ACB is pivoted at C, on a transom piece set in between the tail-ends of the carriage cheeks, its short portion AC being two-pronged, and the two extremities carrying a link motion which forms the support of the breech of the gun; the upper link AD is a short bar headed in a rounded nob which sits in a socket fastened to the gun, the lower one is a flat piece in the form of an arc struck with the radius AC. Between the two prongs of AC a strut FG is also pivoted at C, and made in one with the transom piece, so that the latter oscillates with it like a pair of trunnions; the arc link AE rides in a slot cut through the lower extremity of this strut, and is clamped at this point, in any desired position, by a rod which forms the core of the latter and has a screw and clamping nut at its upper end F. The toe of the strut carries a pair of small truck-wheels which bear upon an inclined slide, formed of two stout pieces of angle iron fixed between the cheeks of the traveller.

By this arrangement the gun is given its required elevation by two men bearing down the B end of the lever, whilst a third directs them from the tail end of the traveller and clamps the arc AE at the proper moment.

As the gun recoils, the toe of the strut, which is the supporting point of the breech, descends the slide until it is brought up by the bow-spring H, and gives the gun an elevation of about 12°, and the link motion will thus act from whatever angle of elevation or depression the gun may be fired, within the 20° of vertical range already mentioned, and enable the muzzle to clear the crest of the parapet as the traveller descends the slope of the platform.

Experiment would probably indicate the point on the side of the traveller at which a sliding stud could be applied, which would tighten up the compressor during the recoil by contact with the arms of the driving spindle.

Travellers.

The short platform, for which the name of "traveller" has been assumed, is built up of plate iron in the form of a wedge-shaped box, so as to ride on rollers up and down the long double platform, and allow the gun carriage to recoil upon it for a distance of about 1 ft. 9 in. Its two cheeks are shod with pieces of light rolled girder, bolted on with channel iron, so as to combine a fair amount of rigidity with the proper shape for riding on the rollers. At the front and rear ends of the traveller, a distance piece of ⊥ iron is set in between the shoes, and carries small truck wheels to act as fenders against the inner faces of the platform girders, and keep the traveller rolling square upon the latter.

At the upper ends of the two travellers, and on their inner faces, with respect to each other, project two stout cylindrical horns (marked S.S., Pl. IV.), which serve to check the action of the balance, when the guns arrive abreast of each other, as will presently be described.

Main platform.
Pls. II. III.

The double platform, upon which the travellers roll up and down, consists of three box girders of plate iron, the outer ones carrying the outer sides of the travellers, and the centre, of double width, carrying the inner ones; these girders are firmly framed together at their ends, and are centrally supported by a transom framework, which rides upon the fixed pivot. The latter consists of a three inch bolt, anchored into the masonry bed, and headed by a flanged cast iron cap; upon this bears the wrought iron hood of the platform transom piece, with the intervention of a loose lubricating washer, so as to reduce the grinding action of the traversing. The extremities of the transom piece are shod with plain truck wheels, which run upon a flat racer.

Rollers.

The rollers, upon which the ends of the platform bear, consist of short conical tubes of cast iron, shrunk upon wooden cores, and are connected in a group by means of a curved rack, which carries a number of small truck wheels to keep it in its proper position, as it rides to and fro with the traversing of the platform; their racers are flat cast iron bed plates, fixed to the masonry in segments. The cylindrical rollers, upon which the travellers ride up and down the platform, are somewhat smaller, but similarly constructed and grouped.

Balance wheel and rope.

The balance wheel is pivoted underneath the centre girder of the platform and near its upper end; if made entirely of wrought iron its possible fracture would be a less serious matter than if it were composite. Its rim is notch-grooved to enable it to move the rope with certainty when driven by the winch.

The rope proposed is of iron wire and $3\frac{1}{2}$ inches in girth, the dead strain upon it would amount to $54\frac{1}{4}$ cwt., but, as it has a safe working strength of 63 cwt., and only breaks at 19 tons, it is considered thick enough for the purpose. Steel wire, though very much stronger, is ill adapted to the system, both on account of its uncertain behaviour when exposed to jerking strains, and its liability to buckle and form kinks in rapidly taking the curve of the wheel rim.

This rope is attached to the heel of the traveller by means of a framework of small ⊥ iron, which projects downwards from the latter, between the platform girders; the eyebolt-fastening itself sits in the core of a tubular coil spring, which will ease the shock of recoil transmitted by the compressors.

Safety rope.

This rope, as a precaution against accident to the other, rides loosely on a pair of broad sheaves, pivoted between the heads of the platform girders, and is attached to the upper ends of the travellers. A girth of 7 inches would give it sufficient strength for its purpose. The mounting of the sheaves is so arranged that this rope may also be depended upon, at all times, to prevent the fore part of the traveller from being tilted up, in the event of the recoil being exceptionally violent.

Tumbler stop.

It has already been shewn that some contrivance is necessary for checking the motion of the travellers on the platform when they arrive abreast of each other. If the recoil of either gun will suffice to bring them rapidly into this position, some firm resistance may be necessary to stop them, but it is supposed that at this point the motion of the balance will nearly have been brought up by its friction, so that the sudden stoppage need not be expected to throw any great shock upon the "tumbler stop" proposed for the purpose. If, on the other hand, manual force be necessary to complete the work thus expected from the recoil, no special contrivance will be wanted. To

K

meet the contingency of the first case, the stop is given the form shewn in the drawings: it consists of a small drum indented in its sectional outline so as to oppose a face to the projecting horn of the ascending traveller, to be turned down, by the advance of the latter, flush with the upper edges of the platform-girders, and then to firmly oppose a corresponding face to the horn of the descending traveller so as to stop its downward progress. The drum thus revolves upon a short stout horizontal axle, set in bearings upon the centre platform girder, its action being otherwise regulated by a tongue, which a coil-spring presses upwards against it, and forces into a slot in it as it rotates. A pedal lever is slung transversely under the platform, and projects a little out from its side, by means of which the tongue may be disengaged from its slot as soon as the men are ready to go round with the winch handles, the ascending gun having been loaded, &c.

This contrivance is at best a makeshift, and would of course give place to a ratchet and pall arrangement, if the escapement of the latter could, with certainty, be made self-acting under various conditions, so as to answer also the purposes of the safety-rope.

Winch gear. As cast iron cog-wheels are too brittle for artillery purposes, the worm-and-screw pinion, which can be easily made of the stronger metal, is in preference applied to the manual working of the balance and traversing of the platform.

The traversing arrangement consists of a small vertical double-flanged driving wheel, running upon a cast iron racer fastened to the masonry revetment of the parapet, and mounted on an axle slung in a framework of $\perp$ iron underneath the upper end of the platform; the other end of this axle carries a small screw pinion. A larger screw pinion, but one whose teeth are cut to the same pitch as those of the smaller one, is keyed to the axle of the balance wheel and underneath the latter.

These two pinions are mounted sufficiently near each other for a piece of small shafting, carrying a worm on its centre and slung at right angles underneath the platform, to be applied to each of them in turn, for working the balance or driving the small traversing wheel.

This shafting, which carries a winch handle on each side of the platform, is supported at the extremities of two pairs of short cranks, projecting from an axle which penetrates the three girders and carries a short lever at each of its ends outside the platform. By means of these two levers the shafting is moved back or forwards so that its worm may be thrown into gear with either pinion, and they are fixed in either position by means of a sliding stud and notched bracket attached to the face of the platform girder (See Pl. II.); this stud projects from a short piece of tubing which is free to slide on the lever, and is moved out of either notch by hand when the gearing has to be changed. This is a rude arrangement less likely to be thrown out of order than the reversing triggers common to steam machinery.

The small driving wheel of the traversing gear is pressed down upon its racer by a vertical bar which carries a coil spring at its head, and thus forms an elastic distance piece between the fore-bearing of the driving axle and the underside of the centre platform girder.

There would be a little risk of the winch gear being injured by accidental shocks if the worm were kept, as a rule, in contact with the traversing pinion and only temporarily applied to the other one, still less if the curved brackets on the sides of the platform had each a third, intermediate, notch so that the worm might generally be out of gear altogether.

With this winch gear, two men could, without over exertion, work up either gun "en barbette" from its loading position in 52 seconds, or four men in 26 seconds if rapidity of fire were necessary. Similarly either two or four men could be employed in traversing the platform, four men being able to move it through its complete splay of 90° in a minute and a half.

Steps. To facilitate the loading of the guns, a light staging is hung under the fore part of the platform, and two short steps are bracketed on the side of each outer girder with the same object; the travellers too have a step set in between the uprights of their framework, on the outside, and might have their backs formed into a broad ladder by bars fixed in the positions of the dotted lines on the rear elevation (Pl. II). Otherwise, the appurtenances necessary for easily working the guns have not been fully considered, as they do not affect the fundamental principles of the scheme, and can only be satisfactorily determined by practical experiment. This test, moreover, could alone decide upon the relative rapidity of fire which a battery would afford by this method, gun for gun, and man for man, in comparison with existing artillery arrangements.

Siege batteries. As has been already mentioned, the details of mechanism necessary in the case of the siege battery would differ from the above only in the abolition of the traversing arrangement. The winch gear would have the same construction, as far as the balance wheel is concerned, and it would still be necessary to provide some kind of switch gear, for throwing the worm into, or out of, contact with the screw pinion.

To set up the platform, &c., in battery, would not require the services of very skilful fitters, although the presence of a few such men would be of value for the repair of any damage to mechanism.

Weights, &c. The following are some of the weights, &c., used in calculating the strains and dimensions of the iron work:—

64 pr. muzzle loading rifled gun........	64 cwt.	
Carriage and appurtenances	14 ,,	
Traveller and ditto..	26 ,,	
	2 × 104	208 cwt.
Double platform and moving gear		140 ,,
Total weight to be moved in traversing		= 348 cwt.
Say		. 17½ Tons.

Friction of each traveller on its rollers $= \dfrac{\cdot 86 + 104}{40} = 2\cdot 236$ cwt.

Strain on balance rope independently of shocks .... $= \dfrac{104}{2} + 2\cdot 236 = 54\cdot 236$ cwt.

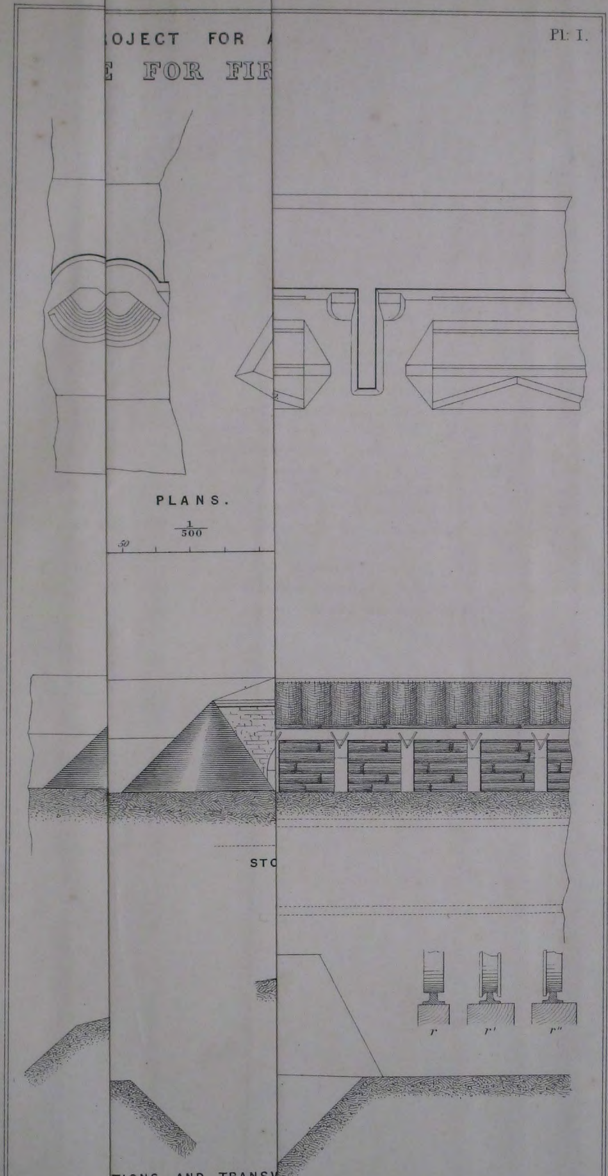
Girth of iron balance rope	$3\frac{1}{2}$ inches.
Breaking strength of ditto	19 tons.
Working ditto ditto	63 cwt.
Girth of hemp safety rope	7 inches.
Breaking strength of ditto	$9\frac{3}{4}$ tons.
Diameter of balance wheel	3 ft. 9 in.
Ditto screw pinion (27 teeth)	$11\frac{1}{2}$ inches.
Ditto traversing wheel	13 inches.
Ditto screw pinion on ditto (13 teeth)	6 inches.
Radius of winch handle	14 inches.
Preponderance of gun	7 cwt.
Power of breech lever	$4\frac{1}{2}$ to 1

In conclusion, it may be repeated that the value of this balance arrangement depends partly, but not wholly, upon the possibility of the recoil being utilized in starting it into action simultaneously with the firing of either gun. If this cannot be done it will be necessary to employ a longer traveller, and perhaps greater winch power, but, in any case, the principle of exposing the gun momentarily "en barbette" may before long have to be seriously considered, as the only solution of the embrasure difficulty as regards earthen parapets.

I am much indebted to Lieutenant A. G. Clayton, R.E., for his co-operation in considering this subject, and for more than one useful suggestion which I have appropriated and embodied in the design.

J. R. H.

Plymouth, September, 1867.



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PAPER VII.

ON DAMP IN POWDER MAGAZINES AS AFFECTED BY VENTILATION.

BY LIEUTENANT INNES, R.E.

Although magazine construction is a subject which has necessarily received a large amount of attention from the Corps at different times, the branch of ventilation—particularly with reference to magazines buried, as many of the most recent examples are, in the earth, or in the basements of massive buildings—has never, it is believed, been treated in a very thorough manner; and it is hoped that the following notes on the subject, compiled at a station where a good deal of magazine accommodation has been provided during the last few years, may be found useful, more particularly with reference to climates having a great range of temperature.

Several complaints of dampness in the powder-magazines having been made by the Military Store Department at Halifax, N.S., where the writer of the present paper was lately stationed, he was instructed to investigate and report upon the subject, and to take over a magazine for the purpose of making such observations and experiments as might seem necessary. A report of these last is appended; but before considering it, it will be well to give some general account of what had been observed previously, and the deductions drawn therefrom.

There are altogether some eight or ten bomb-proof powder-magazines in Halifax citadel and outposts, having accommodation for from three hundred to three thousand barrels in each (expense magazines not being included). Of these, about half are quite new, having been built within the last five years, and and are hardly yet brought into use; the remainder are of considerable age and have been in use for some time past. They are all, with one exception, of the ordinary arched construction, the recent ones being buried in the earth, the others, detached buildings on the surface, with a slated roof outside the arch, as was a common construction some years back; in the exceptional case referred to above, the roof is formed of buckled iron plates resting on the flanges of rolled joists, and covered to a depth of from four to five feet with earth and concrete. The magazines, generally, have detached half-brick linings, with an air space between them and the body of the walls, which in some does, and in some does not, communicate with the interior, and abundant provision for ventilation in the way of inlets and outlets.

The winter at Halifax, N.S., although not quite so long and severe as in other parts of North America, is of considerable duration: generally, it may be said that hard frosts prevail for from three to four months, commencing in November and ending in March, the thermometer occasionally ranging as low as— 20° Far., and the ground in exposed situations being frozen to a depth of five feet by the end of the season. The summer, on the other hand, is rather hotter than in the south of England, the warm weather commonly commencing some time in June, and the heat being greatest in July and August.

The general rule observed in airing the magazines was to open all the ventilators (at least, such of them as admitted of being closed, the outlet shafts in particular being generally open at all times), and often the doors also, on fine (i.e. warm) days at all times of the year; there was, consequently, more or less draught through them at all seasons, but chiefly so in the height of summer. None of the doors or ventilator covers had any special provision for close fitting.

The result was that some of them gave trouble from general dampness, other than what could be traced to such local causes as leaks, stoppage of drains, &c. This was notably the case with those of the most massive construction, and which were deeply buried in the earth, and it is to them that what follows chiefly applies; those built on the surface, and with slated roofs, exhibited much the same phenomena, but not on a scale to cause very much practical inconvenience; at least, they had been in use for the storage of powder for a good many years past. During the winter months the magazines were generally very dry, and if any moisture appeared it was readily removed by throwing open the doors and ventilators and establishing a draught; the interior was at this time warmer than the outside air; towards spring, as the weather became milder, traces of damp gradually appeared, and by the time that the interior of the building had become sensibly colder than the outside air, it was also decidedly damp; the walls, floor, and ceiling being moist to the touch, heavy dew forming on all non-absorbent surfaces, such as metal, stone, and painted wood; and the more it was ventilated the worse matters became. The iron roofed magazine, before mentioned, was a very strongly marked instance. The amount of dew deposited on its iron ceiling on hot days was enormous, so that the moisture sometimes dropped on the floor. This state of affairs continued through the summer, the dampness becoming more decided as the weather grew hotter, but as soon as the heat moderated it began to disappear, and by the time that the interior was sensibly warmer than the outside air it was perfectly dry again. As before mentioned, this applied chiefly to those magazines buried in the earth; those on the surface were much less affected, having merely a slight tendency to be damp in the early part of summer, and being, on the whole, driest in the beginning of winter. The construction of the magazines most affected was quite recent and the details all perfectly well known, but there was nothing in them to suggest any kind of leakage as the cause; moreover, they were all dampest at the season when least, and driest at the season when most rain fell; and the dampness affecting them was of a general character, and not local as that arising from leakage would be. It seemed, therefore, to be attributable almost, if not altogether, entirely to condensation, and on this supposition the explanation was simple enough. As long as the interior of the magazine was warmer than the external air, the latter on entering it had its temperature raised above the dew point, making it dry even in wet weather, and enabling it to carry off any existing moisture; when, on the other hand, the external air was warmer than the interior of the magazine, its temperature on entering was brought down below the dew point (unless the day was exceptionally dry and the difference of temperature small), making it damp and causing a deposit of moisture even in dry weather; of course, the more air passed through, the more moisture would be deposited, and these effects would respectively continue until the inside and outside temperatures became equalized. The less result in the case of magazines built on the surface would be due to the much readier equalization of the inside and outside temperatures, owing to the smaller mass of the walls and roof and the absence of the earthen covering.

Supposing the above hypothesis to be correct, it appeared that the deposit of moisture might be readily controlled by means of the ventilation; the proper course being to dry the interior thoroughly by ventilating it well during the winter, to shut up in it a supply of cold dry air at the end of that season, and to keep it as nearly as possible hermetically closed till the hottest part of summer had passed, and till the body of the walls and covering had been warmed from without. If this were successfully accomplished, no moisture could be deposited during the hot weather, because, the air enclosed in winter being dry at the then low temperature, could only become drier as the temperature rose, unless moisture were supplied to it from without. The interior might, of course, be safely thrown open as soon as the mass of the walls and covering were sufficiently warmed from without, and this process would be much facilitated in the case of magazines having detached linings, by keeping up a circulation of the warm outer air in the space behind them and in any flues or passages in the thickness of the walls, taking care, however, that such summer ventilation did not extend to the interior of the magazine proper: such spaces and passages should, on the other hand, be kept closed and the circulation of air in them effectually stopped whilst the interior was being ventilated during cold weather, so as to prevent the body of the walls being unnecessarily cooled. The experiments detailed in the annexed report were undertaken to test the accuracy of the foregoing theory, and the results obtained seem to bear it out in all particulars.

Halifax, N.S., 29th January, 1867.

SIR,—With reference to the experiments on the ventilation of powder magazines, which I was directed to carry out some time since, I have the honour to inform you that I took over the Main Magazine at Fort Ogilvie from the Military Store Department, on the 9th of January for the purpose of experimenting.

Its general form is shown in the annexed sketch. The walls are of concrete, the magazine proper, having a half-brick lining, with air space behind, and the passage showing the concrete; the roof is an arched one, also of concrete, that to the magazine proper having a solid half-brick lining, with headers laid Flemish bond to tie it into the concrete. The vertical outside surfaces are rendered with cement, and the roof is covered with two thicknesses of asphalte.

The whole building is buried in the earth, and has an average depth of five or six feet on the roof; the floors are of wood, supported on joists and plates in the usual manner; the drainage appears to be in good order, and there are no leaks visible; there are skids fitted in it, which will accommodate about 300 barrels.

The openings provided for ventilation are as follows, viz.; an upcast outlet shaft, from the interior of the magazine opening through the end wall opposite the inner door, and close under the soffit of the arch; the inner opening, 9 in. by 9 in. is closed with a perforated zinc plate, and the shaft does not communicate with the space behind the brick lining; its position is marked *a* on the sketch. Two inlets 6 in. by 6 in. opening from the passage to the interior of the magazine through the inner wall, one on each side of the inner door, and about level with its lintel: their outer ends are covered with perforated zinc, and they are marked *b b* on the sketch.* Four openings from the air space behind the brick lining into the passage; they are about 6 in. by 2 in., placed in pairs vertically over one another in the positions *c c* (see sketch), and covered with perforated zinc; two inlets, 6 in. by 3 in. round the jambs of the external doorways in the positions *d d* covered with perforated zinc the same as the remainder.

I saw this magazine several times during last season, when it was being aired by opening the doors in the hot weather in the usual manner; it was then decidedly damp. On taking it over from the Military Store Department in cold frosty weather, I found the doors shut, and was informed that they were only opened on warm days. The interior was very sensibly warm and decidedly damp,† particularly the *insides* of the doors which were covered with a heavy dew; owing no doubt to condensation from the air which had been admitted in warm weather and cooled below its dew point from without.

On taking it over, I first caused the openings *c c* communicating with the space behind the lining to be securely stopped up, and gave orders for the doors to be opened every cold dry day and shut in warm weather. Under this plan the interior soon dried, and when I examined it two days since there was no condensation on the doors. At the same time the space behind the lining being kept hermetically sealed would prevent the walls from being cooled to any great depth.

Arrangements have been made for making the inner door shut air-tight;‡ and instructions (a copy of which is enclosed) for airing and closing the magazine, have been given to the non-commissioned officer in charge. It will be seen that direct ventilation of the interior, as at present, is to be continued until the winter may be considered almost over, at which time the interior of the maga-

* There was no communication whatever between the air space and interior except indirectly through the passage and door-way.—W.I.

† In this case a reverse of the proper rule for winter ventilation (viz., opening on cold and shutting on warm days), had succeeded in rendering the magazine damp in winter, an unusual circumstance.—W. I.

‡ By means of a strip of vulcanized india rubber, fastened round the edge of the door, and pinched tightly into the joint, when the door closed.—W. I.

zine proper (as distinguished from the passage) will be shut up air tight, and the communications (from the passage) with the space behind the lining re-opened; the intention being to enclose a dry atmosphere at a low temperature in the inside of the magazine, and to keep it there unchanged whilst it is warmed from without; the free admission of the air to the space behind the lining on warm days is intended to hasten this warming, and to effect it, it is necessary to open the outer doors and omit the passage from the closing up in March. This, however, signifies the less, as it is not brick lined, and it would be very difficult to do so effectually on account of the draught between the doors.

Should the measures adopted be successful, it is expected that on opening the magazine in June (at which season all the magazines of similar construction, i.e., masonry vaults buried in the earth, which I have seen at this station are more or less damp) the interior will be found dry, but will become damp after a day or two's exposure; the outer passage will probably present the usual appearance of dampness at the commencement of the hot weather (decided dampness in the passage would be a good means of fixing the time for examining the interior), but may recover from it more quickly than more deeply seated structures, in consequence of the temperature of the walls being more readily raised.

I have, &c.,
W. INNES, Lieut., R.E.

Captain E. O. Hewett, R.E.,
Executive Officer.

Halifax, N.S., 28th January, 1867.

MEMORANDUM.

1. The magazine at Fort Ogilvie will be aired by opening the whole of the doors on every cold dry* day during the month of February, and in the beginning of March.

2. In the middle of March, the three† ventilators now open (viz. one on each side of the inner door, and one at the innermost end) are to be fastened up air-tight, and the inner door locked and sealed, the date being marked on the strip of paper used for sealing, also the state of the weather. As it is important to close on a favourable day, it will be best to fasten up the ventilators on the first dry frosty day after the 10th of March, keeping the doors open whilst this is being done, and shutting up for good in the evening.

3. The four‡ ventilators stopped up some time since to be re-opened when the others are closed, and the two outer doors to be kept open every warm day (whether moist or dry) during the remainder of the spring and summer.

W. INNES, Lieut., R.E.

The N.C.O. in Charge of Works,
Point Pleasant.

* Every cold day would have been better, omitting the word dry.—W. I.

† *b*, *b*, and *a*, see sketch.

‡ *c*, *c*, see sketch.

Progress and result of the Experiment as observed by Captain E. O. Hewett, R.E., Lieut. Innes, R.E., having quitted Halifax in February.

Interior of magazine and ventilators *b b* and *a*, closed and sealed on 9th March, the weather at the time being dry and cold. The interior of the magazine perfectly dry at the time of closing. Ventilators *c*, *c*, opened on same day.

Interior of magazine opened and examined on 22nd May, the weather being warm and clear. Interior of magazine perfectly dry and contained air sensibly cold. No appearance of condensation on painted wood or metal.

Magazine again opened (having been re-closed after former examination,) on 19th June, the weather being warm, with fog and occasional rain. Passage very wet, interior dry and cold.

The experiment being so far satisfactory, orders were given on the 21st of June to reverse the system, and return to the old plan by unsealing the ventilation to the interior, and following the old regulations* for airing.

The magazine was again inspected on the 27th July, when the interior was found to be very perceptibly damp, and the air slightly warm.

The magazine at Cambridge Battery, which is similar to that at Fort Ogilvie in general character, and the ventilation of which had been carried on according to regulation, was at this date (27th July) so damp as to be altogether unfit for the storage of powder.

The Main Magazine, Fort Charlotte, (a large vaulted bombproof deeply buried in the earth with hollow linings, &c., as at Ogilvie, and having a number of smaller rooms and long passages connected with it) the interior of which had been opened, as nearly as circumstances would allow, only on the principle advanced, was on the 26th July perfectly dry; whilst the numerous passages and minor chambers surrounding it, which had unavoidably been frequently opened for work, &c., were damp almost in direct proportion to their proximity to the outer doors (except quite close to the outside, where the walls had become heated). It is presumed that this is due to the air having been cooled and having parted with its moisture as it passed along the cold passages, and gradually became assimilated in temperature to that of the surrounding walls.

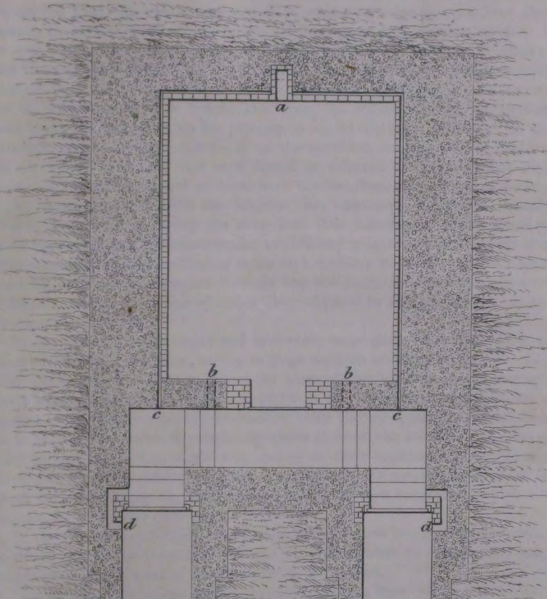
Regard being had to the foregoing, the following points are suggested for consideration in future magazine construction and management.

Sufficient inlets and outlets to establish a thorough ventilation of all parts of the building, should be provided as at present; but they should be arranged in two separate systems, the one for the interior; the other for the space behind the lining, and any flues and passages in the thickness of the walls. There should be no communication whatever between these two, and their ventilation should be so arranged and marked that the one may be readily distinguished from the other.

* "To be opened on every fine day" . . . "To be aired daily, Sundays and wet days excepted." (Vide printed orders for Military Store Department and Royal Artillery.) The above are always understood to apply to all ventilators about a magazine, whether connected with the interior or air spaces; and the doors are also usually opened.

SKETCH OF POWDER MAGAZINE
FORT OGILVIE HALIFAX N.S.

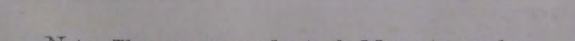
Showing arrangements for Ventilation.



PLAN

Note–*There was no powder in the Magazine at the time of the Experiment.*

Scale of 10 feet to an Inch.



Lithographed at the Royal Artillery Institution.

All ventilation openings should be provided with accessible and close fitting covers or dampers, marked to show to which system they belong, and capable of being closed air-tight or nearly so; the doors should also fit close.

In the case of thick abutment walls the construction with a passage in the centre thickness, (which would communicate with the space behind the lining, but *not* with the interior) would of course be preferable.

The ventilators and doors opening into the interior of the magazine, should be opened freely in winter, and closed in summer; those opening into the air spaces, &c., in the walls should be opened in summer and closed in winter. The proper periods for changing the ventilation would be ascertained by observing the times in spring and autumn at which the temperature outside begins to rise above or fall below that of the interior, and arranging so as to close one set of ventilators a little before, and open the others a little after, particular care being taken to shut up the interior on a cold dry day. The summer ventilation should be opened most freely on the warmest, and the winter ventilation on the coldest days, and this rule should be adhered to without much regard being had to the dampness or dryness of the weather, unless very extreme.

All communication with the interior, not absolutely necessary, should, of course, be suspended during the close time (the duration of which would vary with the season and the construction of different magazines) in the beginning of summer; any needful visit being made on a cool day with the wind in a quarter least liable to create draughts through the building, the doors being opened as little as possible, and trays of quick lime exposed to dry what fresh air is unavoidably admitted.

In the case of large depôt and and store magazines, where the long close time might be an objection, owing to large receipts or issues of powder falling due, the remedy would be to warm the mass of the building in the spring and early summer by some artificial means (such as the admission of hot air, or a system of hot water pipes in connection with the air spaces, passages, &c.), so as to keep its temperature constantly above that of the outside air. The ordinary service magazines would not, owing to their smaller mass, require to be kept closed so long; and powder for a month or two's use, might be taken from them before shutting up, and placed in the expense magazines, which would require a still shorter close time.

To ensure the ventilation of magazines when in use being properly managed, it would be well to furnish the Corps or Department to whom they may be handed over, with a set of instructions on the subject.

The above observations and deductions, having been made in America, are only applicable in their full force to a somewhat extreme climate; but the same train of phenomena will, it is believed, be found in buildings of the ordinary bomb-proof construction wherever there is any range of temperature to speak of; although, in a climate like that of England, the result would be much less marked, and the evil might, perhaps, be remedied in some easier way.

W. I.

Isle of Grain, 6th July, 1867.

PAPER VIII.

ON THE PRESERVATION OF EXPOSED COASTS.

BY CAPT. G. BERKELEY, R.E.

The erosive action of the sea throughout the south and east coasts of England, which has been described in detail by Sir Charles Lyell, Sir Henry de la Beche, and other geologists, has also formed the subject of numerous articles in the Corps Papers, among which may be specified one by Sir William Reid in the quarto series (Paper XIII., Vol. II. of 1838), especially interesting to the Corps, as treating of the line of Devonshire, Dorsetshire, and Hampshire, along which so many important works of defence have been constructed.

The shingle and sand which are continually being removed from this coast, travel in a general direction from west to east under the influence of the prevailing winds and the highest seas; but every southerly storm, from whatever quarter, carries, on and near the surface of its waves, masses of detritus, which are thrown upon the shore, and eventually removed by erosion, as well as a part of the pre-existing land; unless there be some means of retention, either natural or artificial.

Nobody who has watched a point which is subjected to the full force of the sea, can doubt the inefficacy of groynes in such a situation. Their chief faults appear to be that they are sloping and too low. Starting from about high water mark they follow nearly the slope of the coast to low water; and it is evidently intended that a succession with this profile shall between them arrest most of the shingle or sand which passes in either direction. This object is generally fulfilled in a long line of coast where the action is, cæteris paribus, not very violent; but in an exposed situation, the contents of the waves in a high wind are carried over all their tops, they are left bare, and are destroyed in time by the force of the elements. They manage to retain a certain amount in light breezes, but it is usually swept away by the gales of winter and the equinoxes, as they afford it but little protection.

Attention has often been drawn to the cases in which the shingle is permanently arrested in its progress, both by natural and artificial means. The Chesil Bank leading to the island of Portland, and the spit between Hurst Castle and the main land, are exposed to the full force of the sea, and have increased slowly although they suffer from erosion, and the accumulation is retarded by their being pervious. The piers also of many of the south coast harbours have collected much shingle and sand on their windward sides, which in time turn round their heads, and form in the same manner to leeward.

When a work has been built on a projecting point, it is usually protected in front by a stone facing or vertical wall. This is supplemented by groynes, which prove of little avail, although they are kept in continual repair at great expense, and added to in every direction. In time the continual scour of the sea searches out the foundations of the wall, and they have to be brought to a lower level. This is repeated again and again, until, as in some instances, low water mark is almost reached before they can be pronounced safe. It would seem advisable, before entering on these expensive processes, to try the effect of a pier, either of stone or of stout timber construction, to be placed at one or at most two points; its top level, to be a few feet above high water spring tides; its direction nearly perpendicular to that of the prevalent winds from the side of the point opposite to the one on which it shall be built. This cannot but be successful, in a proper position; and if successful, it will add so much land to the position, that the work will be rendered secure from encroachment, and there will be no necessity for any other construction.

The position and number (whether one or two) of these lines must be determined by local circumstances; their direction and height above high water, by experience. The actions of the sea, even along different parts of the same coast, are most various. The situation of the Isle of Wight, far from shielding the adjacent coast of England, intensifies the scouring action of the prevailing winds from the south-west, and affords a clear channel along Spithead roads to those from the south-east. At any headland therefore, in the neighbourhood of Portsmouth or Southampton, it would seem best to erect two piers, one for each prevailing wind, nearly perpendicular to its general direction, but forming an oblique angle on the shore side, to induce the shingle to turn landward. At most places one would suffice, and it should be placed near the point, but a little to the side opposite to the prevailing winds, in an exposed position, where it would have the best chance of meeting all the shingle thrown on to the coast. As an experimental commencement, the line should extend nearly to the average low water mark, which, in an ordinary coast would make it about 80 feet long. I would suggest that the construction for this length be a double row of unhewn piles, 10 inches to 15 inches scantling, and the central intervals of successive pairs diminishing from 6 feet to 3 feet. Between the piles should be a continuous line of vertical fascines about 2 feet broad, which I should adopt for the body of the work in preference to planking, as they do not offer the same passive resistance to the water, although retaining the shingle and sand. The whole to be fixed in its position by a double row of strong waling on each side, brace piles being provided, one to every second pair of vertical piles; and everything to be fastened with iron bolts, tie rods being supplied where necessary. I have a plan and estimate at hand, but will not intrude further details of so simple a scheme. I need merely observe, that the very ordinary precautions of providing all iron bolts with felt washers, and of vulcanizing them if possible, should be taken. It seems odd that these provisions should hardly ever be made, when the destructive effect of rusty iron on wood is so well known. The approximate cost of this length could not exceed £225; but the after expense, as it proceeded, would of course be much greater. It would probably be cheaper in an abruptly sloping coast, as less would be required. It is a matter of consideration as to whether an altogether different plan might not be adopted below low water. Any how this plan, although dearer than *one* groyne, would be nothing in expense, to a system of them, without considering that a sea-wall would be probably unnecessary in the event of its success. As regards height, I should be disposed to have the top about 2 feet above high water spring tides, which would be enough to arrest all the shingle that passes, except in very boisterous weather, and would be ample to prevent any chance of that scour on the opposite side, which is so common with groynes after a gale. Experience will, however, be the guide in this respect.

A stone pier of course would be the best. The one herein-mentioned has merely been proposed for its comparative cheapness. The tremendous force exerted in many places by the open sea on anything that offers it a dead resistance, would necessitate a stone pier being of a substantial form; and I should think it would be at least three times as expensive as the other.

The idea of adopting a horizontal line above high water, instead of a sloping one below it, occurred to me, as it no doubt has to many others before me, on first seeing a complicated system of groynes at an exposed point where the sea had begun to encroach upon the ditch of a large work. A letter in the "Brighton Examiner" about two months ago, on a similar subject, induced me to consider the matter further. Probably the principle will be found in execution to be a just one.

G. B.

30th Sept., 1867.

PAPER IX.

NOTES ON MILITARY AND CONVICT LABOUR.

BY CAPTAIN PERCY SMITH, R.E.

The question of the comparative value of different kinds of labour at the disposal of the Government is one, at all times, containing much to interest the Engineer Officer, and is becoming daily more and more important.

The influence of trades unions in preventing men from working hard, and in raising the market rates of wages, makes it more than ever an advantage to control bodies of men who can be made to do a fair day's work at reasonable rates of pay, and who have no interest in "scamping" for their employers.

The two great sources of labour at the disposal of the Government are the army and the convict establishments. These bodies contain large numbers of men available for employment, a proportion of whom possess the necessary strength and skill for carrying out the most laborious and intricate works.

These men moreover can be employed, without injustice, at rates of wages far below those paid to civilians, and it is the object of this paper to ascertain how far their employment is really profitable.

It is of course not intended to advocate any Government interference with the labour market; but merely to show how far the Government may profit in carrying out military or other public works by means of the cheap labour at its disposal.

The idea that from the employment of military labour great saving must accrue to the public, is one that has long been prominently set forth by many officers.

It has had the distinguished support of the Inspector General of Engineers, in a paper by him on the importance of an efficient Engineer Department, from which the writer has had Sir John Burgoyne's kind permission to quote a few remarks, in order to give value to some of the statements made hereafter.

Colonel Millington Synge, R.E., also warmly advocated the execution of military works by military means, in a lecture delivered before the Royal United Service Institution, on the 18th April, 1866.

The employment of convicts has been recommended by General Wilson (Corps Papers, Vol. IV., O.S.), and some valuable hints upon working both soldiers and convicts have been given by Lieutenant Colonel Wray, in Vol. VII., Corps Papers, N.S.

In these notes it is not therefore proposed to bring forward any new idea, but simply to apply the information and data obtained from actual experience of the value of the labour of soldiers and convicts on large works; to illustrate, work out in more detail, and prove the correctness of general ideas which have long been adopted and promulgated by distinguished authorities.

These ideas having been hitherto unsupported by any recorded facts have been shelved for want of the necessary investigation; and the question of the economy of military and convict labour is generally dismissed with a vague statement to the effect that though the men are paid much less for their labour, yet that they are idle, unskilful, work short hours, use more plant, require more supervision, and that in the end the works are more expensive than if done by contract. In some instances it may be so; but the writer hopes in these notes to show that such a result is not at all necessary, nor in most cases even probable.

It should be stated that the data given with regard to military labour, have been obtained from careful measurements taken during the erection of the Nothe Fort, at Weymouth, by soldiers.

The particulars of convict labour are taken from memoranda relating to work done by convicts at Portland.

It is hardly necessary to remark that the figures must be taken only as approximations. The circumstances connected with work vary so much, that it would be perfectly impossible that the results obtained at one place would be exactly repeated at another.

In order to arrive at the probable saving that may be expected by employing military or convict labour on any particular work, it will be necessary to ascertain the following particulars :—

1. The amount of work done by a soldier or by a convict as compared with a civilian, bearing in mind that the soldier works fewer days in the week (being at drill on Saturdays), and that both soldier and convict work during shorter hours than the civilian.

2. The cost to the works per diem of the soldier or convict, as compared with the civilian.

3. The cost per unit of the work done by the soldier or convict as compared with the civilian.

4. The influence upon the total expenditure in different kinds of work caused by the soldier or convict working at cheaper rates, but in some cases taking longer about their work than civilians.

The consideration of the above will show the value of military and convict labour as compared with that of civilians, and the saving to be expected in any particular kind of work by the employment of such labour; but it will be interesting further to ascertain :

7. The cost and value of piece-work as compared with day-work.

8. The cost to the country of a soldier (regimentally), and of a convict for his keep—that is, the necessary expense incurred by the country for each soldier and for each convict, whether employed on the works or not.

9. The amount repaid to the country by a soldier and also that by a convict during each day he is employed upon the works.

10. The comparative cost to the country of a company of Royal Engineers employed on the works, and of a company of the Line, which, as a rule, cannot be so employed.

For the sake of distinctness these questions are considered separately in the appendices. The results alone are given in the body of the paper, so that any one doubting the accuracy of statements made, or of figures given, may, by referring to the appendix relating to the particular point, ascertain how they were arrived at.

It is hoped that a consideration of the appendices will show that the following results have been obtained:—

Appendix 1, page 93.

(1.) An average soldier in a working party, such as that shown at p. 95, does in his working day of 9 hours, about $\frac{2}{3}$, and a convict in his working day of 7 hours, about $\frac{1}{3}$ of what a civilian does in his working day of $9\frac{1}{2}$ hours.

Appendix 1, page 93.

(2.) In carrying out works, a party of soldiers working only 5 days a week would take about $1\frac{4}{5}$ times as long, and a party of convicts (working 6 days a week) about 3 times as long as a similar party of civilians, working 6 days a week.

Before attempting to ascertain the cost of a unit of work done by either soldier or convict, it is necessary to determine what cost is fairly chargeable to the works for either soldier or convict during each day that he is employed.

It is evident that it is not fair to charge to the works either the regimental pay and cost of the soldier or the expense of maintaining the convict.

The establishment of soldiers and of convicts which it is found necessary to maintain, is limited, not by the numbers required for the works, but by other considerations; and the expense necessary to keep up these establishments must fall upon the country whether the men are employed upon works or not, though it may be a question of interest, to be discussed further on, how much of this expenditure is repaid to the country by judicious employment of the men upon works.

Appendix 1B, page 95.

The only cost to the works for a soldier is his working pay, viz., on an average 1s. 7d. a day.

There is no cost whatever really chargeable to the works for a convict, that is, the department employing him has nothing to pay for him, but there is a certain extra expense which falls upon the country when he is employed upon works, in consequence of the extra supervision required when he is out and away from the prison.

Appendix 2, page 96.

The cost of this extra supervision is assumed, upon the data given in appendix 2, to be 6d. per diem.

Appendix 3, page 97.

(3.) Combining this information with that before arrived at, we find (see appendix 3) that taking working pay only into consideration, the cost per unit of work done by the soldier is on an average $\frac{1}{2}$, and of that done by the convict is (for extra supervision only) $\frac{1}{3}$ of that done by the civilian.

In order to ascertain the effect upon the expenditure on different kinds of work caused by employing military or convict labour, there are two or three points we must take into consideration.

The total value of a work carried out by contract is made up of the following items, viz. :—

Labour
Materials
Plant
Superintendence
Loss of interest upon locked up capital (called here "idle money").
Profit to the Contractor.

Of these the expenditure on materials will be the same whatever be the labour employed.

Appendix 3. page 97.

The labour will vary in cost according to the means used. Thus we know that soldiers' labour will cost $\frac{1}{2}$, and convicts' $\frac{1}{3}$ of what would be paid for civilians' in England.

The amount of plant used will probably be the same whatever be the labour employed, but its cost for deterioration will vary according to the time it is kept in use, and we know that the soldier will keep it $1\frac{4}{5}$ times, and the convict 3 times as long as the civilian.*

Appendix 1, page 93.

The superintendence may be taken as the same in each case;† the extra supervision, that is, for discipline, being already charged to the convict as his cost for labour. (With regard to the loss of interest on locked up capital, the contractor would borrow the money at 5 per cent., whereas the Government would pay only 3 per cent.; but then the latter when employing soldiers would keep the capital locked up $1\frac{4}{5}$ times as long, and with convicts 3 times as long as the contractor would with civilians. The loss of interest sustained by the Government in employing soldiers or convicts as compared with that by a contractor employing civilians, would therefore be as follows :—

With soldiers $1\frac{4}{5} \times \frac{3}{5} = \frac{27}{25}$ of amount lost by contractor on similar work.
With convicts $3 \times \frac{3}{5} =$ ditto

If, therefore, we ascertain the proportions of expenditure on different items in a work executed by civilians, we can, by applying the corrections given above, ascertain how these proportions would be modified when military or convict labour is employed.

* It may be said that convicts would not keep the plant three times as long in an actual state of wear and tear as civilians; for although they use it on 3 times the number of days, yet they work for fewer hours each day; but this is amply made up by their using the plant more roughly; therefore to charge them for plant in proportion to the number of days they use it, is not unfair.

† In contract works the War Department has to provide its own superintendence as well as the 5 per cent. provided by the contractor; but in works executed by military or convict labour it has been found that 5 per cent. beyond the superintendence that would be provided on a contract work, amply suffices for the superintendence required.

The following were the actual proportions of expenditure and profit in the erection of some casemates by contract at Portland:—

	Per cent.
Materials (purchased)	46
Labour—Civilian	31
Superintendence (besides that furnished by W.D.)	5
Plant	3
Idle money, that is loss of interest on locked up capital	2
Profit to Contractor	13
	100

Applying the data above to ascertain the probable expenditure if the work had been carried out by military labour, we have*:—

	Per cent.
Materials (the same)	46
Labour, $\frac{1}{2}$ the cost	$15\frac{1}{2}$
Superintendence	5
Plant (same quantity, but deteriorating $1\frac{4}{5}$ times as long, $3 \times 1\frac{4}{5} = 5\frac{1}{2}$ nearly)	$5\frac{1}{2}$
Idle money (the same amount idle $1\frac{4}{5}$ times as long and paying only 3 per cent. $2 \times 1\frac{4}{5} \times \frac{3}{5}) =$	$2\frac{1}{4}$
Profit (the remainder)	$25\frac{3}{4}$
	100

In reality, however, the idle money is no loss to the Department employing

* The actual proportions of expenditure on £33,000 worth of work done by soldiers at the Nothe Fort, were as follows:—

Materials	43·20
Labour	17·13
Superintendence	3·11
Plant	6·51
Profit	30·05
	100·00

These proportions differ slightly from those arrived at by the analysis above, which was got out quite independently. The plant is here a little in excess, as it was bought from the former contractor, who had for his large working party a greater quantity than was required for the smaller military working party employed. The materials cost a little less than the proportion given above, as the War Department had some slight advantage in purchasing them. The amount charged for superintendence included all officers and non-commissioned officers who would not have been required to superintend the work if it had been done by contract. The non-commissioned officers in charge of parties are included in labour.

the soldier, as, if not in use, it would not be fructifying for its benefit. The actual profit to the department would therefore be $(25\frac{3}{4} + 2\frac{1}{4}) = 28$ per cent.*

Again if the same work had been done by convicts, we find by applying the information we have obtained that the cost would have been as follows :—

	Per cent.
Materials (the same)	46
Labour $\frac{1}{3}$ the cost	10
Superintendence	5
Plant (the same quantity, but deteriorating 3 times as long. $3 \times 3 = 9$ per cent.)	9
Idle money (the same capital, idle 3 times as long and paying only 3 per cent. $2 \times 3 \times \frac{3}{5}$)	$3\frac{3}{5}$
Profit (the remainder)	$26\frac{2}{5}$
	100

In this case again, the idle money is no loss to the Department employing the convicts, which moreover does not pay the 10 per cent. for extra superintendence. The real profit accruing to the Department is, therefore, $(26\frac{2}{5} + 3\frac{3}{5} + 10) = 40$ per cent.

We see, therefore, in this particular instance of a casemated fort, that whereas by contract the Department would have to pay the full value of the work, by employing military labour a profit would result amounting to 28 per cent., and by convict labour a profit of 40 per cent.

This profit is in each case made up of two parts, firstly, the ordinary contractor's profit, which, instead of going into his pocket is retained by the Department ; secondly, the difference in the cost of labour—the soldier costing only $\frac{1}{2}$, and the convict $\frac{1}{3}$ of what would be paid for their work if done by the civilian.

This is not at all a favourable case for shewing the full saving that may be realized by employing soldiers or convicts. In the first place the contractor's profits are assumed to be very small, only 13 per cent, instead of from 20 to 30 per cent., which would often be realized by him.

Moreover, in the kind of work taken as an example, the works are thick and the building generally massive, so that the labour required is less in proportion to the total value of the work than in ordinary buildings with thinner walls, in which latter the labour by civilians would probably be from 35 to 40 per cent. on the total outlay.

If the contractor's profit were taken at from 20 to 30 per cent., and the labour at from 35 to 40 per cent., it will be easily seen that the profit to be shewn from employing military or convict labour, would be very materially increased.

It has been thought better, however, to be on the safe side for fear of coming to exaggerated conclusions, and to take as a comparison a work at rates out of which a contractor could get only 13 per cent. profit, and in which there is a proportion of labour below the average.

*In making a distinction between the saving to the Department and the saving to the country, it is not intended to advocate the former at the expense of the latter, but only to shew that the departmental estimates are affected to a greater extent than the actual saving to the country.

It is evident that as the labour is the only item on which a saving can be effected, the more of it that can be introduced, the greater the saving will be. The proportions given above are for a Fort, the bricks and stone for which are purchased; but if the bricks are made, and the stone quarried by the cheaper labour, the profits of the brickmaker and the quarryman are added to those of the builder, and the resulting profit is, for military labour $38\frac{1}{2}$ per cent., and for convicts 54 per cent.

In appendix 4A, a few different descriptions of work have been analysed, so as to show the probable proportions of expenditure on each of the items given above; it will be seen that the proportion to be expended on labour varies materially. In brickwork, for example, where the material is of great comparative value, the labour is only 18 per cent, whereas in earth work where the material is valueless, the labour amounts to as much as 66 per cent. of the total value of the work.

In colonies where labour sometimes costs two or three times as much as in England, the profit resulting from the employment of cheaper labour will of course be greatly increased. The instance of the Casemated Fort has been taken in appendix 4A to illustrate this, from which it will be seen that where convict labour can be substituted, the contract based on civilian labour costing three times what it does in England, the work can be done for about $\frac{1}{3}$ of the cost.

In new countries it may often be a question whether it is worth while to build a prison in order to make use of the cheaper labour of convicts. This would be settled by ascertaining the cost of the prison, taking into account capital expended and interest thereon, deterioration, repairs, &c.; this amount divided by the estimated daily saving caused by the employment of the party of convicts after deducting cost of extra warders, &c., will give the number of days that would elapse before the cost of the prison is cleared. If there was work more than sufficient to occupy the party for this number of days, it would pay to build the prison; but if there was not so much to be done, it would, of course, result in a loss.

It is plain that in employing soldiers and convicts, but especially with the latter, the retention of the plant in use for so long a time is the great source of reduction of the profit derived from their cheaper labour, and it is therefore advisable to reduce the plant to the smallest possible quantity.

For instance, 20 convicts building a wall with the assistance of sheer legs and two or three ropes must build it more cheaply than civilians, as they use the same materials, their labour costs nothing, and the plant next to nothing. The cost would be:

	£	s.	d.
20 Men, 3 days each at 6d. (for extra supervision only)	1	10	0
Deterioration of sheer legs, &c., at 6d. per diem	0	1	6
	£1	10	6

Whereas if the same 20 men were building with the aid of a very expensive and elaborate gantry, deteriorating at the rate of £5 a day and taking three times as long about the work as civilians, they would cost more than the latter. The cost in this case would be:

	£	s.	d.
20 Convicts, three days at 6d.	1	10	0
Deterioration of plant, 3 days at £5	15	0	0
	£16	10	0

Whereas the cost by civilians who would keep the plant deteriorating only ⅓ of the time (appendix 1), would be—

	£	s.	d.
20 Civilians, 1 day at, say, 4s............	4	0	0
Deterioration of plant, 1 day at £5	5	0	0
	£9	0	0

or not much more than one half the cost of the convicts.

This is, of course, an extreme case*, as it is seldom that so few men would be using plant of such value, but it illustrates the point, and shows that the amount of plant which convicts are allowed to use should be as small as possible.

When from the nature of the work elaborate and extensive plant is absolutely necessary, it is very questionable, and becomes a matter for calculation whether the cheaper but slower labour would be any source of saving in the end.

With regard to the cost and value of piece-work as compared with day-work, it will be seen by appendix 11 that the quantity done by a soldier on piece-work is as a rule double what he does on day-work, and the cost per unit about the same. The piece-work is, however, much cheaper in the end, as by shortening the time the work takes, it lessens all attendant expenses, such as deterioration of plant, idle money, &c.

There is little doubt that a soldier should be employed on piece-work as much as possible; its advantages have been stated by Lieutenant Colonel Wray as follows:—" The work is done better and more cheaply—superintendence in detail is saved—the men improve faster in their trades—the punishment of reduction is heavier and more certain in its application, and the pecuniary condition of the soldier is improved, by which a superior class of recruit is obtained, and desertion rendered less frequent."

The only objection raised to piece-work is the danger of "scamping." With proper superintendence, this danger is, however, very small; if a man caught doing bad work is made to pull down and do over again all that he has done during the previous twenty-four hours, he will be very careful in future. By a properly arranged labour-schedule, nearly all the men on a building might be employed by the piece.

* It is, however, possible, *e.g.* in the case of men building a small fort at the end of a breakwater or out at sea, employing heavy staging, a steamer, barges, &c.

Such a schedule would have other advantages; at present it is optional with a soldier to accept or refuse the rates offered him as payment for piece-work, and frequently, either from ignorance or in the hope of getting a higher price, he declines to accept the rate, and the work is delayed in consequence; the rates given in an approved labour schedule (under interpretation of the officer in charge) might be compulsory.

The labourers carrying mortar, &c., can hardly be worked by the piece, but if the builder, upon whom they attend is on piece-work, he will always, by promising them beer, &c., manage to get a good day's work out of them.

Appendix 11, page 109.

It will be seen that in many cases the convict mechanic does nearly, if not quite, as much as the soldier in 10 hours. This can be accounted for by the fact that the convict is interested in his old trade, and is liable to be turned out to hard manual labour if he does not give satisfaction; whereas there is really very little hold upon a soldier on day-work: his pay may be checked, but he has no fear of dismissal or of degradation to labourer's work.

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With respect to hard manual labour, however, the amount done by the soldier far exceeds that done by the convict. The soldier is stimulated by piece-work to great exertions; and, on the contrary the convict does just as little as he can without being reported. It is probable that some system by which the convict could be credited with some small amount depending upon the quantity of work he does per diem would be productive of very greatly increased exertions on his part, and would be amply repaid by him. In a few instances given by Major General Nelson, convicts employed on piece-work at Bermuda, did from 3 to 5 times as much as when employed on day-work.

We see by appendix 5, that the whole regimental cost of a soldier to the country including enlistment, training, regimental pay of all ranks, clothing, rations, re-engaging, lodging, cooking, good conduct pay, chance of pension, &c., is, for a sapper, 2s. 10d. per diem; for a line soldier, 2s. 4½d., per diem; or for an average soldier in a working party of 65 Royal Engineers and 60 Line, about 2s. 7d. per diem.

We also see by appendix 7, that if such a working party were employed upon a casemated fort, a profit would result as compared with contract rates (so low as to pay the contractor only 13 per cent. on the total value of the work) amounting to 2s. 8d. per man per diem.

That is, each soldier in such a party would, by working at less than the market value of his labour and by enabling the country to adopt a system which retains the contractor's profit instead of paying it away, clear each day he is employed on the works, his whole regimental cost to the country, with 1d. per diem to spare.

Appendix 10, also shows that the employment of convicts on a similar casemated fort results in a saving to the country, as compared with the contract prices, of 1s. 5½d. per diem, or nearly their whole cost to the country, which is about 1s. 8d. per diem. (See app. 9.)

In both cases the saving upon each man per diem would be greater if compared with contract works paying more than 13 per cent. to the contractor, or in which the proportion of labour was greater as compared with the total value of the work, and especially so in countries where the market value of labour is greater than it is in England.

It may, be said however, that even if the figures given are admitted, they prove nothing, as the value of work depends upon its quality. Many officers who may take the trouble to read these notes have doubtless had more opportunities of seeing military and convict work than has the writer, whose experience is derived chiefly from the fortifications in the Portland district, from measurements and notes upon which the data furnished in this paper have been taken. On these works, he is, perhaps, not in a position to give an unbiassed opinion, but still it may be stated with regard to the Nothe Fort (built by soldiers) that the opinion of many impartial judges, inspecting officers, &c., has been that the work is quite equal to that done by civilians, and it was reported on by the late contractor's foreman as "rather superior" to contract work. At Portland there are many buildings erected by convicts which stand side by side with, and cannot be distinguished from, similar works built by civilians.

There is no doubt that a company of Engineers with a regiment of the Line could furnish a thoroughly good working party of the strength and composition given in appendix 1B, page 95, and that such a working party ought to be equal to the erection of any building or fort such as is ordinarily required by the War Department, and, as compared with contract, at a considerable saving, which would vary according to the local rates of wages, the opportunities of procuring materials without purchasing, the nature of the work, &c., &c.

In the same way it may be confidently stated that a penal establishment at home or abroad would always be able to furnish a similar working party.

In both cases, the country gains by being repaid some of the necessary cost incurred in keeping up large establishments, whether military or penal.

The advantages to the soldier in thus employing him are numerous. His pecuniary and social condition is raised, he gains habits of industry, is made "handy" for the field, is physically developed, and fitted to earn a livelihood for himself on leaving the service.

The only objection urged against such employment of soldiers is that it makes them slovenly on parade. Many officers, however, think that this is by no means the case, and prefer the developed intelligence and handiness acquired on the works, to that stiffness and rigidity once looked upon as smartness in the British army, but for which it is now the tendency of all improvements in drill, &c., to substitute celerity and intelligence in manœuvring.

To the Department employing soldiers, their labour has many advantages and also some disadvantages. Among the former may be mentioned—the cheapness of the labour—security that the work is not scamped—no danger of strikes—power of making alterations during the progress of the work without enormous extra charge (in these transition days this advantage is not to be despised).

On the other hand, the delay caused by soldiers working only five days a week, for shorter hours and with constant interruptions from duty, is, wherever time is more an object than money, no doubt a drawback; and, moreover, it is a disadvantage that the proportions of the trades are the same all through the progress of the work. In a large work, there are at first required great numbers of quarrymen, excavators, &c., and the other trades are almost idle; but as the work proceeds, masons, bricklayers, and carpenters are fully employed; again, towards the end, painters and smiths are hard pressed, but the heavy masonry and brickwork have come to an end. With civilians the men of different trades may be taken on and discharged as convenient, but a company of Engineers has its fixed establishment, and this cannot be constantly altered as the work proceeds. An experienced officer, however, looking well ahead and having the plans of details ready in advance, will be able to do away with much of this inconvenience.

The advantages of employing convicts on works are obvious. The hard work necessary for their punishment is made reproductive—it improves them physically, and is not of such a nature as to make them dogged and prevent mental improvement—they acquire habits of industry—and in many instances pick up a trade, or such a knowledge of work that they qualify themselves to earn an honest living when their sentences expire. On the other hand, they work for very short hours—they must be withdrawn from the works on foggy days, for fear of escape—they cannot be kept extra hours on an emergency—they cannot be employed singly without great extra expense for superintendence—nor can they be put into many positions of trust in which they may be required.

In working either soldiers or convicts, in fact in all day work on a large scale, a great deal more labour is thrown upon officers superintending, than in working by contract. In the latter case, the duties of engineers only have to be performed by them, but in the former system, an officer has the duties and responsibilities of both engineer and contractor. Works conducted on this system are, however, a good school in which officers may acquire practical knowledge.

In new colonies and similar situations, it is sometimes necessary to employ military or convict labour, civil labour being unavailable or enormously expensive. In such a case, an officer having estimates to frame, might find notes like these useful, by making an estimate of the amounts required for labour, plant, &c., according to the ordinary rates for civilian labour in England; and then applying the corrections given with regard to cost of labour, time taken, &c., he would arrive at an approximate idea of the money that would be expended in carrying out the work by soldiers or by convicts, whichever happened to be at his disposal.

As these notes are based upon the experience of a single district* they take no doubt a limited view of the subject, and the data furnished are most fragmentary, but they are submitted with the hope that others who have had greater opportunities will communicate the result of their experience for the

* The writer regrets that he has no data with regard to the value of military labour as ascertained at other stations. The short time at his disposal for writing these notes has precluded him from attempting to get such information.

benefit of the corps, any member of which may some day find himself in want of the information.

It would be foreign to the subject of this paper, and would inconveniently extend its limits to enter upon the wide question of the general employment of military labour. The results given above are those that may be obtained, and indeed have been obtained, under the present system, in which the employment of soldiers is the exception and not the rule. Were it determined that all military works should be carried out by soldiers, no doubt a system would be introduced by which they could be worked to a greater advantage than at present.

It may be said, that the general employment of the whole army would be impossible for several reasons. The works annually ordered would not employ all the men—the regimental duties would interfere with their employment—and moreover the predominance of unskilled men in the army is so great, that except for earthworks, &c,, the majority of them could not possibly be made use of. This is no doubt true, but it may be interesting to ascertain approximately what proportion of the army would be employed, if all the works annually authorised were carried out entirely by soldiers, and also to consider whether this partial employment of the army would be beneficial to it.

The amount voted in the annual estimates of 1867-8 for military works is £750,000. (This is of course exclusive of the special works of defence, now in course of erection, under the loan for fortifications.) Of this we may assume that 33 per cent.* or £250,000 would be expended in civil labour.

We learn from Appendix 1B, that an average soldier earns at civilian rates 3s. 2d. per diem, or supposing him to work 250 days in a year, £39 12s.; say £40 per annum.

Now, if each soldier does, at civilian rates, £40 worth of work per annum, it follows that it will take about $250,000 \div 40 = 6250$ men to do the work required in the year.

To meet this demand we have available 30 companies of Royal Engineers, with 80 men in each, on works daily, $= 30 \times 80 = 2,400$. There remain, therefore, 3,850 men to be supplied by Line Regiments.

There are about 86 Regiments serving in England, and at stations abroad, exclusive of India. Leaving out 6 for casualties, we should have 80 Regiments remaining, out of which to find a working party of 3,850 men, or an average of 48 men from each.

Assuming it to be possible that each of these 80 regiments could furnish a working party of 48 men daily, let us see what would be the advantages derived from the arrangement.

1st. From Appendix 4 B, we have every reason to believe that there would be

* 31 per cent. is the proportion given as expended on labour in a casemated fort, see Appendix 4A, page 98, but the ordinary barrack buildings would require a larger proportion of labour, the walls being thinner, &c.

a saving of at least 28 per cent. on the value of the works at contract prices in England, (much more abroad), amounting on £750,000 to £210,000 per annum.

2nd. There would be the further advantage that in each of 80 regiments there would be 48 men employed upon works, who would be improving themselves for the field, ready to form a nucleus in case the regiment had to work on service. These men would be chiefly labourers, and as they would require no qualification but strength, could be chosen by their Colonel because they were married and in want of money, for their good character, or for any other reason.

Surely every Colonel of a regiment would be glad to be able to put 48 of his men into positions in which they could earn from 9d. to 1s. 6d. per diem; especially as any tendency in these men to behave badly or to become slovenly and neglect their drill, would be prevented by the fear of being taken off the works.

The question next arises whether the numbers of mechanics and labourers thus provided would be in the proper proportion. In every 80 men furnished by the Royal Engineers, we may assume that 70 are mechanics and 10 labourers. And we may safely say that each of the 80 Line regiments could furnish 5 artificers and 43 labourers.

The total working strength would, therefore, be thus composed.

30 Companies of Royal Engineers ...	30 × 70 Mechanics =	2100
	30 × 10 Labourers =	300
80 Regiments of Line	80 × 5 Mechanics =	400
	80 × 43 Labourers =	3440
		6240

or a total of 2500 mechanics and 3740 labourers.

Now, it is evident that with such numbers the labourers are greatly in excess of the mechanics.

The works carried out in the annual estimates are chiefly ordinary barrack buildings, the parties for which would probably require about an equal number of mechanics and of labourers.

The 6240 men employed on the works ought, therefore, to be divided into 3120 mechanics and 3120 labourers. We should thus by the arrangement above detailed, have 620 labourers in excess of what would be required, and 620 mechanics too few.

In order to carry out all military works by soldiers, we require, therefore, 620 more mechanics; the only way to get them is by increasing the number of sappers.

To get 620 more sappers daily on the works we should have to enlist about 800 sappers, that is 8 companies more, which after deducting 20 per cent. for casualties and regimental duties, would about give the necessary working party.

To keep up 800 more sappers would seem at first to be a great expense, but if a corresponding reduction were made in the numbers of the Line, it would be found to be an actual saving.

It is true that a company of Royal Engineers costs more to raise and maintain than one of the Line, (viz.: £5193 per annum as compared with £4334), see Appendix 8, yet, as has been said by Sir John Burgoyne (Vide Military Opinions, p. 325), "As the Engineer soldiers are intended to be habitually "employed in work, it is evident that the difference of cost of what is per- "formed by them from what it would be by ordinary means, will mark the "real *bonâ fide* expense to the public of their maintenance."

Adopting this principle, we find that a company of Engineers is far cheaper than one of the Line of equal strength. By appendix 8, we see that it costs originally £5193 per annum, but when employed on the works, which would generally be the case, it repays £2656 per annum, costing really only £2537 per annum.

A company (100 men) of the Line costs (appendix 8, page 106) £4334 per annum, but very seldom has a chance of being profitably employed so as to make any return for the money.

A company of sappers employed on works is, therefore, actually a cheaper body than a company of the Line, which cannot, as a rule, be so employed.

We should thus by an annual expenditure of $8 \times$ £2537 = £20296 get 800 men who are trained soldiers and artificers fit for anything, instead of paying $8 \times$ £4334=£34672 annually for 800 men of the Line, who are of course most useful as soldiers in case of war, but in peace time act only as "a very expensive kind of watchmen."

The advantages of substituting these sappers for an equal number of the Line are obvious.

1. There is an actual saving caused by keeping up soldiers who repay a large portion of the cost of their maintenance in time of peace; and, in fact, a superior man is obtained at a smaller cost.

2. The sappers not only reimburse the country by their cheaper labour, but they also enable a number of Line soldiers to be employed who can thus also repay the country something towards their maintenance, which they could not do unless there were mechanics for them to work with.

3. In the field the sappers are available for all the duties required of the Line and are also always ready for their own particular duties as sappers.

4. The advisableness of keeping up a really efficient and numerous Corps of Engineers has been insisted upon by the most distinguished military authorities for many years. The late Duke of Wellington, Sir John Burgoyne, and many others have pointed out the necessity in terms familiar to all officers of the Corps; the only objection has been the supposed expense in time of peace; but if the sapper is constantly employed he will repay his cost to the country to such an extent as to show that he really is the least expensive as well as the most useful form of soldier in the army.

P. S.

APPENDIX No. 1.

To find the average amount of work done by the Soldier or Convict, as compared with the Civilian.

From Appendices 1B, 1C, 1A, we see that the values at civilian rates of the work done in days of the lengths mentioned are:

	Hours.	Amount.
Soldier	9	3s. 2d.
Convict	7	1s. 7d.
Civilian	$9\frac{1}{2}$	4s. 8d.

Therefore, compared with a civilian, a soldier earns as .... } 3s. 2d. to 4s. 8d. or $\frac{38}{56}$, say $\frac{2}{3}$.

.... a convict 1s. 7d. to 4s. 8d. ... $\frac{19}{56}$ „ $\frac{1}{3}$.

But the soldier, besides working shorter hours, is at drill on Saturdays, and therefore only works $\frac{5}{6}$ the number of days worked by the civilian; the whole amount earned or done by him in a week compared to that done by a civilian is therefore—

$$\frac{2}{3} \times \frac{5}{6} = \frac{10}{18} = \frac{5}{9}.$$

Therefore, a military working party would take $1\frac{4}{5}$ as long to do a work as a similar party of civilians on day work, and as convicts work the same number of days as civilians, a convict working party would take three times as long as a civilian working party of the same strength.

From the above we easily ascertain that in a day of $9\frac{1}{2}$ hours, the following would be the values of work done at civilian rates:—

Civilian	....	4s. 8d.
Soldier	$\frac{19}{18} \times$ 3s. 2d.......	3s. 4d.
Convict	$\frac{19}{14} \times$ 1s. 7d.......	2s. 2d.

The relative amounts of work done by civilian, soldier, and convict, in a day of the same length are therefore as follows:—

Civilian . ..	4s. 8d.	or 56d.	or 11	or 1·0
Soldier	3s. 4d.	.. 40d.	.. 8	.. ·71
Convict	2s. 2d.	.. 26d.	.. 5	.. ·46

APPENDIX 1A.—CIVILIANS.

Average earnings per man in a working party in an average day of 9½ hours.

Trade.	No.	Rate.		Amount.			Remarks.
		s.	d.	£	s.	d.	
Carpenters	14	5	0	3	10	0	All on day work except the excavators.
Sawyers	4	4	9	—	19	0	
Smiths	4	4	9	—	19	0	
Firemen	3	3	0	—	9	0	
Strikers	3	3	6	—	10	6	
Masons, Cutters.	18	5	0	4	10	0	
" Builders	2	5	6	—	11	0	
Bricklayers.....	14	5	0	3	10	0	
Painters	3	4	6	—	13	6	
Excavators......	30	6	0	9	0	0	On piece work.
Labourers	30	3	2	4	15	0	
	125	4	8	29	7	0	

In drawing up this table of the average earnings of a civilian it has been assumed that each man earns for his master about 5 per cent. over what he is paid; the rates given are, therefore, about 5 per cent. above the market rates of wages. It is also assumed that in consequence of the regulations of the trades-unions, no man can work by the piece except the excavators; these men would, of course, not be paid so much as 6s. per diem, though they would earn that amount for the contractor.

APPENDIX 1B.—SOLDIERS.

Statement shewing average amounts paid to a working party of Soldiers, and the value at civilian rates, of the work done ; all in a day of 9 hours.

Trade.		No	Average rate of pay.	Cost. Day Work.	Cost. Piece Work.	Value of Work done estimated at Civilian rates. Day Work. Rate	Day Work.	Piece Work. Rate	Piece Work.	Remarks.
			s. d	£ s. d.	£ s. d.	s. d.	£ s. d.	s. d.	£ s. d.	
Carpenters	Day	14	1 8	1 3 4	....	2 8	1 17 4	...	......	
	Piece	4	2 6	....	0 10 0	...	....	4 0	0 16 0	
Masons ...	Day	6	1 7	0 9 6	....	2 9½	0 16 9	...	......	
	Piece	14	2 8	....	1 17 4	...	....	5 0	3 10 0	
Bricklayers	Day	6	1 6¼	0 9 1½	......	2 8½	0 16 3	..	....	
	Piece	8	2 6	....	1 0 0	..	....	4 6	1 16 0	
Smiths	Day	8	1 7	0 12 8	....	2 6	1 0 0	...	......	
	Piece	2	2 6	....	0 5 0	..	....	4 0	0 8 0	
Painters ...	Day	2	1 7	0 3 2	....	2 8½	0 5 5	.	......	
	Piece	1	2 6	....	0 2 6	..	....	3 7	0 3 7	
Labourers	Day	30	9	1 2 6	....	1 8	2 10 0	..	......	
	Piece	30	1 7	....	2 7 6	...	......	4 0	6 0 0	
Day work ... 66 Piece work.. 59		125		4 0 3½	6 2 4		7 5 9		12 13 7	

Total cost—Day work 4 0 3½ Average per man 1s. 2d½.
Piece work 6 2 4 ditto ditto 2s.

£10 2 7½ Average paid to each man daily 1s. 7d.

Total value of work done in 9 hours :
Day-work 7 5 9 Average per man 2s. 3d.
Piece-work 12 13 7 ditto ditto 4s. 3½d.

£19 19 4 Average done by each man daily 3s. 2d.

The average paid to an artificer is 2s.
" " a labourer is 1s. 2d.
The average value of an artificer's work is 3s. 6d.
" " a labourer's work is 2s. 10d.

This table shows a working party of such an assumed strength and proportion of trades as would be convenient in carrying on a building such as a casemated fort with parapets, glacis, &c.

It is difficult to say exactly what is the value of the work done by some labourers on miscellaneous jobs, but many of them who are employed on gantries, attending bricklayers, &c., are by the nature of their employment kept hard at work, and the average taken may be considered low. With regard to those on piece-work, the value of the work done has been taken from actual measurement.

The value of the work done by carpenters, smiths, &c., on small jobs, repairing tools, &c., has also been carefully arrived at by averages taken on 6 months' work at a time.

APPENDIX 1c.—CONVICTS.

Statement shewing the value of the work done in a day of 7 hours by a working party.

TRADE.	No.	Value of work done per man in 7 hours.	Total value of work done, estimated at civilian rates.	REMARKS.
		s. d.	£ s. d.	
Carpenters	18	2 1	1 17 6	No piece-work.
Masons	20	1 9	1 15 0	
Bricklayers.........	14	1 9	1 4 6	
Smiths	10	2 1	1 0 10	
Painters	3	1 9½	0 5 4½	
Labourers	60	1 3½	3 17 6	
	125	1 7	10 0 8½	

This estimate of the value of the work done per diem by convicts differs from others that have been made, and must be taken simply as an opinion founded upon observation and measurements on work done by convicts, and upon information received from men of great experience in convict labour.

The amounts of work done will, no doubt, vary materially with the state of discipline of a particular prison, the nature of work, climate, &c., &c.

APPENDIX 2.

To find the Cost of Extra Supervision for a Convict when Employed on the Works.

The total cost of the warders in Portland prison during 1865 was £17178. Their number was 223 altogether, including those employed both in and out of prison.

The average cost per warder was, therefore, $\frac{17178}{223} = £77$ per annum.

Average cost per diem = 4s. 3d.

Or per working day = 5s. 0d.

The average number of warders employed on the War Department Works is 1 to 10 convicts.

Therefore, the cost of each convict per working day is for extra superintendence only, $\frac{5s.\ 0d.}{10} = 6d.$ per diem.

It is very doubtful whether, if the convicts were not employed on the works, some at least of these extra warders would not be necessary to look after them in the prison; but in the absence of any definite information as to the number of warders required to look after convicts in their normal condition, and to be on the safe side, it is assumed that they are all required solely for the works.

APPENDIX 3.

To find the Cost per unit of the Work done by the Soldier and by the Convict as compared with the Civilian.

By appendices 1B, 1C, 1A, pages 94-6, we see that the average value of the work done by a soldier in his working day at civilian rates .. is 3s. 2d.
By a Convict .... is 1s. 7d.
By a Civilian .... is 4s. 8d.

By appendices 1B, 2, 1A, we find that the average paid per diem is to

A Soldier .... 1s. 7d.
A Convict .... 0s. 6d. for extra superintendence on works.
A Civilian .... 4s. 8d.

Therefore, the cost of soldier's work as compared with its value at civilian rates is as 1s. 7d. to 3s. 2d. $= \frac{1}{2}$

The cost (for extra superintendence) of convicts' work compared with its value is as 6d. to 1s. 7d. or $\frac{6}{19} = \frac{1}{3}$.

Therefore, with reference to any large building if we know what the labour upon it by civilians would cost, we can find what the labour by soldiers would cost by taking $\frac{1}{2}$; or by taking $\frac{1}{3}$ it will give the cost of convict labour.

APPENDIX 4.

To find the Influence of Soldier and Convict Labour upon the total expenditure.

This will, of course, vary with the nature of the work; where the proportion of labour is great, as in earthwork, the influence of the cheaper labour, upon the total expenditure, will be very considerable. In other cases, such as brick-work, where the materials exceed the labour in value, the influence of any change in the labour will hardly be felt.

The following tables show roughly the probable expenditure and profit on a few different kinds of work executed by contract, and also how these proportions would be modified by the employment of military or convict labour.

These proportions of expenditure are of course merely approximate, and are given more for the sake of illustration than anything else. They would vary with a hundred different circumstances, and would always have to be calculated anew for any particular case.

The sources from which the figures in the first table were derived are mentioned in the column of remarks.

The figures given in the 2nd and 3rd table were obtained from those in the 1st table, by applying the corrections specified at pages 83, 84, for the different cost of soldier and convict labour, deterioration of plant, &c.

APPENDIX 4A.

TABLE showing proportions of expenditure in carrying out different work by contract, and the profit to the contractor.

	Materials.	Labour.	Superintendence.	Plant.	Idle Money.	Profit to Contractor.	Total.	REMARKS.
1. Casemated Fort—bricks and stone purchased.	46	31	5	3	2	13	100	These are the actual proportions of expenditure by a contractor on some casemates at Portland.
2. Casemated Fort—bricks made, and stone quar. by Contr.	26½	42	6	4½	2½	18½	100	Arrived at by combining No. 1 with 3 and 4.
3. Quarrying Portland stone.	11	49	2	7	3	28	100	From good authorities at Portland.
4. Brickmaking.	35	40	·06	11	·14	13·8	100	Partly from actual expenditure, and partly from books.
5. Brickwork in thick walls, one story, bricks purchased.	64	18	5	1	½	11½	100	Analysis of price.
6. Brickwork, (bricks made by contractor)	27	39½	8	5·9	1·9	17·7	100	No. 5 combined with No. 4.
7. Building stone wall 8 ft. thick (large stones requiring gantries.)	43½	28½	3	7¼	3	14¾	100	From analysis and actual expenditure.
8. Carpenter's work.	36	45	4	—	—	15	100	Analysis of price.
9. Casemated fort in a colony where labour costs twice as much as in England. Bricks and stone purchased.	35	47	4	2½	1½	10	100	From No. 1, on the supposition that every item of expenditure and profit, is the same actual sum as in England, with the exception of labour, which is increased in the proportions named in Col. 1; thus altering the total amount expended, and the *per centages* of the remaining items.
10. Casemated fort in a colony where labour costs 3 times as much as in England. Bricks and stone purchased.	28	57	3	2	1	9	100	
Earthwork—digging and wheeling 150 yds.	0	66	4	2	1	27	100	

APPENDIX 4B.

TABLE shewing the probable proportions of expenditure on a work carried out by Military labour, and the saving both to the country and also to the War Department, as compared with contract rates.

	1	2	3	4	5	6	7	8	
	Materials.	Labour, ½ cost of Civilians.	Superintendence.	Plant $1\frac{4}{5}$ of cost to Contr.	Idle money $\frac{27}{25}$ of cost to Contr.	Profit to country.	Total.	Profit to War Dept. Col. 5 + col. 6.	REMARKS.
Casemated work, bricks and stone purchased.	46	15½	5	5½	2¼	25¾	100	28	See page 83.
Casemated work, bricks made and stone quarried on spot.	26½	21	6	8	2¾	35¾	100	38½	
Brickwork— thick walls, bricks purchased.	64	9	5	1⅘	⅗	19⅗	100	20⅕	
Stone wall, 8 feet thick, large stones requiring gantry.	43½	14¼	3	13	3¼	23	100	26¼	
Quarrying.	11	24½	2	12½	3¼	46¾	100	50	
Carpenter's work.	36	22½	4	—	—	37½	100	37½	
Casemated Fort—labour twice cost of what it is in England. Bricks & stone purchased.	35	12	4	4½	1¾	42¾	100	44½	
Casemated Fort—Labour 3 times cost of what it is in England. Bricks and stone purchased.	28	10	3	3¼	1¼	54½	100	55¾	
Earthwork — digging and wheeling 150 yards.	0	33	4	4	1	58	100	59	

APPENDIX 4c.

TABLE howing the probable proportions of expenditure on different works carried out by convict labour.

	1	2	3	4	5	6	7	8	9
	Materials.	Labour. Cost of extra superintendence $\frac{1}{3}$ cost of civil labour	Superintendence.	Plant, 3 times cost to contractor.	Idle money $1\frac{4}{5}$ cost to contractor.	Profit to country.	Total.	Profit to War Department. Col 2 + 5 + 6.	REMARKS.
Casemated work — bricks and stone purchased.	46	10	5	9	$3\frac{3}{5}$	$26\frac{2}{5}$	100	40	
Casemated work — bricks made and stone quarried on spot.	$26\frac{1}{2}$	14	6	$13\frac{1}{2}$	$4\frac{1}{2}$	$35\frac{1}{2}$	100	54	
Brickwork in thick walls. Bricks purchased.	64	6	5	3	1	21	100	28	
Quarrying.	11	16	2	21	$5\frac{1}{2}$	$44\frac{1}{2}$	100	66	
Making Bricks.	35	13	1	20	$\frac{1}{4}$	$30\frac{3}{4}$	100	44	
Stone wall 8 ft. thick, heavy stones requiring gantry.	$43\frac{1}{2}$	$9\frac{1}{2}$	3	$21\frac{3}{4}$	$5\frac{1}{2}$	$16\frac{3}{4}$	100	$31\frac{3}{4}$	
Carpenter's work	36	15	4	—	—	45	100	60	
Casemated fort — Labour costing twice what it does in England. Bricks and stone purchased.	35	8	4	$7\frac{1}{2}$	$2\frac{3}{4}$	$42\frac{3}{4}$	100	$53\frac{1}{2}$	
Casemated Fort — Labour costing three times what it does in England. Bricks and stone purchased.	28	6	3	$5\frac{1}{2}$	$2\frac{1}{4}$	$55\frac{1}{4}$	100	$63\frac{1}{2}$	
Earthwork—digging and wheeling 150 yds.	0	22	4	6	$1\frac{4}{5}$	$66\frac{1}{5}$	100	90	

APPENDIX 5.

To find the cost to the Country of a Sapper.

Cost per annum of a Company of Royal Engineers, 100 strong. Regimental cost only.

This supposes 40 men to be discharged after their first period of service, and 60 to re-engage during a term of 21 years.

				Per annum.		
				£	s.	d.
1 Colour-Sergeant, 3s. 6½d. per diem				64	12	8½
5 Sergeants .... 3s. 0½d. „				277	11	0½
6 Corporals .... 2s. 4½d. „				260	1	3
6 2nd Corporals, 2s. 0⅜d. „				225	16	10½
2 Buglers ..... 1s. 4½d. „				50	3	9
80 Sappers ..... 1s. 4½d. „				2007	10	0
60 Re-engaged men at 1d. per diem				91	5	0
100 Men, beer money at 1d. „				152	1	8
Good conduct pay				130	0	0
Contingent allowance to Captain				56	10	0
Stationery ditto......				5	5	0
Library and recreation room				2	10	0
Paymaster's pay, &c., per company				24	0	0
Postage expenses				5	0	0
100 Men, clothing, per annum ...				445	4	3
*100 Men, enlistment expenses at £13.15.6	1377	10	0			
At the same rate to 40 men who replaced those that took their discharge	551	0	0			
†60 Men, re-engaging at £8.2.6 each ..	487	10	0			
Total for 21 years	2416	0	0			
For one year				115	0	11½
Lodging allowance to 12 married Men out of Barracks at 4d. per diem				73	0	0
88 Single Men's allowance of fuel and light, valued at 2½d. per man, per week				47	13	4
88 Single Men's cooking, valued at 2s. 6d. per man per annum ..				11	0	0
Probable expense of Barrack accommodation for 88 men at £2 per annum each				176	0	0
Carried over				£4220	5	10

* *Enlistment Expenses.*

	£	s.	d.
Bounty	2	0	0
Free kit.................	4	2	6
Attesting fee	0	1	0
Recruiting party ...	1	1	0
Travelling expenses	0	9	4
Training at head-quarters	6	1	8
Total	£13	15	6

† *Allowances on Re-engagement.*

	£	s.	d.
Bounty	2	0	0
Free kit	4	2	6
Gratuity	1	0	0
Twenty days' allowance	1	0	0
Total	£8	2	6

		£	s.	d.
Brought forward		4220	5	10
Difference in amount paid by men for rations, and amount paid to contractors—				
100 Men at $1\frac{1}{2}$d. per diem		228	2	6
Pensions for 25 men discharged after 21 years, at an average rate of 1s. 4d. a day, and lasting 23 years	£13992			
Add $\frac{9}{21}$ of ditto for 10 men of the 40 who replaced the men who took their discharge after 12 years, but who will only serve 9 out of their 21 years in the company whose expense is now being estimated	2398			
For 21 years ..	£16390			
For one year......		780	9	8
Total		£5228	18	0
Deduct average amount paid for purchase of discharge		36	0	0
Total for 100 men ..		£5192	18	0
Average cost per man per annum		51	18	6

Ditto ditto per diem 2s. 10d. nearly.

This table and the one following have been altered by Corporal Tyler, R.E., for present rates of pay, from that given by Quartermaster Connolly, page 328 of Sir John Burgoyne's "Military Opinions;" it includes nothing for cost of officers, hospital, transport, or recreation, nor working pay of any description.

To find the cost to the Country of a Line Soldier.

Cost per annum of a Company of the Line, 66 stron g.

This supposes 25 men to take their discharge at the expiration of their first period of service, and 41 to re-engage, during a term of 21 years.

	£	s.	d.
1 Colour Sergeant, 2s. 8d. per diem	48	13	4
3 Sergeants .... 2s. 2d. „	118	12	6
4 Corporals .... 1s. 6d. „	109	10	0
56 Privates ... 1s. 2d. „	1192	6	8
66 Men, beer money, at 1d. per day	100	7	6
41 Re-engaged men, at 1d. per day	62	7	1
Good conduct pay........	85	0	0
Contingent allowance to captain	27	7	6
Library and recreation room allowance	2	10	0
Postage and stationery	4	0	0
Paymaster's pay, &c. per company	26	9	3
Lodging allowance to 8 married men out of barracks, 4d. per diem	48	13	4
58 Men's cooking, valued at 2s. 6d. per annum	7	5	0
58 Men's allowance of fuel and light, valued at 2½d. per week..	31	8	4
Barrack accommodation, probable expense for 58 men, at £2 per annum	116	0	0
66 Men's clothing, per annum....	179	2	9
Difference in amount paid by men for rations, and amount paid to contractors, 66 at 1½d. a day ..	150	11	3
* Enlistment expenses, 66 men, at £8 14 4...... 575 6 0			
At the same rate to 25 men, who replaced those that took their discharge........... ...217 18 4			
† 41 Men, re-engaging at £6 each 246 0 0			
Total for 21 years 1039 4 4			
For one year	49	9	9
Carried forward........	£2405	6	9

* *Enlistment Expenses.*

	£	s.	d.
Bounty	1	0	0
Free kit..................	3	0	0
Attesting fee	0	1	0
Recruiting party......	1	4	0
Travelling expenses	0	9	4
Training at head-quarters...............	3	0	0
Total	£8	14	4

† *Allowances on Re-engagement.*

	£	s.	d.
Bounty	1	0	0
Free kit..................	3	0	0
Gratuity..................	1	0	0
20 days' allowance...	1	0	0
Tota	£6	0	0

Brought forward ...		2405	6	9
Pensions for 16 men, discharged after 21 years' service, at an average rate of 1s. 4d. per day, and lasting 23 years........	£8955			
Add $\frac{9}{21}$ of ditto to 6 men of the 25 men who replaced the men who took their discharge after 12 years, but who will only serve 9 of their 21 years in the company whose expense is now being estimated	1439			
Total for 21 years,	£10394			
For one year		495	0	0
Total....		£2900	6	9
Deduct average amount paid for purchase of discharge		21	6	0
Total for 66 men...		£2879	0	9
Average cost per man per annum		43	12	5
Ditto ditto per diem ..		2s. 4½d.		

APPENDIX 6.

To find the Regimental Cost of an average Soldier in the Working Party, Appendix 1B, *page* 95.

We know (appendix 5, pages 101-4) that a Royal Engineer soldier, average

	s.	d.
all ranks, costs regimentally, per diem, ...	2	10
an average Line soldier..................	2	4½

In the working party of the strength given in appendix 1B, page 95, we have

	£	s.	d.
65 Sappers at 2s. 10d.	9	4	2
60 Line at 2s. 4½d..................	7	2	6
	£16	6	8

and the average regimental cost per soldier in the party will be $\frac{£16\ 6s.\ 8d.}{125} = 2s.\ 7d.$

APPENDIX 7.

To find the Amount repaid to the Country by a Soldier each day he is employed upon Works.

Taking an average soldier in the working party, appendix 1B, employed on a casemated fort which would pay the contractor only 13 per cent.

We know (appendix 1B, page 95) that he does 3s. 2d. worth of work (valued at civilian wages) per diem, and that he receives on an average 1s. 7d. per diem.

We know also that the value of civilian labour in this casemated fort equals 31 per cent. of its whole value, and that the contractor's profit equals 13 per cent. of its whole value.

The contractor's profit gained upon each man's work per diem will, therefore, be to the labour (valued at civilian rates) of each man per diem, as 13 to 31, that is the contractor's profit will be $\frac{13}{31}$ of 3s. 2d. = 1s. 4d. on each man's work per diem.

We have found that the soldier keeps the plant $1\frac{4}{5}$ times as long as the civilian; it costs, therefore $5\frac{2}{5}$ instead of 3 per cent. He loses, therefore, $2\frac{2}{5}$ per cent. on plant. This will be 3d. on the day's work. We have, therefore, the following as the gain per diem of an average soldier.

	s.	d.
He does 3s. 2d. worth of work for 1s. 7d.—saving	1	7
He saves the contractor's profit $\frac{13}{31}$ of 3s. 2d.	1	4
	2	11
He loses on plant $\frac{2\frac{2}{5}}{31}$ of 3s. 2d.	0	3
Resulting gain per diem	2	8

We have seen that the average regimental cost of a soldier in the working party before detailed (appendix 6, page 104), is 2s. 7d. per diem. An average soldier in such a party clears, therefore, each day he is employed on works his whole regimental cost to the country, with 1d. per diem to spare.

This is the amount cleared each day he is on the works by the average soldier in the working party taken above. The amounts saved differ somewhat, however, for mechanics and labourers.

The fact is, that at the present time, the mechanic in the army, that is the Sapper, is paid better in proportion to the market value of his labour than is the labourer.

Thus by appendix 1 B, we see that the soldier mechanic does on an average 3s. 6d. worth of work per diem, and receives for it 2s.

The soldier labourer does on an average 2s. 10d. worth of work per diem, receiving for it only 1s. 2d.

The comparative savings effected by employing them would therefore stand thus,—

	s.	d.
Soldier Mechanic		
Does 3s. 6d. work for 2s.—saving	1	6
Contractor's profit saved $\frac{13}{31}$ of 3s. 6d.	1	5
	2	11
Loss on plant $2\frac{2}{5}$ per cent.	0	3
Saving on mechanic per diem	2	8
Soldier Labourer		
Does 2s. 10d. worth of work for 1s. 2d.—saving	1	8
Contractor's profit saved $\frac{13}{31}$ of 2s. 10d.	1	2
	2	10
Loss on plant, $2\frac{2}{5}$ per cent....................	0	3
Saving on labourer per diem	2	7

APPENDIX 8.

To find the comparative Cost of a Company of Royal Engineers and of one of the Line of equal strength.

We know by (appendix 5, pages 101-2) that an average Royal Engineer soldier costs the country for all regimental expenses, 2s. 10d. per diem; or a company of 100 Royal Engineers, all ranks, would cost per annum 100 × 365 × 2s. 10d. = £5170 16s. 8d.

Out of a company of 100, 20 may be considered casualties, and the remaining 80 as employed on the works. Of the 80 men employed on the works, we may say that 70 are mechanics, and 10 labourers; and that after deducting Saturdays, Sundays, and a few casual days, they are employed on the works on 250 days in the year.

We have found that a mechanic repays the country 2s. 8d. per diem, and a labourer repays 2s. 7d. per diem. A company of Royal Engineers would, therefore, repay as follows:

	£	s.	d.
70 Mechanics, 250 days at 2s. 8d.	2333	6	8
10 Labourers, 250 days at 2s. 7d.	322	18	4
	£2656	5	0

We have found that a company of Royal Engineers costs £5170 16s. 8d. per annum originally; it, therefore, follows that each year it is employed on the works it costs only (£5170 16s. 8d. — £2656 5s.) = £2514 11s. 8d.

One hundred Line soldiers would, we know, cost the country 100 × 365 × 2s. 4½d. = £4334 7s. 6d. per annum; but at present the number of men who have any chance of making a profitable return in the shape of labour on the works is so small as to be inappreciable; 100 Line soldiers may be said, therefore, to cost per annum £4334 7s. 6d.

APPENDIX 9.

To find the cost to the country of a convict per diem.

The total cost of the Portland Convict Establishment during 1865 was £48,839 18s. 2d.

The cost of 223 officers included above, but some of whom are chargeable to the works, was as follows:

Wages	£10,964
Officers' rations	3,692
Uniforms	1,289
Salaries—Manufacturing department......	1,234
Total cost of officers	£17,179

Of these 223 officers, about half * may be considered as kept on exclusively for the works, and have been taken as chargeable to the works as "extra superintendence."

Therefore their cost (£8,589) should be deducted from the whole cost of the prison, leaving the latter £40,250.

The average number of prisoners in 1865 was 1454.

The cost per annum per convict was $\frac{£40250}{1454}$ = £27 13s., or the cost per diem 1s. 6d.

Adding £3 per man for the annual rent of prison, we have the total cost per diem of each convict, 1s. 8d.

APPENDIX 10.

To find the Amount repaid by a Convict each day he is employed on the Works.

A convict costs on the average, without the extra guarding required for the works, about 1s. 8d. per diem. (Appendix 9.)

The work he does each day is worth, at civilian rates, about 1s. 7d. (appendix 1C, page 96), and he costs for extra supervision 6d. per diem. Supposing him to be employed on a casemated fort, we know that the value of the labour, civilian rates, is 31 per cent., and that the contractor's profit is 13 per cent. of the whole value of the work. The convict keeps the plant three times as long in use, and it costs, therefore, 9 instead of 3 per cent.; he loses on it, therefore, 6 per cent.

* This depends entirely upon the force of warders that would be required for the same number of convicts, if they were not employed in the works, which is not easy to be ascertained. In order to be on the safe side, it has been assumed that every warder employed on the works is required entirely for that purpose.

The value of the work done, is at civilian rates, 1s. 7d. per diem, therefore, the contractor's profit would be $\frac{13}{31} \times$ 1s. 7d. = 8d.

The convict would clear per diem, therefore, as follows:

	s.	d.
He does 1s. 7d. worth of work for 6d.—saving	1	1
He clears the contractor's profit, 13 per cent.	0	8
	1	9
He loses on the plant, 6 per cent.	0	3½
	1	5½

That is, he clears 1s. 5½d. per diem out of 1s. 8d., his daily cost to the country. But as the department employing him pays nothing at all for him, he clears for the department as follows:

	s.	d.
He does 1s. 7d. worth of work for nothing................	1	7
He saves contractor's profit, 13 per cent...................	0	8
	2	3
He loses on the plant 6 per cent.	0	3½
He clears for the Department	1	11½

APPENDIX 11.

The following table shews the amount done per diem in a few descriptions of work by a soldier (both on day work and piece work) and by a convict, as compared with a civilian.

It also gives the cost per unit of work done by the artificer only, not including the wages of attendant labourers.

This list is very meagre in consequence of the difficulty (in comparing work done at different times and places) of being sure that the conditions in each case were exactly the same, without which such comparisons, are of course, valueless.

The piece-work prices quoted are those which were given at the Nothe, and are not in all cases exactly what experience has since shewn to be correct.

The tasks given for civilians are, except in the few instances noted, taken chiefly from Hurst's Hand-Book.

Nature of Work.	Unit of Measurement.	Civilian.		Soldier.				Convict.		Remarks.
		Daywork.		Daywork.		Piecework.		Daywork.		
		Amount done per diem.	Cost per unit.	Amount done per diem.	Cost per unit.	Amount done per diem.	Cost per unit.	Amount done per diem.	Cost per unit.	
Excavating clay and filling barrows	cube yd.	[a] 6 to 10 yds.	$4\frac{1}{5}$d.	[a] 5 to [N] 6	$1\frac{3}{4}$d.	[N] 10 to [N] 12	$1\frac{1}{2}$d.	[a] 2	3d.	
„ easy soil, ditto	Ditto	9 to 12	....	[b] 7 to 8	$1\frac{1}{4}$d.	[b] 12 to 14	1d.	[P] $3\frac{1}{2}$	$1\frac{3}{4}$d.	
Wheeling a run of 25 yds..	Ditto	27	....	....	....	[N] 40	$\frac{1}{2}$d.	....	1s.	
Breaking limestone from spawls, to pass through $1\frac{1}{2}$ inch mesh	Ditto	$1\frac{3}{4}$	1s. 9d.	[N] 1	$9\frac{1}{4}$d.	[N] $2\frac{1}{3}$	9d.	[P] $\frac{3}{4}$		
Mixing and laying concrete.	Ditto	$3\frac{1}{3}$	1s.	1	9d.	[N] 3·8	8d.	....		
Brickwork in mortar arches	ft. cube	66 (1000 bricks)	1d.	[N] 44 (666 bricks)	$\frac{2}{5}$d.	[N] 79 (1183 bricks)	$\frac{1}{4}$d.	[P] 18 (270 bricks)	$\frac{1}{3}$d.	Cost of bricklayer only
Ditto thick walls ...	ft. cube	80 (1200 bricks)	...	....	....	[N] $81\frac{1}{2}$ (1222 bricks)	$\frac{3}{8}$d.	....		Ditto.
Pointing arches in mortar .	yds. sup.	8	$7\frac{1}{2}$d.	[N] 4 yds.	$3\frac{1}{2}$d.	[N] 8 yds.	$3\frac{1}{2}$d.	....		
Masonry, setting ashlar....	ft. cube	[N] 111	$\frac{1}{2}$d.	......	....	[N] 132	$\frac{1}{5}$d.	....		Cost of setter only.
Coping	ft. run	[P] $1\frac{1}{2}$	3s.	....	....	[N] $2\frac{1}{2}$	1s.	....		
Making D lights for casemates	ft. sup.	[P] $6\frac{1}{4}$	8d.	[N] 5	3d.	[N] $8\frac{1}{4}$	$4\frac{1}{2}$d.	[P] $3\frac{3}{4}$	$1\frac{1}{2}$d.	
Laying $1\frac{1}{2}$ inch rebated, filleted, deal floor, prepared by machinery ..	square	1	5s.	[N] $\frac{1}{2}$	2s 6d.	[N] $1\frac{1}{3}$	1s.6d.	[P] $\frac{2}{5}$		
2 inch bead and flush solid panelled door	ft. sup.	8	6d.	[N] 5	3d.	....	.....	[P] 6	1d.	
Sawing (chiefly soft wood)	square	2·00	2s$11\frac{1}{2}$d	[N] ·55	1s.11d.	1·51	1s.6d.			

a Captain Tilly, Corps Papers, Vol. VII, page 96. *b* Captain E. S. Tyler, Portsmouth. N Measurement, Nothe Fort. P Ditto Portland.

PAPER X.

A COMPARISON BETWEEN FREE AND CONVICT LABOUR.

BY CAPTAIN HARVEY,

Late of the Austrian Service, and Deputy Governor of Portsmouth Prison.

Communicated by Captain E. F. Du Cane, R.E., Director of Convict Prisons.

The enquiries on which the following report is based, were made at my request, by Captain Harvey, in consequence of a particularly favourable opportunity presenting itself in the new works at Portsmouth Dockyard, where freemen and convicts were working at no great distance apart, and at works of an exactly similar character. At the same time it must be observed that there are certain special circumstances which diminish the results which might be obtained by convict labour. The tables drawn up by Captain Harvey are interesting in many points of view, and I do not think the condition of workmen in the several points examined, has ever been so closely considered before.

E. F. Ducane, Capt. R.E.

H. M. Convict Prison, Portsmouth,
7th December, 1867.

Sir,

In compliance with your verbal order requesting a report on the comparative value of free and convict labour, and in submitting the following particulars to your notice, I beg to add that I have considered the subject under the various conditions which affect both classes of workmen.

The tables appended embrace an interesting mass of facts, and represent the contrasts between the physical capabilities, mode of life, food, and previous occupation of convicts and navvies, and as an appropriate sequel to these, the average earnings of each class.

Table A shows by the first heading that the navvies were nearly all born and bred in the country, whereas the majority of prisoners in towns; thereby, to a certain extent accounting for the superior stamina of the former—in the second column, that the prisoners were on an average 7 years younger—3rd, 4th, and 5th ditto, that the navvies were physically superior, in height 2 inches, in size round chest 2 inches, and in weight nearly 23 lbs.; a fact which in itself speaks volumes, and cannot be too highly appreciated when the relative value of both classes of labour is under consideration.

It will also be seen that the navvy is much more warmly clad, his weight of clothing exceeding that of a prisoner's by about $4\frac{1}{2}$ lb.

The last heading, "*Previous occupation,*" is most important as far as labour results are concerned, and shows what a disparity there is in the component parts of both classes of workmen: the navvy having been trained and inured to the work from childhood, the prisoner almost the reverse.

TABLE B shows the amount of food consumed by an equal number (20) of navvies and convicts.

Without wishing to pass an opinion as to whether the present scale of diet for prisoners at hard labour is sufficient or not, I think it but right to call attention to the fact that the disparity in food is far greater than the difference between labour results would account for.

If, however, diet is to form part of the punishment a convict has to undergo, then I submit that this should also be taken into consideration when comparing the capabilities of both classes of workmen.

The two following circumstances that came under my notice while abroad, will, I think, prove how highly foreigners appreciate the result of a superior diet, viz.: "the English workman." While in France, a large employer of labour (a gardener) informed me that the reason he paid such high wages to Englishmen, compared with what his own countrymen were receiving, was that in addition to their superior skill in certain branches of gardening, they did double and treble the work; the way in which he accounted for it was that they lived well and thereby recouped what strength they had expended during the day. The second illustration tends more to show how, even twenty years ago, in Poland, the possibility of regulating diet to labour was acknowledged. As is well known the serfs at the period named, had to give a certain number of days in the week to the proprietors of the land, and as I was credibly informed, in most instances when thus employed received a graduated scale of food for the day, viz.: men felling and sawing timber in the forest more than drivers, and so on, even to the amount of spirit (corn or potato brandy) served out.

To arrive at accurate results, Dr. Clarke kindly assisted me in weighing and examining 20 navvies and the same number of prisoners. The former were not picked men, but represent a number of navvies that I saw working in one portion of the excavations. The latter belong to No. 7 party, and were selected for comparison on account of having, for the last two years, been employed on similar work, viz.: excavating foundation for sea wall, driving piles, and fixing sheeting, &c.

TABLE C shows the average amount of earnings of both classes of labour, and the number of hours daily employed on the works.

Notwithstanding the drawbacks, to be hereafter enumerated, I think it proves that when prisoners are fairly dealt with, that is work on equally favourable conditions with the navvy, they are capable of earning good wages. To judge of the capabilities of convict labour under any other conditions is not just, and fails to represent the true state of things. A fair estimate cannot be made from results only, as there are many drawbacks to a full development which none but the initiated are cognizant of. Should, however, labour results be the only recognized test, then I submit that the average amount of work performed by free men employed on day-work be taken, but not by navvies working by the piece, as the latter system produces very superior results, and places the convict naturally at a great disadvantage. Day-work in both classes of labour would be found to yield, I think, nearly, if not quite, the same amount of work.

TABLE C shows in the first column the average earnings of No. 7 party, and proves by the great fluctuation in labour performed, ranging (from 1s. to 3s. 3d.) that the system under which the prisoners have worked is defective. It also shows that, although the work upon which they were employed was of the heaviest description, viz., excavating for foundation of sea wall in hard blue clay at a depth of 25 feet, throwing up by stages and filling into trucks (by piecework), in June they approached the navvy in earnings to within 7d., allowing the average earnings of the latter to be 4s. In October they came within 10d., the navvies averaging, to my certain knowledge, 3s. 10d. in that month. The relative value being as 36 to 46. Although exception may be taken at the *average* earnings of a navvy being fixed at 4s, I think on investigation it will be found that anything above that sum forms the exception and not rule—in the same way that 3s. 3d. is the exception with convicts.

The real test is not what a man earns on a specific day or week, but what he *averages throughout* the year.

As far as I could discover, the schedule prices do not materially differ. On some items we gain, and on others lose slightly.

The second column shows a considerable falling off on Admiralty works generally, compared with No. 7 party.

The average earnings of 2s. 7d. on prison works has been obtained by a careful supervision and economical organization, and I think proves what results are possible when the prisoners' labour is entirely in the hands of the convict service. They were employed in alterations to Infirmary and Offices, carting rubbish, cleaning bricks, and clearing drains.

As another illustration, I bring to your notice the house building for the assistant surgeon, where it will be seen that the amount and character of work performed not only deserve great credit, but justify the belief that a vast improvement is possible.

Out of the following elements the results as shown below were obtained.

Five bricklayers, three of whom were learners and two fair average tradesmen, built 19 rods of front faced brickwork, cut and set 10 gauged arches, in 37 days, showing average earnings, including eight labourers attending, of 3s. 7d. per day. Five carpenters, two of whom are learners, one indifferent, one only for a short time employed on the job, and one a fair tradesman, but rather old, trimmed floors, prepared and laid the flooring, skirting, ceiling joists, and roof, battened walls, made angle staves, doors, sashes and frames, and fixed ditto, besides other things necessary for the house (three storeys high and containing 9 rooms) in 56 days, showing average earnings of 3s. per day.

In examining the tables attached, the following points ought, I think, to be kept prominently in view, both for the purpose of doing justice to convict labour and considering what remedies are possible to meet and obviate existing drawbacks to it.

1st. Mode of employment.

2nd. Difference of incentives for industry.

3rd. Physical and individual qualifications.

With reference to the first, viz., "mode of employment," it will be found that in free labour, everything combines to produce the maximum amount of work that the human frame is capable of yielding.

In the first place, the organization is such as to ensure a steady and uninterrupted flow of work for each man throughout the day at a minimum cost; such a state and condition of things being absolutely necessary for the interest of both employer and employed.

2ndly. Capital is always forthcoming to supply all necessary plant for carrying on the works properly, including the purchase of any machinery that tends to economize labour and expedite work.

Lastly, the interests of master and man are made almost identical by the system of piece-work, which is always resorted to when practicable.

The advantages above enumerated cannot be said to be enjoyed by convict labour even in a modified form.

The "mode of employment," viz., in gangs, is necessarily extravagant, as it often fails to bring out the full individual capabilities of each prisoner.

Although in the second point, "difference of incentives for industry," the advantage enjoyed by free labour is too obvious to need being insisted on, I think it right to state what an inducement for exertion the introduction of the mark system has proved.

As regards the 3rd point, the tables attached speak for themselves, and almost deal with the above heading.

The physical disparity between the two classes of labour is no doubt great, at the same time it should be remembered that the navvy must of necessity be strong and muscular to enable him to perform his ordinary task and consequently represents the flower of manhood; whereas convict labour is composed of men below the ordinary average. In addition, it may be said, that in the one case, the work from its nature selects the man, in the other, the man (the convict) whatever his capabilities, has to accommodate himself to the work; a drawback which makes it doubly necessary to consider the individual qualifications of both classes of workmen.

By TABLE A, in the column for previous occupation, it will be seen that out of twenty navvies only one had ever been otherwise employed, whereas out of twenty convicts only two had ever done any thing of the kind before, the rest being amateurs. I acknowledge that this is almost unavoidable, at the same time the propriety of employing bookbinders, shoemakers, &c., as navvies, is questionable, both as to present results and future prospects of prisoners on discharge.

A man who for a certain number of years is prevented from following his trade, cannot be said to have been made the most of while in prison, nor to have the same means of earning a livelihood on discharge as when he was received, unless another trade has been taught him in the meantime.

This, however, opens out such a large field for speculation, as to compel me with reluctance to close an already lengthy report, for fear of again digressing from the subject in question.

Having attempted to show the relative value and conditions of both classes of labour, and likewise ventured to make certain suggestions, I hope I may be allowed to bear witness to the great strides that have been made in England as regards the treatment and employment of prisoners.

From what I have seen abroad, I can safely say, that in no country is the moral influence so successfully exercised, and the reformatory element so perceptible.

The staff employed for supervision and safe custody is less than in other countries* (of course including troops that are employed to maintain discipline and safe custody) and the system of labour very superior.

The fact of men who are undergoing long sentences for crimes, often connected with personal violence, being intrusted with weapons like a pick, shovel, or axe, and watched over by men armed with staves only, speaks for itself; but when it is considered that out of such elements good and useful work is obtained, it must be conceded that a great deal has been done, and that we are far in advance of any other country in the management of prisoners.

The convict is made by labour to lessen the burden of his maintenance, acquire habits of industry, and, by an evenhanded administration of justice while a prisoner, learn to respect regulations and laws.

I am, Sir,

Your obedient servant,

W. TALBOT HARVEY, Dept. Gov.

Captain Du Cane, R.E.
Visiting Director.

* I am speaking of what was the case five years ago in Italy.

NAVVIES.

Name.	Birt	ge.	Height.	Size round Chest.	Weight. with Clothing.	Weight. without Clothing.	Navvy.	Previous occupation or employment.	Remarks.
		ars.	ft. in.	in.	lbs.	lbs.			
T. L.	Lon	0	5 5¾	34½	138	123¼	Always		Average weight of navvies' clothing, including boots, 14¾ lbs.
R. G.	Cou May	3	6 0¼	37½	189	174¼	Ditto		
J. D.	Man	2	5 11	40½	190	175¼	Last 9 years	Stoker.	
T. W.	Coun Long	0	5 7	34½	154	139¼	Last 12 years	Previously farm labourer.	
G. C.	Napl	8	5 7	34½	140	125¼	Always		
D. M.	Lond	0	5 11	37½	173	158¼	Ditto		
D. L.	Lond	0	5 2	36½	154	139¼	27 years	Began as a farm labourer.	
P. S.	Leed	2	5 2	37½	182	167¼	Always		
J. K.	Rosc	2	5 6¾	35½	154	139¼	Ditto		
B. B.	Galw	2	5 7½	35½	154	139¼	Ditto		
W. S.	Cardi	6	5 7	35½	154	139¼	Ditto		
J. M.	Lond	26	5 6½	38¼	187	172¼	Ditto		
G. H.	Brist	3	5 7½	36½	159	144¼	Ditto		
A. C.	Lond	37	5 10	37	180	165¼	Ditto		
S. H	Galw	40	5 6	33½	154	139¼	Ditto		
H. J.	Lond	38	5 7½	33½	159	144¼	Ditto		
J. D.	Cardi	24	5 7¾	37	186	171¼	Ditto		
H. O'H.	Arma	38	5 5½	35¾	170	155¼	Ditto		
J. C.	Birmi	37	5 5¼	35	175	160¼	Ditto		
P. W.	Baden	54	5 8½	44	245	230¼	Ditto		
	Tot	02	111 11¾	730	3397	3102			
	Ave	·1	5 7 4/20	36 10/20	169 17/20	155 1/10			
		·4	1⅘	1 19/20	27 6/20	22 16/20			

W. TALBOT HARVEY, Deputy Governor.

	Average Earnings of							Labour Hours of												
	CONVICTS.			NAVVIES.				CONVICTS.				NAVVIES.				Average time on works.		Total average earnings.		REMARKS.
	No. 7 party.	Admiralty works.	Prison works.	Day-work.	Piecework. from	Piecework. to	Average by piece	Time scale		Dinner hour.		Time scale		Dinner hour.		Convicts	Navvies	Convicts	Navvies	
Month.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	from	to	from	to	from	to	from	to	Hours.	Hours.	s. d.	s. d.	
November	1 6½	1 10½	2 3½	3 3	3 8	4 6	4 1	a. m. 7.10	p. m. 4.15	a. m. 11.50	p. m. 12.50	a. m. 7	p. m. 5	a. m. 12	p. m. 12.45	9	10	2 3	3 9½	The labour hours of convicts includes marching to and from the work, parading, searching, putting by tools,&c. The navvy actually begins and leaves off at the time shown.
December	1 7½	1 9¾	2 4¾	..	..	...	...	7.15	4. 4	...	..	..	..	...	..	...	..	..	..	
January..	1 ..	1 8½	2 6	..	...	..	.	7.15	4.15	..	...	..	..	..	...	..	..	..	..	
February	1 6	1 9	2 6¾	...	..	...	...	7.10	4.45	...	..	6	5	..	...	...	...	..	..	
March ...	2 10½	1 11¾	2 4½	...	..	..	..	7	5.15 5.45	...	..	..	..	..	..	..	..	..	..	
April.....	2 7½	2 0¾	2 6¼	..	...	..	..	7	5.45	..	...	...	...	..	..	...	..	..	..	
May	1 8	1 11½	2 10	...	..	...	..	7	5.45	...	..	..	..	..	..	..	...	..	..	
June	3 3	2 1	3 3½	..	..	..	..	...	..	..	..	...	..	..	..	..	..	..	...	
July	1 4	2 0	3 0	..	...	..	..	..	..	...	..	..	..	..	..	...	..	..	..	
August ..	2 0	1 11¾	2 4	..	..	..	..	..	..	..	..	..	...	..	..	...	..	...	..	
September	2 3	1 11½	2 1	..	...	...	..	..	...	..	..	..	...	..	...	..	..	...	..	
October ..	3 0	1 11¾	3 0½	..	..	..	..	...	..	..	...	...	..	..	..	..	..	...	..	
Total	24 8	23 1¾	31 2¾	39 0	44 0	54 0	49 0	..	..	...	...	..	..	..	..	...	..	...	...	
Average ..	2 ⅖	1 11$\frac{2}{12}$	2 7¼	3 3	3 8	4 6	4 1	...	..	...	...	...	..	...	...	...	..	..	..	

W. TALBOT HARVEY, Deputy Governor.

PAPER XI.

REPORT ON OPERATIONS IN BLOWING UP WRECKS IN THE RIVER HOOGHLY,

DURING THE YEARS 1863—1864 AND 1865.

FROM LIEUTENANT W. A. J. WALLACE, R.E.,

Officiating Executive Engineer, Strand Bank Improvement, to the Officiating Secretary to the Government of Bengal, Public Works Department.

No. —, dated Calcutta, the 4th of April, 1866.

In reply to your Office memorandum No. 400 R., dated Fort William, 29th January, 1866, I have the honour herewith to forward a Report on the blowing up of the wrecks sunk in the River Hooghly during the years 1863-64 and 1865. As a detailed report upon the effect of each explosion would be extremely monotonous, I have given, *first*, a short description of the means at my disposal for carrying out the work; *secondly*, a few memoranda on the general plan of operation; and *thirdly*, a Tabular Statement of the position of each wreck, the number of charges and quantity of powder expended.

BATTERY.—The Battery employed was one of Siemen's Magnetic Transmitting Instruments which was obtained from the Telegraph Department. It consisted of a powerful built up magnet, between whose poles an armature containing the coil was made to rotate at a very high speed by means of a multiplying wheel. It fitted into a mahogany case, and the whole was contained in a stout deal box 1 ft. 8 in. by 1 ft. 8 in. by 1 ft. 3in., which could be carried easily upon a bamboo by two coolies. The chief advantages of this kind of battery over the voltaic arrangements are portability, strength, constancy and the absence of all acids. There are two disadvantages however,—*first*, the necessity for perfect insulation in the conducting wire; and *secondly*, the impossibility of ascertaining that such is the case without exploding the charge.*

WIRE.—Gutta percha covered, No. 16 gauge copper wire, was used in all the operations, but I do not think it is by any means the best form of conductor which might be employed with a magnetic battery; for, even when the gutta percha covering is quite new, it is liable to be cut or chafed by coming in contact with any sharp substance in a strong tide-way; it melts when exposed to the heat of the sun if not carefully looked after and wetted constantly, besides it deteriorates and is apt to crack after the wire has been

* The latter objection is perhaps more probably attributable to the form of fuze employed.—W. A. J. W.

used five or six times. If the gutta percha covered wire were paid over with strong tape soaked in a water-proof composition, a great source of uncertainty would be lessened. Professer Abel says, "a copper wire of the same gauge coated with India Rubber and provided with an efficient protective hemp covering, is considered to possess undoubted advantages over gutta percha covered wire."

FUZES.—The Fuzes were similar to those invented by Professor Abel for Wheatstone's Magnetic Exploder, (*vide* R. E. Professional Papers, Vol. X.) The fuze composition consists of nine parts of the subsulphide of copper, two parts of the subphosphide of copper, and three parts of chlorate of potash; but in the composition prepared here the addition of one part of sulphur was found necessary, owing, perhaps, to a slight difference in the materials used, or in the mode of preparing them, which was as follows :—

SUBSULPHIDE OF COPPER.—Brask a crucible with charcoal; then melt in it as much sulphate of copper as can be got in, adding more as the sulphate becomes reduced by heat. Having brought the whole to a white heat allow it to cool.

SUBPHOSPHIDE OF COPPER.

Electrotype Copper well pounded	8 parts	Well mixed.
Bone ash (stags' horns are best)	10 ,,	
Very clean fine sand	5 ,,	
Borax............................	5 ,,	
Charcoal	1 part	

Raised to a very high heat in a brasked crucible for about one hour.

RECEPTACLES FOR THE CHARGES.—Hogsheads, half-barrels, and kilderkins were employed. They were capable of holding respectively 500, 300 and 150lbs. The two large sizes, which were used in almost all cases where the water was more than 3 fathoms deep, required strengthening at the ends to enable them to resist the external pressure. This was effected in several ways (*vide* Plate I.); but I do not think any method superior to that shewn in Figure 3, which was adopted by Sir C. Pasley in his operations upon the wreck of the *Royal George*. It is simple and effectual and would have been employed from the first had I known that coopers were available. Out of twenty-four barrels prepared on the plan shewn in Figure 1, only two yielded at the ends, although most of them were subjected to very severe trials. The method shewn in Figure 2, although apparently more efficient, was not nearly so successful; this I attribute to the work having been unavoidably executed without personal supervision; for, by referring to the drawings, it may be seen that unless the two iron rods which pass underneath the head of the barrel are in contact with it throughout, they will be of little use as supports.

When the ends of the barrel have been strengthened, a leaden tube 12 in. long by 1 in. in diameter closed at the inner end, having a collar about 6 in. in diameter, soldered round the outer end, is let into a hole carefully cut in the side of the barrel for its reception; a washer of canvas soaked in pitch and tar is placed under the collar, which is then tacked down to the barrel. This done, the whole of the barrel, after being well paid over with a mixture of pitch and tar, is sewn up in strong canvas and again paid over with the composition. The canvas is only necessary if the charges have to remain a long time under water, and may be dispensed with when they are to be exploded immediately on being lodged.

In Plate II., Figure 1 shews the fuze, and Figure 2 shews the manner of placing it in the bursting tube. The fuze with the wires attached is inserted, a small quantity of powder is then poured in, and the remainder of the tube is filled with Kitt's composition, which is first worked up between the hands until of about the same consistency as glazier's putty and then well rammed in with a stick. Melting the composition and pouring it into the tube, a plan which answered very well in a cold climate like England where the cement became hard almost immediately, was found to be a very slow process here. Several compositions, consisting of pitch, bees' wax, and tallow in various proportions were tried for closing the bursting tubes; but, owing to the difficulty of procuring good pitch, some disappointments were met with in the earlier operations. Latterly, Kitt's cement, which is an ordnance store, (used in fitting the fuzes of shells) was employed, and answered the purpose satisfactorily.

The barrels were slung and weighted as shewn in Plate II. Fig. 3; the weight varying according to the size of the charge, and the strength of the tide. Some times in a strong tide-way a charge of 500lbs. of powder required a weight of about 400lbs. to sink it; whereas in slack water less than half the amount was sufficient.

Boats.—The boats used for lowering the charges were the ordinary heave-up boats belonging to the Harbour Master's Department. They are fitted with a davit and windlass and are capable of lifting upwards of three tons; smaller and more manageable boats would have answered better, but there were none available. Anchor boats, which are of the same description, but larger and fitted with more powerful purchases, were employed for lifting the debris of the iron ships after the explosions.

Divers.—The want of a trustworthy diver skilled in using the diving apparatus was much felt. Several amateurs and professionals were tried, but no satisfactory results were obtained, and on one or two occasions accidents were narrowly escaped. The employment of any but a first class diver is to be avoided in operations of this sort, for, in addition to the natural difficulties a man has to contend with in the Hooghly, such as the strength of the tide,* the under-currents, quicksands, &c., he has to descend among masses of wreck and risk getting his ropes and air tube entangled in the same.

The native divers rendered very valuable assistance in marking out the positions of the wrecks and of their different parts, and in guiding the charges to the intended positions. They are able to go to great depths, but as they could only remain about one minute under water, and ascertain the state of things only within reach of the bamboo or rope along which they have descended, they could not report very accurately upon the effects produced by the explosions.

* From March to July, when the south-west wind blows, the spring tides run from 4 to 6 miles an hour, and from July to November the ebb lasts from 8 to 10 hours, running at the rate of about 5 miles an hour. Between November and February the spring tides run from 3 to 4, and the neap tides from 1½ to 2 miles an hour.

PLAN OF OPERATION.—Having ascertained the locality of the wreck, the next step is to mark its position accurately; this is done by sending down divers, who tie ropes to the bow, stern, and all other important points, such as the hatchways, masts, &c., the ends of those ropes are then buoyed with small pieces of wood. Three or more large buoys should be placed round the wreck at distances of about 50 yards from it, to which ropes may be attached for the purpose of hauling the boats into the positions required for lowering the charges.

To place the charges in the most advantageous positions is of course a very important matter, and the method of doing so must vary with circumstances. When the vessel to be operated upon lies on an even keel or nearly so, the barrels can, with very little difficulty, be lowered down the hatches by tying the sling of the barrel loosely to a long bamboo held firmly with one end in the hatchway, and allowing the barrel to slide gently down, until it has reached the bottom, when the bamboo can be withdrawn. This simple means of getting the charges into the desired positions was employed in all cases where advantage could not be taken of the tide or current to carry the barrels against the side or under the bilge of the wreck. For instance, when a vessel is lying up and down stream on its beam ends, there is nothing against which the barrel can take on the keel side at all events, and by lowering it vertically, it may be, although exactly below the keel, some considerable distance from any part of the wreck. Whereas by causing it to slide along the bamboo held in a slanting position it can at once be placed in contact with the underside of the vessel if required. When a vessel lies across the stream there is no difficulty in getting the charges against it, for the tide then does the work of the bamboo if the barrel is not too heavily weighted.

The best time for working was found to be, as a general rule, just before and after low water; it was then possible to place charges on one side of the wreck during the last of the ebb, and on the opposite side when the flood made, from which disposition very effective simultaneous explosions were often obtained; besides, the water being then shallower, it was easier to place the charges advantageously. If the vessel is in a strong tide-way it is preferable to work during the neaps; should, however, the wreck be partly uncovered at low water, as was the case with the *Lady Franklin*, *Ville de St. Dennis*, and *Govindpore*, spring tides are the most convenient for two reasons,—*first*, you can at low water see more of the wreck and place the charges better; *secondly*, as the flood tide comes in with a rush, the wreck is sooner covered, and consequently the charges have not to remain so long under water, for it is unsafe to fire them while any portion of the wreck is above the surface, owing to the liability of pieces of timber to be blown into the air. On one occasion, while working at the *Ville de St. Dennis*, a charge of 300lbs. had been successfully placed inside the remains of the wreck, and was to have been exploded when the tide had risen sufficiently, but the coming in of an unexpected bore obliged us to fire it while there was still a good deal of the timbers uncovered, in order that the boats might get away to a place of safety, for the bore rushes along the Howrah side at this point with great force. The result was very unpleasant, several pieces of wreck were blown high into the air, and some of them fell into the boat, but fortunately nobody was seriously hurt. A very small depth of water over the wreck effectually prevents any part of it rising with violence above the surface when the explosion takes place.

SIZE OF CHARGES.—The size of the charges when they cannot be placed inside or under the wreck should, in my opinion, be regulated by the depth of the water.

In from 4 to 9 fathoms, charges of between 450 and 500lbs. were found to answer very well, but I think they might have been increased with advantage at the latter depth.

Between 3 and 4 fathoms, 250 and 300lbs. charges are generally the most economical; a larger quantity simply throws the water to a greater height without producing a corresponding increase in the destructive effect. If, however, the case is such as will admit of a barrel being placed in the hold, or completely under the vessel, a charge of the larger magnitude might be employed with advantage. The *Lady Franklin's* deck was partly above water at low tide when a charge of 475lbs. was lowered down each of her hatchways, and a fourth charge of 275lbs. was placed under her stern at the port side; these were ignited simultaneously at high water; the explosion was not very violent, but the effect was quite satisfactory, although the demolition was by no means complete. Had the vessel been empty, instead of being heavily laden with rice, and situated in a strong tide-way, instead of comparatively slack water, it is quite possible that the simultaneous explosion of these four charges would have entirely destroyed the wreck. It has been stated that a strong tide is objectionable whilst these operations are being carried on, as it increases the difficulty and uncertainty of placing the charges, but at the same time it greatly assists the work by removing the pieces of wreck not quite detached, which would otherwise hang on.

THE DISTANCE BETWEEN THE CHARGES.—In laying two or more charges for a simultaneous explosion care should be taken that they are not put too close together; for, in the event of one failing to ignite, it would be liable to collapse from the concussion produced by the explosion of the other. In estimating the safe distance, I think one should be guided by the depth of the water, and allow once and a half the depth to be the least distance between any two charges.

When operating upon the *Southern Cross*, the first two charges were placed 55 feet apart on the same side of the wreck, the depth of the water being 48 feet; only one exploded, and on the other being raised, it was found that the end had been partially stove in and the powder in consequence destroyed. The non-ignition was satisfactorily accounted for on examining the conducting wire, which was found to have been laid bare for about one inch, from the gutta percha covering having come in contact with some sharp substance, probably a projecting sheet of copper on the ship's bottom. A great source of uncertainty in submarine explosions would be removed by using a conducting wire which could not be injured in this way, for the slightest flaw in the covering of the wire is sufficient to ensure failure when electricity of high tension is employed.

W. A. J. W.

Tabular Statement of Wrecks totally and partially destroyed by Gunpowder in the River Hooghly during the years 1864-65.

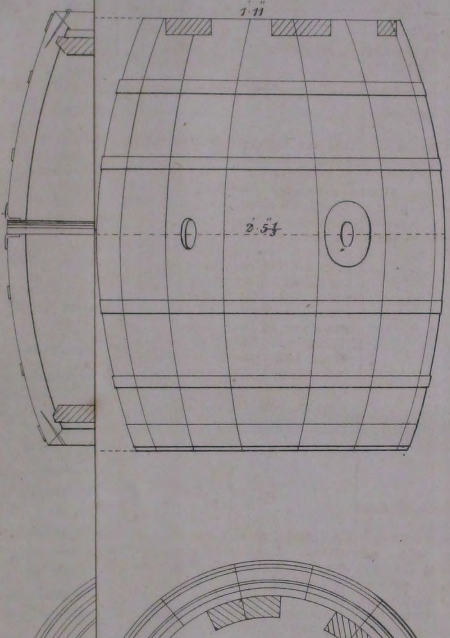
Date of Operation.	Names and Descriptions of Wrecks.	Situations.	Quantity of Powder Expended.	Remarks.
1864.	*St. Leonard. Express.*			
12th May 23rd ,, From June to September.	These were two wooden vessels, which took fire and were sunk at their moorings near the Government Dockyard in December 1863	They lay alongside each other close to the shore. The side of the *St. Leonard* next the bank was almost completely buried, the ribs projecting only 1 or 2 feet above the surface of the mud. These ribs were visible at low water, when the depth between the wrecks varied from 2½ to 6 fathoms, and outside the *Express* from 4 to 7 fathoms. Both wrecks were full of mud.	About 6,740 lbs., in 23 charges, varying from 500 lbs. to 45lbs. each. Two charges of 450 lbs. and one of 45 lbs. were non-effective	The whole of the *Express* and the outerside of the *St. Leonard* were removed sufficiently to admit of the moorings being re-occupied.
	Waterloo.			
From 4th to 16th June	An iron ship, which sank at the southern end of the James & Mary Sand close to Hooghly Point.	The depth of the water over the hull of the vessel averaged 4 fathoms at low tide. She lay upon her port side; masts pointing up the river; deck nearly vertical. Round the vessel the average depth of the water was 7 fathoms.	5,000 lbs., in 10 charges of 500lbs. each. No failures.	The wood-work of this ship was of course blown to atoms, and the iron sides were much shattered, but the exact nature and extent of the damage could not be ascertained by the native divers owing to the depth of the water and the great strength of the tide off this point at all times.
1865.	*Banshee.*			
From 13th to 20th January.	Tug Steamer, sunk during the Cyclone of 5th October, 1864.	Nearly in the centre of the river, off Baboo Ghât, about 3 fathoms all round the wreck at low tide.	16,000 lbs. divided into 5 charges. No failures.	The hull of this vessel was entirely destroyed and the machinery was much shattered.

Date of Operation.	Names and Descriptions of Wrecks.	Situations.	Quantity of Powder Expended.	Remarks.
1865.	*Lady Franklin.*			
From 27th January to 4th Feb.	1,187 tons, 190 ft. long, drawing 21 feet 11 in. sunk during the Cyclone of 5th October, 1864.	On the edge of the sand, opposite Prinsep's Ghât; 4 fathoms at low water all round the wreck.	4,100 lbs. in 11 charges. No failures.	This obstruction, although not in the immediate track for shipping, was causing the channel to contract. Its total demolition was effected, and a week afterwards there was an increase of five feet in depth where the sand had been forming.
	Azemia.			
15th March 16th ,, 22nd ,, 23rd ,, 24th ,, 3rd April.	Iron ship, 1,179 tons, 210 feet long, sunk in the Cyclone of 5th October, 1864.	Near Howrah Railway Ghât, a little south of the *Vespasian*, in 6 fathoms of water, $1\frac{1}{2}$ fathoms over her deck at low tide.	5,100 lbs. in 12 charges. Three failures (1,260 lbs.) owing to the barrels having been badly prepared.	This vessel was much shattered, all the wood-work came to the surface of the water, the two steel masts which had been standing were blown out and afterwards recovered. The exact result of the explosions could not be ascertained as no professional diver was willing to venture amongst the broken pieces of iron; but the Harbour Master and his Assistant sounded over the wreck and could not find any obstruction.
	Ville de St. Denis			
16th March 26th ,, 4th April 7th ,,	503 tons, 130 feet long, drawing 18 feet 6 inches sunk during Cyclone of 5th October, 1864.	Close to the Howrah shore on top of the tugsteamer *Linnet*, a little to the southward of the railway station, and interfering with the traffic to the coal jetty.	2,400 lbs. in 8 charges. No failures.	This wreck was completely demolished.
	Vespasian.			
10th Feb.	Iron ship, 919 tons, 180 feet long, drawing 19 feet 6 inches sunk during Cyclone of 5th October, 1864.	Near Howrah railway Station, in 6 fathoms at low tide, lying across the tide, heading towards Howrah.	1,400 lbs. in 3 charges, 1 of which met with an accident in being lowered and was lost.	Operations were suspended at this vessel in order to proceed and blow up the *John Vanner* and were never resumed, as the Harbour Master having carefully examined the locality reported all clear to a depth of 5 fathoms.

Date of Operation.	Names and Descriptions of Wrecks.	Situations.	Quantity of Powder Expended.	Remarks.
1865.	*John Vanner.*			
From 10th to 25th February.	726 tons, 170 ft. long, drawing 20feet,wrecked on 30th Jan. 1865.	Off Nynan, lying on her starboard side, across the tide, 1½ fathoms above the wreck, and about 6 fathoms immediately round her at low tide.	4,000 lbs. in 14 charges. One charge of 300 lbs. and one of 160 lbs.were lost.	This wreck was completely broken up, and after the spring tides which followed, no traces of it could be found. The charge of 300 lbs. which failed, was so jammed amongst the debris of the wreck that all efforts to raise it proved ineffectual. The barrel containing 160 lbs. was stove in while being lowered.
	Satellite.			
From 1st to 14th March	Tug Steamer, sunk during Cyclone of 5th October, 1864.	Near the centre of the river, opposite to Bankshall Ghât. Depth of water round the wreck varied between 3 and 4 fathoms at low tide.	2,950 lbs. in 14 charges. Two failures (450 lbs.)	The whole of the hull of this steamer was destroyed and the machinery began rapidly to disappear into the mud. The 300 lbs. charge was lost from the barrel being insufficiently strengthened. The 150 lbs. charge did not explode and was broken in being raised owing to its having got foul of the machinery.
	Margaret Davis			
From 14th to 18th April.	Barque,271tons, 130 feet long, drawing 15 ft., lost in April, 1865.	On the Rungafullah Sand near Middle Point, 3 fathoms over the wreck and an average of 6 fathoms all round it.	2,250 lbs. in five charges. No failures.	Complete demolition. Some of the charges had to be raised and lowered several times before they were made to explode, owing to the wire having been laid bare by rubbing against the wreck.
	Hindustan			
From 22nd to 28th April.	P. and O. Hulk, sunk during Cyclone of 5th October, 1864.	Off Camperbatch's Point, in Garden Reach, about 8 fathoms of water immediately round the wreck and 4 fathoms above it.	4,400 lbs. in ten charges. Two failures (875 lbs.)	The depth of the water and the great velocity of the tide at all times off this point rendered it dangerous for divers to go down, and consequently made the laying of the charges a very difficult operation. The complete removal of the wreck was however effected, and one of the Harbour Masters reported that the dangerous eddies caused by the obstruction had disappeared entirely.

Date of Operation.	Names and Descriptions of Wrecks.	Situation.	Quantity of Powder Expended.	Remarks.
1865.	*Govindpore.*			
From 18th to 30th May. 25th July. 8th & 9th August.	A new iron ship 1,357 tons burden, 253 feet in length, sunk during the great Cyclone of 5th October, 1864.	Near the Bonded warehouse wharf, lying on her port side with her bow close to the shore, the forecastle and starboard side for some distance from the bow being visible at low water. At the stern the depth was about 4½ fathoms, and the whole hull was just covered at high water.	4,284 lbs. in 25 charges. One charge (250 lbs.) lost.	The proximity of certain lofty houses, some of which were shaken in an alarming manner, when only 300 lbs. of powder were exploded, necessitated the employment of very small charges. This, together with the fact of the vessel being of iron and very strongly built, rendered the operation a very tedious one. The whole of the upper or starboard side was blown to pieces, the three masts were knocked out, and the interior of the ship was completely shattered; an anchor boat was then employed in raising the debris, and by the 1st July there was a depth of 9 feet at low water above the highest point of the wreck.
	Futteyool Aziz.			
19th 29th to 30th August 17th & 18th September	A very old wooden ship, 894 tons, 175 feet long, drawing 19 feet 3 inches, sunk in Garden Reach on the 11th Aug. 1865.	Up and down stream, leaning over on her port side; fore and mizen masts standing; part of the rail of the poop visible at low water. The depth of water round the wreck varied from 5 to 7 fathoms.	4,600 lbs. in 12 charges. Four failures (1,400 lbs.)	Complete demolition. The barrels supplied from the Dockyard for the demolition of these two wrecks were not so carefully prepared as usual, the proportion of failures was consequently much greater than on any previous occasion. Out of 20 barrels six yielded at the ends to the external pressure in 7 fathoms of water.
	Southern Cross.			
1st Nov. 2nd " 3rd "	575 tons, 130 ft long, drawing 12 feet, sunk in the stream off Hautkhola about the middle of October, 1865.	Lying across the stream on her starboard beam ends; bows pointing towards the Calcutta side; average depth of water 7 fathoms at low tide.	3,600 lbs. in 8 charges, of which 3 were non-effective	Complete demolition. One barrel was stove in by the explosion of another, which was placed too close to it. A simultaneous explosion was intended and would have taken place, but that the gutta percha covering of the conducting wire leading to one received a slight injury as the charge was being lowered.

Fig 3.



Lithographed at the Royal Artillery Institution

PAPER XII.

EXPERIMENTS ON IRON ARMOUR.

By LIEUT. COL. INGLIS, R.E.

The last account left off at Page 166, Volume XIV., with a description of the first day's firing at the "Hercules" target.

Although not quite the next in order, the further trial of the same target will be first noticed here.

"Hercules" target, further trial 7th Dec., 1865.

It will be remembered that on the first day's practice, guns of 9·22, 10, and 10½ in. calibre, failed to do any serious injury to this target. It remained, therefore, to ascertain how it would resist the hardest hitting gun in existence; namely, our 13-inch gun, commonly called the 600 pdr., described at page 132, Volume XIII.

The range used on this occasion was 700 yards.

The first shot was of steel, cylindrical, weighing 573 lbs., and 17 ins. long. It was fired with a charge of 100 lbs. of powder, which gave a striking velocity of 1,268 feet per second, its energy on impact being represented by 6,388 foot tons, or 156 foot tons per inch of shot's girth. It struck the 8-inch plate in front of a rib, and buried itself in the target, with its base 3 or 4 inches in from of the face of the armour. One rib was broken, and another bent, the inner skin was slightly bulged, and a few rivets were broken.

Another shot, of almost exactly the same kind, gave nearly the same results.

After this a chilled shot, weighing 577 lbs., with the same charge, struck the 9-inch armour with a velocity of 1,310 feet per second, but too high up, and too near the edge of the plate to give any useful result. Another shot, of the same kind, striking the 8-inch plate, just above one of the steel shot before described, penetrated the target, breaking one rib, bulging two others, and bursting open the inner skin over a length of about 4 feet, besides doing other damage. The shot itself broke up into innumerable pieces, and with the splinters from the target, would have been very destructive between decks.

A third chilled shot, weighing 580 lbs., with the same charge, struck the 8-inch armour and buried itself in the target. It broke up of course, and when the fragments were removed, the depth to which it had reached was found to be 22 inches; there was very little effect on the back of the target. The velocities of the last two shots were not taken.

These three chilled shot had the ogival head, the curves of which were struck with radii equal to 1·25 diameter of shot.

A blind steel shell, weighing 567 lbs., next struck the 9-inch plate with a velocity of 1,307 feet per second, its energy on impact being equivalent to 6,482 foot tons, or 159 foot tons per inch of girth of shot. It cracked the armour a good deal, and made an indent $3\frac{1}{2}$ in. deep. There was very little injury behind, but the whole structure seemed to have been moved more than usual.

Thus, it will be seen that in no instance was the target penetrated when struck on a sound place; the only shot which did penetrate having struck close to a hole made by a previous round. It is a pity this experiment was not carried a little further, to ascertain whether, at any range, this gun, with 100 lbs. charge, could penetrate the "Hercules," but considering that the loss of velocity in the shot while passing over 700 yards did not reduce the work stored up in it by more than 18 or 20 per cent., it is not improbable that the gun would have failed to effect complete penetration even with its muzzle close to the target; and it must not be overlooked, that the charges used on this occasion were some 30 per cent. above what, after further experience, has been fixed as the limit for the battering charges of this or any other gun of like calibre.

A short time before the last experiment a steel shell, designed by Captain Alderson, R.A., fired from the 7-inch wrought-iron muzzle-loading gun of $6\frac{1}{2}$ tons, succeeded in completely penetrating the "Warrior" target, and it was the first instance of this being done by a steel shell of so small a calibre as 7-inch, although Whitworth accomplished very nearly the same thing from a 7-inch gun in 1862. The object sought to be attained in the construction of this shell, was that of attaching the head to the body in such a manner that the bursting charge should, on explosion, blow the head forward, and exert all its force in the work of penetration, and it certainly did this with great success. The shell, when filled, weighed 103 lbs., the bursting charge being 3 lbs. 5 oz. It was fired with a charge of 25 lbs., at a range of 200 yards.

Spherical steel shot against $4\frac{1}{2}$ and $5\frac{1}{2}$-inch plates on 'Bellerophon' backing. 1st and 21st Dec., 1864.

It may be well here to notice briefly an experiment which was not included in former accounts, where spherical Bessemer steel shot were used against $4\frac{1}{2}$ and $5\frac{1}{2}$-in. plates, fixed to a backing similar to that of the "Bellerophon," described Vol. XIII, page 129.

The 68-pdr. with a steel shot of $76\frac{1}{2}$ lbs. to 77 lbs., charge 16 lbs., striking velocity 1,322 ft. per second, and energy on impact equivalent to 930 foot tons, or $37\frac{1}{2}$ foot tons per inch of shot's girth, broke through the $4\frac{1}{2}$-in. plate and remained sticking there.

The same shot on the $5\frac{1}{2}$-in. plate made indents of from 3 to 4 inches deep, but did not quite break through.

The 100-pdr. smooth bore gun, with a steel shot of 104 lbs. to $104\frac{1}{2}$ lbs., charge 25 lbs., striking velocity 1,475 feet per second, and energy on impact of 1,573 foot tons, or $56\frac{1}{2}$ foot tons per inch of shot's circumference, broke through the $5\frac{1}{2}$-in. plate, and made a total indent of from 7 to $8\frac{1}{2}$ inches deep.

Also a steel shot of 165½ lbs., fired, with a charge of 35 lbs., from the 10½-inch or 150 pdr. muzzle-loading gun of 12 tons, struck the 5½-inch plate, with a velocity of 1,461 feet, energy on impact being 2,450 foot tons, or 75·3 foot tons per inch of circumference of shot, and passed clean through the target.

In the course of the year 1865 the subject of determining the relative penetrative effect of two shot striking with equal energy, notwithstanding that one should be heavy with low velocity, and the other light with high velocity, was revived, and some experiments were set on foot in this direction, as well as others, to shew the relative resistances of armour to shot of similar form of head from different guns, their energy on impact being proportionate to their diameters.

Commencing with the first point—

Shot of different weights striking with equal energy. 22nd March, 1865, and 13th March, 1866.

The gun used was the 6·3 inch muzzle-loading rifled shunt gun, at a range of 100 yards. The shot were of steel, hemispherical headed, 6·22 in. diameter, and of the following weights:

Spherical	35·5 lbs.
Elongated	71·0 lbs.
Ditto	106·5 lbs.
Ditto	64·0 lbs.

The charges were arranged so that each shot struck with the same energy.

The armour was of 5½-inch rolled iron unbacked.

The spherical shot, with a charge of 15·848 lbs., struck with a velocity of 1,920 feet per second; the 71 lb. shot, with 12 lbs. of powder, struck with a velocity of 1,345 feet; the 106·5 lbs. shot, with a charge of 11·219 lbs., with a velocity of 1,110 feet; and the 64 lbs. shot with 12 lbs. of powder, struck with a velocity of 1,417 feet per second. The energy was nearly the same in all, and the effects were very nearly the same; that is to say, the plates were every time perforated, and the shot buried themselves in a bank of earth behind, to depths varying from 3 ft. 3 in. to 5 ft. 6 in.

Subsequently, this experiment was repeated against 4½-inch unbacked plates with the same gun, the charges being arranged so that the shot should strike with a force which would be *just* sufficient to penetrate.

The energy was very nearly constant, and the effect was in each case to do as nearly as possible the same work, namely, just to penetrate the plate.

The conclusion drawn therefore was, that armour unbacked will be perforated with equal facility by steel shot, of similar form of head and the same diameter, provided their energy on impact is the same; and it is immaterial whether this energy be the result of a heavy shot with low velocity, or a light shot with high velocity.

Next, as to the other point, namely, what would be the relative penetrations of two shot, of similar form of head, from different guns, striking with work proportionate to their respective diameters.

Shot of different diameters striking with equal energy.

The guns used in this experiment were the 6·3-inch and 7-inch muzzle-loading rifled guns, and the 100 pdr. 9-inch smooth bore gun. The range was 100 yards.

The 6·22-inch spherical steel shot weighing 35·5 lbs., with 13·875 lbs. of powder, and a velocity on impact of 1829 ft., giving an energy on impact of 824·9 foot tons, just perforated a 5½-inch unbacked plate; and a 6·88-inch cylindrical shot, weighing 110 lbs., with 12 lbs. of powder, and a velocity on impact of 1,090 ft., giving 906 foot tons for its energy on impact, did exactly the same.

Also, a 6·92-inch cylindrical steel shot, weighing 100·3 lbs., with a charge of 13·5 lbs., striking with a velocity of 1,131 ft. per second, giving an energy of 889 foot tons, and an 8·87-inch spherical steel shot, weighing 104·125 lbs., with a charge of 15·437 lbs., striking with a velocity of 1,254 ft., with an equivalent energy of 1,135 foot tons, both did as nearly as possible the same thing, that is, they both passed through the plate (5½-inch) and with nearly equal facility.

With a similar result, the 6·92-inch rifle shot, of 100·3 lbs. was compared with the 8·87-inch spherical shot, of 104 lbs. with reduced charges, and the 6·22-inch rifle shot with the 8·87 spherical, in each case the energy being proportional to the different diameters of the shot.

The conclusion therefore here drawn was, that unbacked armour will be equally penetrated by solid steel shot of the same form of head but different diameters, provided their striking energies vary as the diameters.

Resistance of plates as the squares of their thicknesses.

It was also observed in the course of the above experiments, that while a 6·22-inch spherical projectile, from a 6·3-inch gun, is *just* able to penetrate a 5½-inch plate with energy on impact of something less than 825 foot tons, both spherical and cylindrical projectiles, of various weights, from the same gun, were just able to penetrate a 4½-inch plate with a work of 542 foot tons; and from this the conclusion was drawn that the resistance of unbacked armour of the best quality to penetration by solid steel shot of similar form and equal diameter, varies nearly as the squares of the thicknesses. But, for the present, too much dependence must not be placed on this rule.

After the very great success that had attended the use of projectiles cast in chill, as advocated by Major Palliser, in many recent trials, it became desirable, in the early part of 1866, to follow up this invention more closely, and with that view a series of experiments was put in hand which will now be described.

Palliser projectiles against inclined plates 22nd and 23rd May, 1866.

After a short preliminary trial against 5½-inch inclined plates, with shot cast in chill, from the 7-inch breech-loading gun, from which nothing is to be learnt, except that the hemispherical form is not well suited for chilled shot intended for penetration, another experiment was carried on at Shoeburyness, on the 23rd May, 1866, against unbacked 4½-inch armour set up at an angle of 52° from the vertical. The object here was to ascertain the effects of chilled shot, with pointed heads, in comparison with steel, when fired under circumstances that of course will principally occur in actual engagements.

The gun used was the 7-inch rifled muzzle-loading gun, and the range was 200 yards.

The result did not afford any satisfactory comparison between chilled iron and steel, as there was no fair hit with the projectiles of the latter material;

but two chilled shot, with pointed heads, one weighing 115 lbs. 3 oz., and the other 113 lbs., fired with 22 lbs. charges, completely penetrated the plate, and so far proved themselves effective against highly inclined surfaces of iron. These two shot struck with velocities of 1,339 and 1,372 ft. respectively, their energies on impact being 1,432 and 1,475 foot tons, which are equivalent to 66 and 68 foot tons per inch of shot's girth. A similar shot, with a somewhat more pointed head, hereafter described, and called the "Belgian" head, striking with a velocity of 1,339 feet made a jagged indent 12 in. long, and a small hole through the plate, but did not itself penetrate.

Another chilled shot, with pointed head, weighing 114 lbs., fired with a 16 lbs. charge, striking velocity 1,277 ft., energy on impact 1,289 foot tons, or 59·47 foot tons per inch of shot's girth, scooped out a hole 11 in. by 6½ in. and about 2 in. deep.

The effect of a steel projectile would have been very little if any more than this. It may be well here to remark, that a 7-inch vertical unbacked plate, of the best make, would have been just penetrated by this last shot.

Chilled projectiles, with different forms of head,—1st June and 5th July, 1866.

The next trial was to ascertain the effect of chilled shot, with several different forms of head, in comparison with steel, against backed plates. The practice took place on 1st June, 1866, against a target composed of the 6-inch armour plates that were on the original "Bellerophon" target, described at page 129, Vol. XIII., backed by 18 in. of timber and a structure somewhat resembling that of the "Warrior," but a little inferior to it.

The gun and range were the same as in the last experiment.

The charge was 22 lbs. in all cases. The projectiles varied in weight from 115 lbs. to 117 lbs. and had the following forms of head, namely,—

The pointed head, now called "ogival," or arched, struck with a radius of one diameter, and brought to a point.

The "Belgian" head struck with a radius of 1·47 diameter, and cone-pointed.

The elliptical, the height of the ellipse being equal to the diameter of the projectile.

The hemispherical, which speaks for itself.

A chilled shot, with the elliptical or blunt head, striking velocity 1,328 ft. per second, energy 1,432 foot tons, or 66 per inch of shot's girth, passed through the armour and stuck in the timber backing; total depth of impression, 15 in. A chilled shot, with the "Belgian" head, same velocity and energy, completely penetrated the target, as did also both a steel and a chilled shot, with the ogival head and the same velocity, on rather stronger parts of the target. But a steel shot, with the hemispherical head, striking velocity 1,380 feet, energy 1,518 foot tons, or 69·85 foot tons per inch of shot's girth, only penetrated the armour, and lodged in the backing, the total depth of impression being 18 inches.

From this, and the experiment last described, it appears that for direct penetration, the Belgian and ogival heads are superior to the elliptical and hemispherical forms, and that for penetration in the case of highly inclined surfaces, the ogival is somewhat better than the more pointed Belgian head.

The practice of the 5th July, 1866, was against the same target as the last experiment, and the same gun and range were used. On this occasion, the advantage that the pointed head has over the hemispherical, was shewn in a marked manner. A steel shot with the latter form of head, struck the target fair between two ribs, with a velocity of 1,371 ft., the energy on striking being 1,498·9 foot tons, or 68·95 foot tons per inch of shot's girth, and penetrating the armour, only lodged in the backing, making a total impression of 14·5 inches; whereas, an ogival-headed steel shot, striking similarly in every respect, with a velocity of 1,360 feet, energy 1,481·4 foot tons, or 68·14 foot tons per inch of shot's girth, penetrated the whole target completely, and struck with some force an armour plate in rear. On this occasion, also, a chilled shell, with an ogival head, weighing 115·5 lbs., with a bursting charge 1·406 lbs., fired with a charge of 22 lbs., and striking with a velocity of 1,354 feet, completely penetrated the target, and burst on its way through. The head, and many fragments of the shell, including the screwed plug of its base, were found inside, and the target was set on fire.

Steel & chilled shells, against the "Warrior" target.—29th August, 1866.

The object of this experiment was to ascertain the best form of shell for penetrative and destructive effect; the best material, whether steel or chilled iron; and the most effective way of retarding the bursting of the shells. The gun used was the same as in the last experiment, namely, the 7-inch muzzle-loading wrought-iron gun, with a battering charge of 22 lbs.

The target was of the "Warrior" construction. There were several patterns of steel shells used, all weighing from 114 lbs. to 117 lbs., but the only one that actually penetrated the target was of the Ordnance Select Committee pattern, with a thick head, radius 1 diameter, and the base screwed on; its weight was 116 lbs. and it carried a bursting charge of 3 lbs. It struck with a velocity of 1,375·8 ft. and burst in the backing, carrying away a large portion of the supports, and breaking a hole about 11 in. by 10 in. in the skin.

Of the chilled shell, two weighing respectively 117 lbs. and 116·5 lbs., pointed head 10 in. radius, with the full battering charge, and bursting charge of 1 lb. 5 oz. struck with velocity of 1,365 ft., and completely penetrated the target. So, also, did a similar shell filled with sand, fired with a reduced charge of 18 lbs., striking velocity 1,262 ft. per second; and another chilled shell, fired with a charge further reduced to 16 lbs., penetrated to a depth of 9 in. measuring to the nearest point of the base of the shell. This shell struck fair on a rib, which it broke, and it was thought at the time that had it struck between two ribs, it would have effected complete penetration.

These results were considered to establish, in a great measure, the superiority over steel of chilled iron for shell, as well as for shot; the only drawback being the sacrifice of capacity for bursting charge in the chilled shell here used. The consequence was the immediate suspension of the manufacture of steel shells for the 7-inch muzzle-loading gun, and the substitution of chilled iron in future issues.

Further trials of steel and chilled projectiles. 13th and 14th Sept. 1866.

The experiments last described having shewn the superiority of chilled shell over steel in direct fire at the "Warrior," no time was lost in following it up with a more extended trial in the same direction. For this purpose, a target consisting of two faces was used; one stood directly facing the battery, the other was thrown back at an angle of 30°, so that it formed an angle of 60° with the line of fire of the battery.

The target consisted of 8-inch armour plates, backed with 18 inches of wood, on a skin and framing somewhat similar to the "Warrior," only that the ribs were placed at much closer intervals, in order that every spot on which a shot could be planted, should present one uniform resistance.

In determining the thickness of armour and strength of this target, it was intended that it should just allow the best projectile from the 9-inch 12-ton gun with the full battering charge, to penetrate the direct face; and the result, it will be seen, bore out these calculations.

The guns used were the 9-inch muzzle-loading gun of 12 tons, with the full battering charge of 43 lbs., and the 8·03-inch gun of 9 tons, with 30 lbs. charge.

The range was 200 yards.

First, with regard to the *direct* face.

A steel shot, weighing 250 lbs., with an ogival head, curves having a radius of 1 diameter, striking with a velocity of 1,338 feet, energy 3,103 foot tons or 110·7 foot tons per inch of shot's girth, penetrated the armour, and remained sticking in the backing. In rear 3 ribs were slightly bent, and one angle iron of a rib cracked through a rivet hole. This shot broke up.

Next, a flat headed steel shot of 245 lbs. striking with a velocity of 1,312 feet, energy 2,924 foot tons, or 104·4 foot tons per inch of shot's girth, only indented the armour to a depth of 4·6 inches, and rebounded 3 yards, with its head very much set up.

After this, four chilled iron shot of 252 lbs. with ogival heads, curves having a a radius of 1·47 diameter, were fired. They struck with a velocity of about 1,324 feet, energy 3,055 foot tons, or 109 foot tons per inch of shot's girth. In one instance, when the shot struck within 12 inches of a previous shot mark, the target was penetrated, but when the shot struck on a fair part, it only passed through the armour, sticking in the backing, making a hole 15 inches deep, and bulging one of the ribs in rear.

After this some shell were fired at the direct face from the same gun.

Of three steel shell with ogival heads, curves having a radius of 1 diameter, weighing from 252 to 254 lbs., carrying bursting charges of 7·3 to 8·12 lbs., striking velocity 1,329 to 1,337 ft., energies 3,111 to 3134 foot tons, or about 111 foot tons per inch of shell's girth, one only penetrated the armour and forced its way to a depth of 11 inches. The others only indented the armour 4·5 and 8·2 inches, and did little or no harm in rear.

The next two were chilled shell with ogival heads, radius of curves 1·5 diameter. The first of these weighed 248 lbs., and carried a bursting charge of $2\frac{1}{2}$ lbs.; velocity on striking 1,331 feet; energy 3,046 foot tons, or 108·7 foot tons per inch of its girth. It completely penetrated the target, bursting in its passage through. The head was picked up in rear uninjured. The other weighed 252 lbs., carried a bursting charge of 2·37 lbs., struck with a velocity of 1,323, giving an energy of 3,059 foot tons, or 109·4 foot tons per inch of its girth. This also completely penetrated the target, bursting in the backing. Its head, also, was picked up in rear uninjured. Thus far, therefore, the chilled material maintained its superiority in a very marked manner, as regarded both shot and shell.

After this a steel shot, from the 8·03-inch gun, with an ogival head, curves having a radius equal to 1 diameter, weight 178·5 lbs., striking velocity 1,282 feet, energy 2,034 foot tons, or 81·8 foot tons per inch of shot's girth, made a total indent of 10 inches. Then a chilled shot, from the same gun, weighing 177 lbs., with the same head as the last, struck with a velocity of 1,276 ft., energy 1,998 foot tons, or 80·4 foot tons per inch of shot's girth, and stuck in the armour, its fragments filling up the hole; but it appeared to have just got through the plate. Another chilled shot, very similar to the last, did, as nearly as possible, the same. Here, therefore, although the target was too strong for the gun, the chilled iron did quite as much work upon it as the steel.

Next, with regard to the *oblique* face of the target, inclined, as already said, at an angle of 60 degrees with the path of the shot.

A steel shot, with an ogival head, curves having a radius of 1 diameter, weighing 251 lbs., struck with a velocity of 1,340 feet, energy 3125 foot tons, or 111·5 foot tons per inch of shot's girth, and scooped out a piece of the armour 14½ ins. by 11 ins. and 3 ins. deep.

Another steel shot, with a flat head, weighing 245 lbs., striking velocity 1,310 feet, energy 2,915 foot tons, or 104 foot tons per inch of shot's girth, bit well into the plate, and forced it in to a depth of about 6·6 inches; two timber bolts were driven in, but no other injury was done in rear.

Then a chilled shot, with the Belgian head, weighing 252 lbs., striking velocity 1,326 feet, energy 3,072 foot tons, or 109·9 foot tons per inch of shot's girth, scooped out an indent 14 ins. by 11 ins., and 7·75 ins. deep; two timber bolts were broken and one rib slightly bent.

Of the shell that were fired from this gun at the oblique face, the following is a summary:

One steel shell with an ogival head, 1 diameter, carrying a bursting charge of 7·3 lbs., struck with a velocity of 1,345 feet, energy 3,155 foot tons, or 112·6 foot tons per inch of shell's girth, and scooped out a piece of the armour, 12 ins. by 11 ins., and 3·85 ins. deep; no effects in rear. Another shell, very similar to this, struck 14 ins. from it, and made an indent 8·25 ins. deep; no effects in rear. And a third made an indent 7·5 ins. deep, measuring to the base of head which stuck in the target.

Of two chilled shell, with ogival heads, 1·5 diameter, which struck this oblique face, one weighed 250 lbs., carried a bursting charge of 2·12 lbs., and struck with a velocity of 1,313 feet, energy 2,989 foot tons, or 106·9 foot tons per inch of its girth. The other weighed 250·5 lbs., carried a bursting charge of

2·5 lbs., and struck with a velocity of 1320 feet, energy 3027 foot tons, or 108·7 foot tons per inch of its girth.

The former struck within 16 ins. of two former shot marks, and broke through the armour, making its way to a depth of 19·5 ins. into the backing, measuring to the head of the shell. In rear, a rib was bent and one wood bolt broken.

The latter struck a fair part and made a hole 13 ins. by 10 ins. and 7·4 ins. deep. No effect behind.

Here then, again, if the chilled shell did not do more work in the inclined face of the target than the steel, at least they did as much, and that is all that could have been expected of them.

On the whole, this experiment was considered to have resulted in establishing, still more definitely, the advantage of using chilled iron instead of steel; and it only required a little further experience, on oblique surfaces, to warrant the adoption of this material in preference to steel, for all projectiles required in the service for battering purposes.

Steel and chilled projectiles fired obliquely against the "Warrior" target, 14th Sept., 1866.

Before finally deciding on this contest between steel and chilled iron for battering projectiles, it was thought right to give one day's trial against the "Warrior" target, inclined at an angle of 57° to the line of fire of the 7-inch muzzle loading rifled gun, of 130 cwt.

The gun was placed at 200 yards, but the charge was reduced to 20 lbs. in order to give a blow equivalent to that which the full battering charge would deliver at about 500 yards.

Only seven reliable results were obtained, in consequence of the target having previously been struck by such a number of shot that it was difficult to find a sound part to hit. Of these seven, two were chilled shot, two steel shot, two chilled shell, and one a steel shell.

The first chilled shot, weighing 115½ lbs., with an ogival head, curves having a radius equal to 1 diameter, struck with a velocity of 1,339 feet, energy 1,436 foot tons, or 66·2 foot tons per inch of shot's girth, penetrated the armour, and lodged in the backing at a depth of 17 inches; in rear, one rib was broken, and the shot appeared to be nearly through.

The second chilled shot, with a head, struck with a radius of 1·25 diameter, but in other respects very similar to the first, lodged in the backing at a depth of 15 inches.

The first steel shot, weighing 115 lbs., with an ogival head, curves having a radius of 1 diameter, struck with a velocity of 1,350 feet, energy 1,453 foot tons or 66·9 foot tons per inch of its girth, just penetrated the armour with its point, and scooped out a piece of the plate measuring 14 ins. by 8 ins. No damage was done in rear.

The second steel shot, weighing 113 lbs., flat headed, struck with a velocity of 1,320 feet, energy 1,365 foot tons or 62·7 foot tons per inch of girth, and penetrated the armour, lodging in the backing at a depth of 11½ inches, and breaking one rib.

The first chilled shell, weighing 115½ lbs., with an ogival head 1·5 diameter, bursting charge 1·25 lbs., struck the target with a velocity of 1,337 feet, energy

1,432 foot tons or 65·9 foot tons per inch of shell's girth, and penetrating the armour, burst in the backing, and forced its head to a depth of 14 inches. In rear the skin was cracked and bulged, and seemed as if the shell had nearly penetrated the whole.

The other chilled shell was similar to it, and did nearly the same work on the target.

The steel shell weighing 114½ lbs., with an ogival head 1 diameter, and bursting charge 3·5 lbs., struck the target with a velocity of 1,325 feet, energy 1,394 foot tons, or 64·1 foot tons per inch of girth, scooped a piece out of the plate 13 ins. by 8 ins., and indented to a depth of 8½ in. It burst when in the hole, and cracked a rib in rear.

Taking these results with those already described, it was proved that while the chilled projectiles, both shot and shell, did superior execution in direct fire on a ship's target as compared with steel, in oblique fire they were, certainly, in no way inferior.

Continuation of experiments with chilled projectiles. 24th October, and 3rd December, 1866.

On the first of the days named, the object of the experiment was to ascertain whether Palliser shot have greater penetrative effect than Palliser shell of small capacities; whether the capacities of these shell can be increased without detriment to their efficiency in other respects; and whether their penetration is facilitated by sharpening the points. It is scarcely necessary to describe this trial in all its detail. The target used was that of the strengthened "Warrior" construction, with 8-inch armour plates, as described above, in the experiment of 13th and 14th September. The gun was the 9-in. rifled gun, of 12 tons, with full battering charges, and the range 200 yards. In no instance did a solid chilled shot from this gun penetrate a sound part of the direct face of the target. One of Grüson's chilled shot, with Belgian head, striking within 12 inches of a previous shot, energy equivalent to 106·8 foot tons per inch of shot's girth, did get through the target; and so did a Palliser shot, with a head of 1·5 diameter, energy 109·3 foot tons per inch of shot's girth; both these struck on weak places, and must not be taken as fairly penetrating the target. The Palliser shell, with head 1·5 diameter, and bursting charge 2·5 lbs., energy 109·1 foot tons per inch of shell's girth, again completely penetrated the direct face; and one with an increased bursting charge of 5·25 lbs., also did the same.

It is curious that on subsequent occasions these shell failed to penetrate the target at the shorter range of 70 yards, an anomaly only to be accounted for by the supposition that the projectiles have for a certain distance some slight irregularity in their motion; and this is borne out by the fact that at 70 yards the projectile, 8·9 inches diameter itself, makes a hole in the armour of nearly 10 inches diameter, whereas at 200 yards the hole is 9 inches diameter.

A steel shell fired on this occasion burst on striking the direct face, and its head stuck in the armour with its point at a depth of 7½ inches, doing no further damage.

Neither shot nor shell could fairly penetrate the oblique face, inclined as before at an angle of 60° with the line of fire, and subsequently they also failed at 83° and 87°. The only shot that got through was a chilled shot with a head 1·5 diameter, energy 109·3 foot tons per inch of girth; but this struck 7 inches above a former shot mark, and 12 inches from another, so it cannot be taken as a fair penetration. The shell that could not penetrate had 1·5 diameter head, bursting charges 5·25 and 2·62 lbs., energy 108 foot tons per inch of girth.

Two shells were tried that had their heads chilled, but not their bodies, and these proved nearly as efficient as the shells wholly chilled; but as little or no advantage was gained by this attempt at partial chilling, either in facilitating the manufacture, or reducing the cost, it was not carried further.

The conclusion drawn from this day's firing, was, that against a structure altogether superior to the power of the gun, solid chilled shot will have more effect than loaded chilled shell; and this equally applies to surfaces inclined to the line of fire, at such an angle that the outer armour cannot be perforated. But on the other hand, where there is any chance of penetrating the outer armour, chilled shell should be used in preference to shot. The advantage of increasing the capacity of these shell to the full extent, consistent with their strength, was made evident on this occasion, and also that of sharpening the point of the head of all chilled projectiles.

On the second day's trial, namely, 3rd December, the object was to ascertain the relative superiority of chilled shell, when fired loaded and blind respectively in point of penetrative effect against very strong structures; to determine what form of head is on the whole best for chilled projectiles required for battering purposes; and to ascertain whether shot made of white iron, cast in sand, would be as effective as shot cast in a chill on Major Palliser's principle.

The gun used was the 9-inch 12-ton gun. Range, 200 yards.

The result of three blind chilled shell, which struck the direct face of the strengthened "Warrior" with 8 inch armour, was decidedly in favour of the use of loaded shell under such circumstances, for none of the three penetrated the target, whereas the loaded shell, in previous experiments, had passed completely through it.

The corresponding comparison between loaded and blind chilled shell on the face of the same target, inclined to the line of fire at an angle of 51°, did not lead to any reliable result.

Of an elaborate practice with 7-inch guns, land service of 140 cwt., and sea service 130 cwt., at 70 yards at the "Warrior" target, in the course of which some 56 chilled projectiles struck, the results may be briefly described as follows.

First, with regard to *direct* fire.

Chilled shell of 114·25 lbs., with ogival heads 1·25 diameter and 1·5 diameter, and bursting charges of 1·5 lbs., fired with a charge of 13 lbs. from the 140 cwt. gun, striking velocity 1,216 feet, energy 1,171 foot tons, or 54 foot tons per inch of girth of shell, completely penetrated the target and set it on fire. But similar shell fired with the same charge from the 130 cwt. gun, at the same range, striking velocity 1,180 feet, energy 1,110 foot tons, or 51·2 foot tons per inch of girth, did not quite penetrate.

Similar shell filled with sand, weighing 117 lbs., from the 140 cwt. gun, fired with the 13 lbs. charge, striking velocity 1,200 feet, energy, 1,170 foot tons, or 53·8 foot tons per inch of girth, did penetrate.

Chilled shot, weighing 115·5 lbs., with ogival head 1 diameter, from the 140 cwt. gun, striking velocity 1,211 feet, energy 1,174 foot tons, or 54·1 foot tons per inch of girth, penetrated the target. But similar shot from the 130 cwt. gun with a less striking velocity of 1,185 feet, energy 1,110 foot tons, or 51·2 foot tons per inch of shot's girth, did not go through.

White iron shot cast in sand, weighing 122 lbs. with ogival head, 1·64 diameter, fired with a charge of 16 lbs., striking velocity 1,245 feet, energy 1,312 foot tons or 60·5 foot tons per inch of girth, completely penetrated the target; but, unfortunately, there was not one of these fired with a charge calculated to give an energy corresponding with the chilled shot just described, and, therefore, a comparison between them cannot fairly be drawn.

Next, with regard to *oblique* fire at an angle of 60 degrees with the face of the "Warrior" target. A solid chilled shot with ogival head 1 diameter, weighing 114 lbs., charge 22 lbs., striking velocity 1,420 feet, energy 1,594 foot tons, or 73·4 foot tons per inch of shot's girth, completely penetrated the target. But with 20 lbs. of powder and the same range (70 yards), energy 1,473 foot tons or 67·9 foot tons per inch of shot's girth, these shot only penetrated the armour and lodged in the backing; and a shot with 1·25 diameter head, energy 1419 foot tons or 65·5 foot tons per inch of its girth, did much the same. Similar shot fired with 16 lbs. charge, energy 1,265 foot tons or 58·3 foot tons per inch of shot's girth, made a scoop in the armour from 5·5 to 7·2 inches deep.

A loaded chilled shell, weighing 116·25 lbs., with an ogival head, 1·25 diameter, bursting charge 1·25 lbs., fired with a charge of 20 lbs., striking velocity 1,331 feet, energy 1,428 foot tons or 65·8 foot tons per inch of shell's girth, penetrated the armour of the inclined face and lodged in the backing, breaking a rib and cracking and bulging the skin.

A similar loaded shell, fired with a charge of 16 lbs., striking velocity 1,245 feet, energy 1,258 foot tons or 57·9 foot tons per inch of shell's girth, only scooped out the armour to a depth of 7·4 inches; and two similar shell filled with sand, fired with a 16 lbs. charge, striking velocity 1,250 feet, energy 1,265 foot tons or 58·3 foot tons per inch of shell's girth, scooped to depths of 9·15 in. and 12·1 in. or somewhat deeper than the loaded shell, with the 16 lbs. charge.

Altogether, the results of this practice against the "Warrior" shew that, in direct fire the loaded chilled shell were somewhat more effective than the blind shell and the solid shot, but on the oblique face the loaded shell had certainly no superiority over the shell filled with sand or the solid shot.

Although no satisfactory comparison was made between the white iron shot cast in sand and the chilled shot, yet it appeared that some of the white iron was quite as hard as that cast in the chills. It appeared also, that if there was any difference between the results gained by the several forms of head used, it was in favour of that struck with the radius of 1·5 diameter.

In some few instances the loaded chilled shell passed through the "Warrior" without bursting.

The limit of resistance of the "Warrior" to chilled projectiles was very clearly defined in the course of this practice—thus an energy of about 54 foot tons per inch of projectile's girth was just sufficient to penetrate the direct face, and an energy of 73 foot tons was sufficient for penetration on the oblique face, when the angle of incidence was 60°.

9-inch gun against the "Warrior" at long range, 24th October, 1866.

This trial was to ascertain at what range the "Warrior" target would be penetrated by Palliser shell from the 9-inch 12-ton gun, and it was found that a chilled shell, weighing 249 lbs., with an ogival head, curves having a radius of 1·5 diameter, with a bursting charge of 2·5 lbs., fired with a charge of 23 lbs., representing a range of about 2,666 yards with the full battering charge, was sufficient to penetrate completely the side of the "Warrior." The shell struck with a velocity of 976 feet, energy 1,645 foot tons, or 58·9 foot tons per inch of shell's girth, and burst on passing through, doing considerable damage in rear.

From the experience gained in the former experiments described above, it may be assumed that a less charge would have effected penetration on this occasion, or in other words, that the 12-ton gun, with full battering charge, would penetrate the "Warrior" at a range little short of 3,000 yards.

Trial of various kinds of washers and bolts, 3rd Dec., 1866.

Advantage was taken of the experiments above described to put to trial several different suggestions that had been made from time to time for the improvement of the fastenings of armour plates. With this object one of the "Warrior" targets was fitted up in three different ways—namely ;

1st—Specially made wire bolts.

2nd—Palliser bolts, the principle of which is that a certain length of the stem or shank commencing where the thread ends, is reduced to the lesser diameter of the screw part. The thread of these was fine, (16 to the inch).

3rd—Ordinary bolts, with elastic washers under the nuts ; one sort of washer being made of Clarkson's patent material of cork and canvass combined ; the other of india rubber, confined in shallow wrought iron cups.

The different kinds of fastenings were distributed in alternate series of threes all over the face of the target; and without entering into detail, the result may be given as follows :—

The wire bolts failed altogether. The ordinary bolts with elastic washers stood nearly as well as the Palliser bolts without them, and there was little to choose between the two elastic materials. The cork, not requiring the iron cups, would be considerably the cheaper of the two.

This experiment cannot be considered a conclusive one as regards washers, as no doubt there are many other materials, such as leather, rope, and tough wood, that would answer the purpose very well.

7-inch gun at Chalmers' target obliquely. 8th March, 1867

This was a trial made for the purpose of comparing the resistance of the Chalmers target with that of the "Warrior," when exposed to oblique fire.

The target is described at page 138, Vol. XII., where it is shewn that the armour plates are $3\frac{3}{4}$ inches thick, backed by a compound mass of iron plates on edge, and wood between them, these being again backed by a second armour plate, $1\frac{1}{4}$ in. thick, with a cushion of wood behind, and skin and ribs something like the "Warrior's."

The gun used was the 7-inch rifled gun of 7 tons, at 70 yards, with battering charges of 22 lbs., fired at an angle of 60° with the target, and it was found that a chilled shot with a head of 1 or 1·5 diameter striking in a sound part, with an energy equivalent to 76·3 foot tons per inch of shot's girth, did not penetrate the target, the only damage in rear being one rib broken, one bolt and some rivets gone.

A Palliser shell was similarly stopped and burst in the backing.

With reference to the above, it will be remembered that this same gun has penetrated the "Warrior" at an angle of 60° with 73·4 foot tons per inch of shot's girth; but that target is lighter than the Chalmers by about 40 lbs. per foot superficial.

Plates of steel and iron combined. 14th May and 12th June, 1867.

Hitherto, all experience had taught that the armour capable of offering the best resistance under repeated heavy blows, from projectiles at high velocities, was that which was made of the toughest and most ductile iron; but these qualities can be obtained only in soft irons, and necessarily, armour so composed admits of deeper penetration by hard projectiles than other armour of a more brittle and crystalline nature.

With the great improvements that were taking place in the treatment of steel and cast-iron for projectiles, especially the latter, under Major Palliser's system, the comparative softness of our armour was considered by some a defect that might and ought to be remedied. With that view some of our leading steel and iron makers were consulted; and the result was that orders were given to two of them for the preparation of plates of steel and iron combined in various ways. It was expected that these would present all the advantages of good tough armour with the additional merit of obtaining in the steel greater powers of resisting penetration.

Messrs. Cammell & Co., of Sheffield, commenced by producing a plate 7 inches thick, composed of a number of very thin wrought iron and steel plates welded together in alternate layers. This was bolted to a mass of timber 42 inches thick on board the "Thunderer," at Portsmouth, and fired at on the 12th of March, by the 68-pounder and 7-inch guns, but failed completely. It scarcely resisted penetration so well as ordinary armour, and what was worse, it cracked very much and would soon have been knocked to pieces. The welding was good, but the attempt to make this perfect had evidently led to the injury of both the iron and the steel.

After this, some 7-inch plates were prepared by Messrs. Cammell & Co., as follows: one composed of $4\frac{1}{2}$ inches soft rolled iron with a face of $2\frac{1}{2}$ inches of steel welded to it; another of a centre of 3 inches of steel with two faces of 2 inches of soft iron; one of 4 alternate laminations of steel and soft iron of about equal thicknesses; and one standard rolled iron plate of their best make for armour. Messrs. Brown and Co. sent one soft rolled iron plate with a face of 3 inches of steel; one of the centre of steel with two outer layers of soft iron as before; and a standard rolled plate; all 7 inches thick. The Mersey Steel and Iron Company sent a 7-inch plate of hard iron, both hammered and rolled.

The plates were all 9 feet by 4 feet, set up vertically against upright timber frames, without backing, and were fired at by the 7-inch muzzle-loading rifled gun of 7 tons, at a range of 70 yards.

Without going over all the elaborate detail of two days' firing (14th May and 12th June) it will be sufficient to give the following results :—

The projectiles were all Palliser chilled shot with 1 diameter head.

The Mersey hammered and rolled iron plate, struck direct by a shot of 113·75 lbs., with 15 lbs. charge, striking velocity 1,276 feet, energy on impact 1,284·2 foot tons or 59·24 foot tons per inch of shot's girth, retained the base of the shot, the rest being picked up immediately in rear of the plate.

A shot of 113 lbs, with a 22 lbs. charge, struck the same plate at an angle of 60 degrees, and made a scoop of 13 ins. by 7·75 ins., and 4 ins. deep; in rear there was a bulge of 1 in. with a slight crack. The striking velocity of this shot was 1,423 feet, energy on impact 1,586·6 foot tons, or 73·19 foot tons per inch of shot's girth.

Next to this plate, and very nearly equal to it, was Messrs. Cammell's standard rolled iron plate. A shot of 116·87 lbs., with 15 lbs. charge, striking velocity 1,244 lbs., energy on impact 1,254 foot tons or 57·8 foot tons per inch of shot's girth, fired direct, stuck in it with its base 3½ ins. out, and its point showing 4 ins. in rear; and a shot of 114·5 lbs., fired with a 22 lbs. charge, struck the same plate at an angle of 60 degrees, and made a scoop of 11·5 ins. by 8 ins, and 5·5 ins. deep; in rear the plate was bulged and cracked rather more than the Mersey plate. The striking velocity of this shot was 1,455 feet, energy on impact 1,680·8 foot tons or 77·54 foot tons per inch of shot's girth.

There was, therefore, very little difference indeed between these two plates as to resistance.

The next in order of resistance was Messrs. Cammell's plate of soft iron faced with 2½ ins. of steel.

A shot of 116·87 lbs., fired direct with 15 lbs. charge, stuck with its base projecting 5 inches, and its point shewing in rear about 1·5 inches; a large piece of plate in rear was forced back, and there were large cracks both front and rear. The striking velocity of this shot was 1,260 feet, the energy on impact 1,287 foot tons, or 59·4 foot tons per inch of shot's girth.

A shot of 116·62 lbs. fired at an angle of 60 degrees, with a charge of 22 lbs., broke up in this plate, and made a large star and bulge behind; at the edges of the plate, the steel and iron were found to be separating through almost its whole length. The striking velocity was 1,443 feet, the energy on impact 1,684 foot tons, or 77·7 foot tons per inch of shot's girth.

Of the combined plates this shewed the best resistance, but it was certainly inferior to the hammered and rolled iron of the Mersey Company, and the ordinary rolled armour of Messrs. Cammell.

This last plate was afterwards turned with its steel face to the rear, but it was then penetrated by a shot of 114 lbs., fired direct with a charge of 15 lbs., striking velocity 1,283 feet, energy on impact 1,301·2 foot tons or 60·03 foot tons per inch of shot's girth; as also by a shot of 114 lbs., fired with 22 lbs., at an angle of 60 degrees, striking velocity 1,454 feet, energy on impact 1,671·1 foot tons, or 77·09 foot tons per inch of shot's girth.

Messrs. Brown's plate of rolled iron, let through a shot of 116·87 lbs., fired direct with a charge of 15 lbs., striking velocity 1,254 feet, energy on impact 1,274 foot tons, or 58·8 foot tons per inch of shot's girth; but it just resisted penetration by a shot of 117·12 lbs., fired at an angle of 60 degrees, with a charge of 22 lbs., striking velocity 1,461 feet, energy on impact 1,733 foot tons, or 80 foot tons per inch of shot's girth.

Messrs. Brown's plate of rolled iron faced with 3 inches of steel was penetrated by a shot of 116·75 lbs., fired direct with a 15 lbs. charge, striking velocity 1,259 feet, energy on impact 1,284 foot tons, or 59·3 foot tons per inch of shot's girth; and also by a shot of 115 lbs., fired direct with a 15-lbs. charge at its reverse side, striking velocity 1,293 feet, energy on impact 1,333 foot tons, or 61·5 foot tons per inch of shot's girth. It was also penetrated by an oblique shot, 22 lbs. charge, when its steel face was to the front; but there was no reliable result obtained on it with the oblique shot on its reverse side.

Both the plates made of two outer layers of soft iron and a centre of steel were penetrated by shot fired direct with 15 lbs. charges, and 22 lbs. charges at angles of 60 degrees; the plate made by Messrs. Cammell of four alternate laminations of steel and iron also let them through, whether the plate were placed so that the steel was to the front and the iron in rear, or vice versa.

It is clear from this experiment, that it is almost impossible to weld steel and wrought iron plates together so as to retain in each material the qualities they separately possess. Here, although, great skill was shewn in the difficult treatment of some of these compound plates, not one of them offered superior resistance to the ordinary soft iron armour.

This result has suggested one further trial, namely, that of securing a facing of steel, merely by bolts or rivets, to a wrought iron plate. By this plan there would be no obstacle to making the steel of any quality and temper that might be required, and the danger of injuring the wrought iron would also be removed.

Armour in one, two, and three thicknesses. 29th July, 1867.

About this time it was considered desirable to set at rest a question which had been much disputed, and on which erroneous opinions were very generally held. The point to be ascertained was: what would be the resistance offered by a given thickness of armour, disposed in two layers mechanically fitted and held together, and what in three layers, as compared with the same thickness in one solid mass. The question had become one of great importance on account of the expense and uncertainty attending the manufacture of armour of great thickness.

It had been argued that, inasmuch as the resistance of plates to punching by shot had been proved to be nearly in proportion to the squares of their thicknesses, a solid plate would resist three times as much as a plate in three, and twice as much as one in two thicknesses; and the early experiments on laminated targets were held to bear out the argument.

When fairly considered, the fallacy of all this becomes apparent; for, the rule of resistances being as the squares of the thicknesses, applies of course only to single plates, and not to the case of plates backing each other up ; and the early experiments on laminated targets were conducted against masses composed, with the exception of a face plate of 1½ in. or 2 in. plates, of a number of layers of only ordinary boiler plate, ⅝ in. thick.

The targets used on this occasion were each 5 ft. by 4 ft., and 7 ins. thick, the one being made up of two 3½ ins. plates, the other of three 2⅓ ins. thick. The plates in each were held together by twelve 2 in. rivets, and four 3 in. bolts near their edges.

As so exact a measure of the energy required for a 7 in. chilled shot to penetrate a solid 7 in. plate had been obtained in the experiment last described, the iron of these targets was of identically the same quality and make as Messrs. Cammell's standard rolled iron plate there noticed ; and these targets were held to a timber frame without backing, just as that plate was held. The gun, range, and shot were also precisely the same ; that is to say, the gun was the 7 in. muzzle-loading rifled gun, the range 70 yards, and the shot Palliser chill shot, with a head struck with 1 diameter radius. All the firing was direct.

It will be seen that in the last experiment Messrs. Cammell's standard 7 in. plate just stopped a direct shot, the energy on impact of which was 1,254 foot tons or 57·8 foot tons per inch of shot's girth.

The following results were obtained on this occasion :

The target of two thicknesses was first struck by a shot of 114 lbs., fired with a charge of 11 lbs., striking velocity 1,077 feet, energy on impact 916·9 foot tons or 42·18 foot tons per inch of shot's girth. The point of this penetrated to a depth of 6·2 inches, the shot sticking in the plate with 7½ inches of its base end out. In rear there was a bulge, and a crack about 13 inches long and 1½ inches open.

Next, it was struck by a similar shot with a 12 lbs. charge, striking velocity 1,138 feet, energy on impact 1,028·2 foot tons or 47·3 foot tons per inch of shot's girth. The head of this shot remained in the plate, and 6·2 inches in length of the body fell in front. In rear there was somewhat more of bulge and crack than in the last round.

The next round was with a similar shot, with 13 lbs. charge, striking velocity 1,200 feet, energy on impact 1,148·3 foot tons or 52·82 foot tons per inch of shot's girth. The head of this shot remained in the plate with its point just shewing in rear ; 5·8 inches of its body fell in the front of target. In rear the plate was more bulged and cracked than in the last round.

The same target was afterwards struck by another shot with 14 lbs. charge, striking velocity 1,245 feet, energy on impact 1,225·3 foot tons or 56·36 foot tons per inch of shot's girth, and the shot got through. This result was not quite reliable, owing to the target having been so much damaged before, but from the general effect, and the appearance of the fracture with the 13 lbs. charge, there is every reason to believe that this shot would have just penetrated a sound part ; or, in other words, that 57 foot tons per inch of shot's girth is the measure of force requisite to pierce 7 inch armour in two thicknesses.

Next, as to the target in three thicknesses.

The first round was with a shot of 115 lbs., and 13 lbs. charge, striking velocity 1,185 feet, energy on impact 1,119·8 foot tons or 51·51 foot tons per inch of shot's girth. This shot remained in the plate with its base just flush with the face, and its head projecting in rear; very little more force was requisite to send it completely through—in fact, but for the shot coming in contact with the edge of one of the timbers supporting the target, it would perhaps have effected complete penetration.

A shot of 114·5 lbs., with a 12 lbs. charge, was next tried. The striking velocity of this was 1,147 feet, energy on impact 1,044·5 foot tons, or 48·05 foot tons per inch of shot's girth. This shot remained in the plate with its base 4 inches out, and its point just showing in rear.

A 13 lbs. charge was again used with a shot of 114·5 lbs., striking velocity 1,200 feet, energy on impact 1,143·3 foot tons, or 52·59 foot tons per inch of shot's girth. This stuck in the plate with its base 3 inches in from the face, and may be said to have almost penetrated. Therefore, 53 foot tons per inch of shot's girth was proved to be the measure of force requisite to pierce 7-inch armour in 3 equal thicknesses.

Taking these results, therefore, with that from the 7-inch standard solid plate in the last experiment, we find that—

7-inch armour, solid...... stands about 59 foot tons per inch of shot's girth.
" " in 2 equal thicknesses, stands about 57 " "
" " in 3 " " 53 " "

In other words, assuming the resistance of the solid plate to be 100; that of the two thicknesses would be about 96, and that of the three thicknesses about 89.

Had the rule of the squares of the thicknesses, before alluded to, been applicable to this case, the resistance of the two thicknesses would have been equal to about 30 foot tons per inch of shot's girth, and that of the three thicknesses to about 20 foot tons; or taking, as before, the solid at 100, the strength of the two thicknesses would have been but 50, and that of the three thicknesses only 33·3—figures so utterly inconsistent with the results of this experiment as to show that the rule cannot be applied in this case at any rate.

In connection with this experiment, it is worth observing that the resistance of the 7-inch armour in three thicknesses is as nearly as possible equal to that of the " Warrior" side, while it is about 20 per cent. lighter.

Rodman 15-in. gun, at target of " Warrior" construction with 8-in. armour. 24th July and 25th Sept., 1867.

Before proceeding with this experiment, it may be worth while giving a few particulars of the gun and its performances. It is of cast-iron; weight, 19 tons 4 cwt.; length over all, 14 ft. 8 in.; length of bore, 12 ft. 2 in.; breech-preponderance, 6 cwt. 1 qr. 7 lbs.; calibre, 15 in.; smooth bore, of course. The American cast-iron shot used with it, weighed 453 lbs., and were of very superior quality; windage, ·1 inch.

The American powder averaged about 25 grains to the ounce; it contained about 1½ per cent. more saltpetre, and about 1 per cent. less charcoal than our powder.

With 35 lbs. of American powder the initial velocity was 931 feet per second; with 50 lbs., 1,134 feet; with 60 lbs., 1,220 feet; and with 100 lbs., about 1,530 feet.

With 35 lbs. of English powder, the velocity was about 1,041 feet, and with 50 lbs, 1,220 feet. At 30 degrees elevation, the range with 100 lbs. charge, was 7,680 yards.

The only target against which this gun has yet been fired, is that described before in this paper, as something like the "Warrior," only with 8-inch plates substituted for the $4\frac{1}{2}$ inches of that ship. It is this target that the chilled shell from our 9-inch 12-ton gun, with service battering charge of 43 lbs., will just penetrate at 200 yards.

The range was 70 yards.

On the first day's practice three shots were fired.

The first one was of American cast iron, weighing 453 lbs., charge 60 lbs. American powder, striking velocity 1,168 feet, energy on impact 4,285 foot tons or 91·79 foot tons per inch of shot's circumference. This shot struck partly on a joint of the armour, which, from previous firing, was separated from its backing by about half-an-inch. The shot forced in the plate over an area of 14 ins. by 13 ins., to a depth of 4 ins.; in addition to which, the armour was buckled 5 ins. It rebounded from the target partly broken, but its fracture shewed it to be of excellent iron. In rear two ribs were cracked, four bulged, and a bolt on which the shot struck was driven in some 3 ins.

Next, a shot made at Woolwich, of No. 6 Pontypool iron, cast in sand, struck with very nearly the same velocity and energy, but this broke up into fine pieces, and part remained sticking in the face of the armour. In rear there was little or no injury observable.

The next was an English made steel shot, weighing 498 lbs., fired with the same charge, striking velocity 1,135 feet, energy on impact 4,448 foot tons or 94·75 foot tons per inch of shot's circumference. This shot remained sticking in the armour, with as nearly as possible one half out. When it fell out from the concussion of a subsequent round, it was found to be cracked, but not much set up. The indent was then found to be 8·1 ins., and the plate was broken away round the indent. In rear there was a slight crack in one rib.

On the second day's practice, the gun was kept at the same range, and the same target was used. The charges were increased to 100 lbs. of American powder.

The first shot weighed 453·5 lbs. of American cast iron; it struck with a velocity of 1,520 feet, giving an energy on impact of about 7,265 foot tons or 155 foot tons per inch of shot's circumference; but unfortunately it did not strike where it was intended, which was the only sound part of the target remaining, and no reliable result was obtained. It, of course, did great injury to the target, but the effects are not worth recording.

The second shot was also of American cast iron, weighing 451·5 lbs. It struck with a velocity of about 1,535 feet, energy on impact about 7,377 foot ons or 156 foot tons per inch of shot's circumference. The blow fell partly on a joint of the armour, and the target was completely penetrated. The armour plate showed evident signs of previous injury from a shot that had struck near the same spot. In rear, three ribs were broken, and a very large hole burst in the skin. The destruction in-board was very great.

On the same day, two solid shot were fired from the 9-inch 12-ton gun, at 70 yards range, at the same target, inclined at angles of 65° and 70° to the line of fire.

The shot had 1 diameter heads, and were fired with full battering charges.

In the first case, namely at 65°, the point of the shot got into the backing to a depth of 13·8 inches; in rear there was very little effect beyond the skin being slightly bulged, and one wood bolt being broken.

In the other case, namely at 70°, the point of the shot passed in nearly to the skin, which was slightly bulged, and two ribs were cracked.

T. I.

PAPER XIII.

ADDENDUM TO LIST OF BOOKS OF REFERENCE ON PROFESSIONAL AND SCIENTIFIC SUBJECTS.

BY LIEUTENANT COLONEL COOKE, R.E.

In the list of books of reference given in the last Vol. of the Professional Papers, those relating to Architecture were left incomplete, and the following are now added to supply the omission.

Gwilt's Architecture. An encyclopœdia of Architecture by Joseph Gwilt. A new edition, with alterations and considerable additions by Wyatt Popworth. Additionally illustrated with nearly 400 engravings in wood, by O. Jewett. Longman, 1867. Size, 9 in. by 6 in. Price, £2 2s. 6d.

The following are the subjects treated of. The history of architecture, being a short account of the styles that have prevailed in all countries. The theory of architecture, comprising—mathematics as applicable to architecture; a description of the materials used in building; method of construction of arches, girders, roofs, &c.; carpentry, masonry, glazing, plastering, painting, specifications, &c.; drawing and perspective. The practice of architecture, comprising—the theory of beauty in architecture; details of construction of the different orders; details of windows, staircases, rooms, and other parts of a building; buildings adapted to different purposes.

This is a most valuable work of reference.

HISTORY OF ARCHITECTURE. FERGUSSON. A history of Architecture in all countries from the earliest times to the present day, by James Fergusson, F.R.S. &c. Three vols., 1865 to 1867. Published by Murray. Size, 9 in. by 6 in. by $2\frac{1}{4}$ in. Price, 1st vol., £1 15s.; 2nd vol., £1 15s.; 3rd vol., £1 6s. 6d.

The first two volumes embody, with additions, the information contained in the "Handbook of Architecture," and the third, that contained in the "History of Modern Architecture," by the same author. The first two volumes are divided into an introduction and three parts. The introduction comprises the theory and ethnography of architecture; the first part, ancient architecture; the second part, Christian architecture; the third part, Pagan architecture.

The first volume contains the theory of the principles of beauty in architecture, and an outline of the Egyptian, Assyrian, Grecian, Etruscan, and Roman styles. It then continues with a description of Christian architecture, up to the end of the Gothic period, in France, Belgium, Holland, Germany, and Scandinavia.

The second volume contains the continuation of Christian architecture in England, Spain, Portugal, Italy, and in countries where the Byzantine style prevailed. It concludes with an outline of Pagan architecture in Persia, India, China, Mexico, and Peru.

The third volume contains an account of the renaissance and other styles, which arose after the decline of the Gothic.

This most interesting work treats of architecture more from an æsthetic than a practical point of view. Whether the somewhat dogmatic opinions of the author are always accepted or not, this work cannot fail to be of value to those who wish to understand what are the principles of beauty in architecture, and how far they have been carried out in the styles of different nations.

A very valuable work on projections for maps has just been published in Paris, which enters more fully into the theoretical part of the subject than Hughes' Manual of Geography, given at page 120, vol. xv. It is entitled

TRAITÉ DES PROJECTIONS DES CARTES GÉOGRAPHIQUES. Représentation plane de la Sphère et du Sphéroide par A. Germain, ancien élève de l'école Polytechnique, &c., &c. Première partie: Théorie des projections. Deuxième partie: construction et usage des principales projections. Accompagnées de 14 planches gravées. Ouvrage approuvé par S. Exc. le Ministre de la Marine et des Colonies. Published by Arthus Bertrand, Paris. Size, 9 in. by 6 in. by $1\frac{1}{2}$ in. Price 15 francs (about 12s.)

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